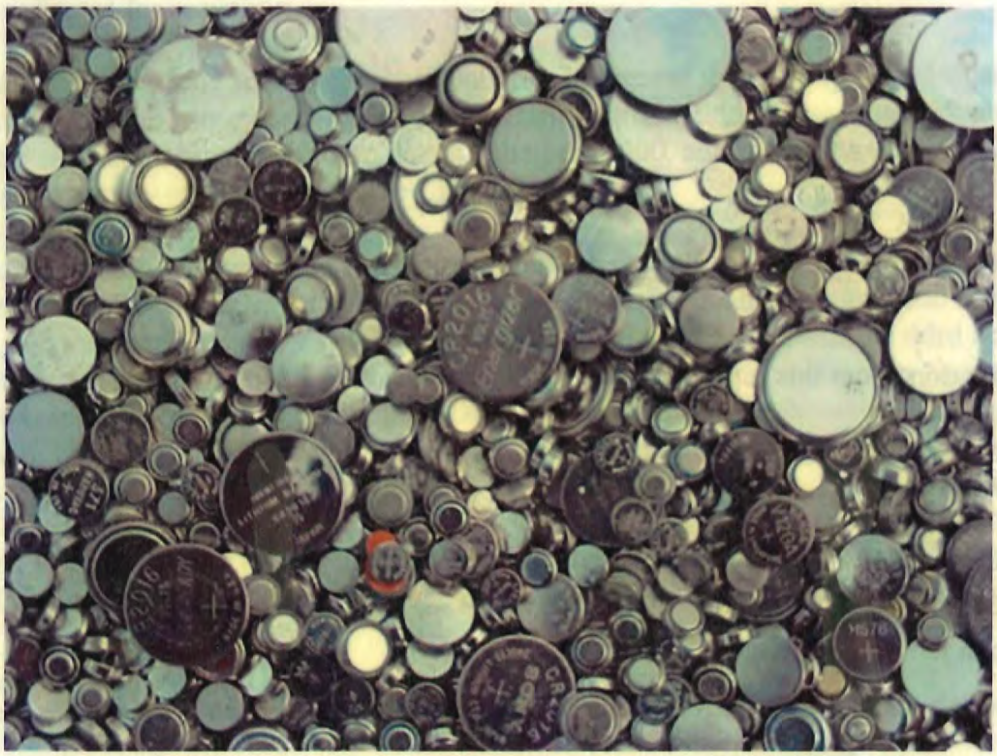
MERCURY USE IN BUTTON BATTERIES
A Report to the Joint Standing Committee on Natural Resources, 122th Maine Legislature



Prepared by:

Maine Department of Environmental Protection

March 2005

For information about this report contact:

John James
DEP-BRWM
17 SHS
Augusta ME 04333
(207) 287-7866
john.james@maine.gov

Cover photo courtesy Cape Elizabeth Recycling Committee

MERCURY USE in BUTTON BATTERIES
March 2005

I. Introduction

This report has been prepared pursuant to the requirements of Resolves 2003, Chapter 125, a copy of which is attached as Appendix A. The resolve directs the Department of Environmental Protection (department) to review the use of mercury in button batteries, including:

- The amount of mercury in foreign-made batteries sold in the United States, including batteries sold with a consumer product;
- The availability of mercury-free batteries;
- Whether 38 MRSA § 2165 should be revised to further restrict the mercury content of batteries; and
- Whether mercury-added batteries that remain in commerce should be labeled and collected for recycling.

Manufacturers have long used mercury in batteries to prevent the buildup of hydrogen gas, which can cause the battery to bulge and leak. Battery production still accounts for about 1/3 of the global mercury demand based on data for the year 2000, and over 95% of this usage is attributed to battery makers outside the United States.[1]

In the U.S., the use of mercury in consumer batteries has declined sharply over the last two decades. In the early 1980s, battery manufacture constituted the largest domestic use of mercury (over 1,000 tons annually). By 1990, usage had dropped to 117 tons, still the third largest domestic use of mercury.[2] Shortly thereafter, usage by U.S. battery makers dropped to a few tons per year as several states, including Maine, became concerned about the hazard posed by disposal of mercury-added batteries and enacted legislation that greatly restricted the mercury content of batteries.[3]

By 1993, battery manufacturers had begun selling mercury-free alkaline batteries. This became the national standard in 1996 with passage of the federal Mercury-Containing Battery

---

[1] Peter Maxson, *Mercury Flows in Europe and the World*, p. 41 (European Commission, 2004).
[2] Stephen Jasinski, S., *The Materials Flow of Mercury in the United States*, p. 17 (U.S. Bureau of Mines, 1994).
[3] See PL 1991, c. 808, § 2, enacting 38 MRSA §2165(6) to read:

6. Mercury content. A person may not sell, distribute or offer for sale in this State the following batteries:

A. An alkaline manganese battery that contains more than .025% mercury except that any alkaline manganese battery resembling a button or coin in size and shape may contain no more than 25 milligrams of mercury;

B. Effective January 1, 1993, a consumer mercuric oxide button cell;

C. A zinc carbon battery manufactured on or after January 1, 1993 that contains any added mercury; or

D. An alkaline manganese battery manufactured on or after January 1, 1996 that contains any added mercury except that any alkaline manganese battery resembling a button or coin in size and shape, may contain no more than 25 milligrams of mercury.

Management Act.[4] Today, most U.S. made batteries do not contain added mercury. The two exceptions are mercuric oxide batteries and button cell batteries, i.e., batteries that resemble a button or coin in size or shape.

In mercuric oxide batteries, mercury is used as an electrode rather than an additive to control gas buildup. The mercury accounts for up to 40% of the battery weight and cannot be reduced without reducing the energy output of the battery. Mercuric oxide button cells once were widely used in hearing aids but now are prohibited under both Maine and federal law. Larger mercuric oxide batteries still are produced for military and medical equipment where a stable current and long service life is essential. Both Maine and federal law allow these batteries to be sold, but only if the manufacturer has established a system to collect the waste batteries and ensure that the mercury is properly managed. Users are prohibited from disposing of spent mercuric oxide batteries except through the collection system established by the manufacturer.[5]

In button batteries, small amounts of mercury still are used to prevent the formation of gases. There are three separate button battery chemistries that typically contain added mercury. These include the zinc air batteries used mainly in hearing aids; silver oxide batteries, most of which are used in watches and cameras; and alkaline manganese batteries used in digital thermometers, calculators, toys and a myriad of other products requiring a compact power source.

Maine law and the federal Battery Management Act limit the mercury content of alkaline manganese button cells to no more than 25 milligrams (mgs), but the use and disposal of mercury-added button cells is otherwise unregulated. They do not have to be labeled; it is legal to dispose of them in the household trash; and they rarely are collected for recycling in most U.S. jurisdictions, including Maine. The remainder of this report explores whether mercury-added button cells should be targeted for additional regulatory action.

II. How much mercury are we talking about?

Available data indicate that button batteries currently contribute from 3 to 5 tons of mercury to U.S. commerce each year. This includes sales of original equipment (e.g., toys, watches, calculators) with embedded button batteries and button batteries sold separately to replace batteries in original equipment.

U.S. made batteries account for about half of the U.S. consumption of mercury in button batteries. The National Electrical Manufacturers Association (NEMA) reports that U.S. manufacturers Duracell, Energizer, Kodak, Panasonic and Rayovac collectively used about 5,300 pounds of mercury in button cell batteries sold in the U.S in 2002.[6] Zinc air button cells for hearing aids accounted for over 4,500 pounds or 85% of this total. The mercury totals for silver oxide and alkaline manganese button cells sold that year were about 475 pounds and 270 pounds respectively.

---

[4] 42 USC § 143301 et seq.

[5] *See* 38 MRSA §§ 2165(2) and (4).

[6] Richard Tozer, *Analysis of Battery Industry Sponsored Button Cell Collection Programs*, p. 10 (National Electrical Manufacturers Association, 2003). A copy of this reported is attached in Appendix D.

Data on mercury use in imported batteries is limited. Only two foreign battery manufacturers—the Shanghai Biba Battery Company and Toshiba— have disclosed their mercury usage for U.S. sales. Based on information filed with the Interstate Mercury Education and Reduction Clearinghouse (IMERC)[7] by importers of products containing button cell batteries, at least 10 other foreign companies are known to make mercury-added batteries sold in the U.S. either individually or as a component in a larger product.

Table I below lists all known manufacturers of mercury-added button cell batteries sold in the U.S., and shows the total mercury for U.S. sales where known.

Table I. Manufacturers of button batteries sold in the U.S.

Manufacturer	Location	Battery Chemistry	Annual Hg - US sales
NEMA - Duracell, Energizer, Kodak, Rayovac, Panasonic	United States	alkaline manganese	270 lbs*
		silver oxide	474 lbs*
		zinc air	4540 lbs*
Shanghai BiBa Batteries Co.	Hong Kong	alkaline manganese	603 lbs**
		silver oxide	157 lbs**
Toshiba	Japan	zinc air	288 lbs**
Chener Battery Works	Hong Kong	alkaline manganese	?
Chung Pak (Evergreen)	Hong Kong	alkaline manganese	?
Gold Peak	Hong Kong	alkaline manganese	?
		silver oxide	?
Hitachi Maxell	Japan	alkaline manganese	?
		silver oxide	?
New Leader	China	alkaline manganese	?
		silver oxide	?
Renata	Switzerland	silver oxide	?
Schenzhen Konnoc (Konnoc)	China	alkaline manganese	?
Sony	Japan	silver oxide	?
Varta	Germany	silver oxide	?
Zhuhai Zhi Battery Co., Ltd	China	alkaline manganese	?

* based on sales in 2002 as reported by NEMA
**based on sales in 2001 as reported to IMERC

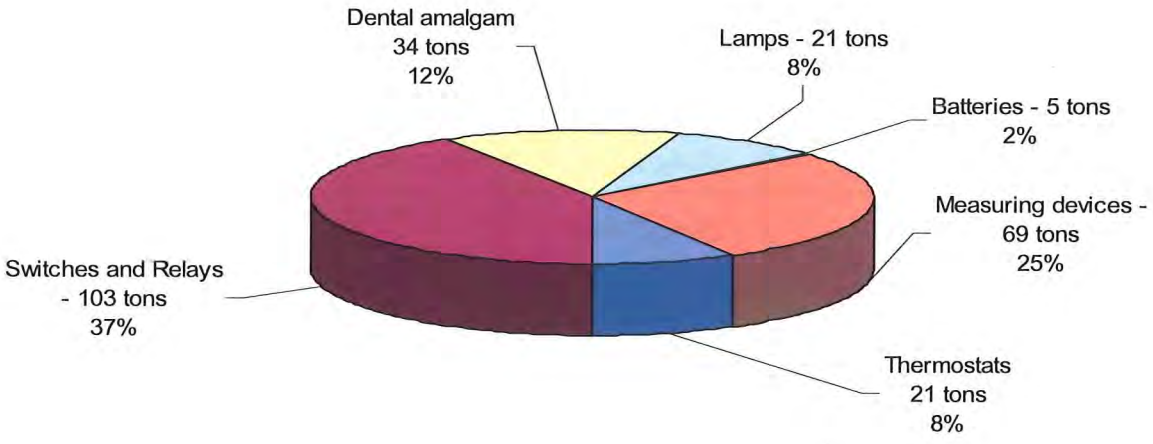
TOTAL > 6,347 lbs

[7] The Interstate Mercury Education and Reduction Clearinghouse or IMERC is operated by the Northeast Waste Management Officials Association. IMERC was formed in 2001to coordinate the collection of data on mercury-added products under disclosure laws in Connecticut, Maine, Massachusetts, New Hampshire and Rhode Island. These states prohibit the sale of a mercury-added product unless the manufacturer has disclosed the amount and purpose of the mercury.

The degree to which Table 1 under-represents the total amount of mercury in all button batteries consumed annually in U.S. cannot be estimated with certainty. However, if each of the 10 manufacturers that have yet to disclose mercury totals contribute an average of 200 pounds of mercury annually to U.S. commerce, then the total annual U.S. consumption of mercury in button batteries exceeds 10,000 pounds or 5 tons. This in turn represents about 2% of the annual U.S. consumption of mercury in products as estimated by the U.S. Environmental Protection Agency and shown in Figure I.

Figure 1. Estimated Annual U. S. Consumption of Mercury in Products

Total annual consumption = 280 tons



Sources: Jasinski, S., *The Materials Flow of Mercury in the United States*", U.S. Bureau of Mines, 1994; US Geological Survey, *Minerals Yearbook: Mercury*, 1994-2002; Minnesota Pollution Control Agency, *Substance Flow Analysis of Mercury in Products*, 2001; Interstate Mercury Education and Reduction Clearinghouse, *Mercury in Products Database*, http://www.newmoa.org

Maine's share of the estimated annual U.S. consumption of mercury in button batteries is 45 pounds [10,000 lbs x .0045] based on 2000 census data.[8] Because button batteries currently are not widely targeted for recycling in Maine, almost all of this mercury presumably ends up in the municipal solid waste stream where it is either incinerated or landfilled.

[8] Maine's population as reported by the U.S. Census Bureau for 2000 is 1,274,923 or 0.45 percent of the U.S. population of 281,421,906. See http://www.census.gov/population/www/cen2000/respop.html

Mercury emissions from Maine's four waste-to-energy incinerators totaled 58 pounds in 2002; mercury emissions from landfills were estimated at 6 pounds that year. Together, these two sources accounted for about 11% of the estimated total amount of mercury emitted to the air from in-state sources in 2002.

Given that button batteries are only one of numerous mercury-added products that contribute to these emissions, the battery industry argues that mercury use in button batteries is insignificant and undeserving of regulatory attention.[9] The department disagrees. Here is why:

- Although button battery manufacture accounts for only about 2% of annual mercury consumption in the U.S., button batteries account for a higher percentage of the mercury in Maine's solid waste. This is because, of the mercury-added products shown in Figure 1, only batteries still can legally be placed in the trash in Maine. The other products either are targeted for recycling or elimination or, as in the case of dental amalgam, typically do not end up in the municipal waste stream.

- Sales of mercury-added button batteries appear to be increasing. NEMA members, for example, report using over 1000 pounds more mercury in 2002 than in 2000, presumably due an increase in the number of batteries sold. In Maine, button battery sales have grown from an estimated 450,000 units in 1990[10] to over 1.5 million in 2002.[11] And this estimate accounts only for Maine's share of button battery sales by NEMA members. Total button battery sales in Maine could be significantly higher due to the sale of toys, novelties and other products containing button batteries that enter the state from foreign sources.

  NEMA's data on mercury usage, for example, suggest that its members sold about 11 million alkaline manganese button batteries in the U.S. in 2002. Yet the Kellogg Company, in a single nation-wide promotional campaign for its breakfast cereals, distributed 17 million Spider Man toys powered by a foreign-made alkaline manganese button battery. Further, China produced about 2.5 billion button cell batteries in 2003 and is expected to produce 5 billion in 2005. "It can be reasonably assumed that significant amounts of these batteries are included in original equipment manufactured in Asia and ultimately sold in the United States."[12]

- There is little scientific support for the proposition that it is "safe" to dispose of batteries or other mercury-added products in the trash. Mercury is a persistent neurotoxin that has bio-accumulated in the aquatic environment to the point where the state Bureau of Health now advises children and women of child bearing years to limit their consumption of fish from Maine waters. This pollution problem has evolved out of the cumulative impact of mercury releases from multiple sources. All releases of mercury, regardless of amount, are problematic because they contribute to the overall adverse health risk.

---

[9] *See* Ric Erdheim of the National Electrical Manufacturers Association in correspondence to John James of the Department of Environmental Protection, December 17, 2004. A copy of the letter is included in Appendix C.
[10] Maine Waste Management Agency (MWMA), *Maine Used Dry Cell Battery Management Plan* (November, 1993), p. 10.
[11] Catherine Galligan and Greg Morose, *An Investigation of Alternatives to Miniature Batteries Containing Mercury*, p. 14 (Lowell Center for Sustainable Production, 2004). A copy of the LCSP report is included in Appendix B.
[12] *Id.* at 13.

- Maine remains committed to the goal of virtual elimination of anthropogenic uses and releases of mercury, as called for in the Mercury Action Plan adopted by the Conference of New England Governors and Eastern Canadian Premiers in June 1998. The continued disposal of mercury-added batteries in the trash is contrary to this goal.

The elimination of button cell batteries from Maine's waste stream will not solve the mercury pollution problem. Battery use in Maine, after all, consumes only about 45 pounds of mercury per year, compared with global consumption estimated at over 1000 tons in 2000.[13] Regional, national and global action ultimately is needed. Nevertheless, the actions of a single state, even one as small as Maine, can spur national and international action to eliminate unnecessary mercury uses and reduce the global demand for this poison. Prudence alone dictates that we shouldn't dump toxins like mercury in the trash when we have clear alternatives.

III. Can this mercury use be eliminated?

The purpose of mercury in batteries

As previously mentioned, mercury has long been used in batteries to prevent the buildup of hydrogen gas that otherwise could cause the battery to bulge and leak. The formation of hydrogen gas is a phenomenon associated with batteries that have zinc anodes.[14] This includes alkaline manganese, silver oxide batteries, zinc air and zinc carbon batteries. The mercury coats the anode to prevent gas from forming.[15]

By the early 90s, the battery industry had found ways to eliminate the use of mercury to control gas formation in cylindrical and rectangular batteries. This was accomplished by reducing impurities that cause gassing, by using other techniques to suppress gas formation, and by redesigning the batteries to allow the gases to escape more readily. The relatively large size of cylindrical and rectangular batteries also "allows them to be packed less fully such that any buildup of gases will not lead to internal gas pressures that cause leaking or rupturing of the battery sealing systems."[16]

Current limits on the mercury content of batteries

In 1992, the Maine Legislature codified these mercury reduction gains when it enacted 38 MRSA §2166(6) prohibiting the sale of zinc carbon and alkaline manganese batteries containing added mercury. At that time, however, the industry had been unsuccessful in eliminating mercury from button cell batteries because their relatively small size leaves little room for internal gas buildup before the battery is adversely affected.[17]

---

[13] Maxson supra n. 1 at 35.
[14] *Household Batteries and the Environment*, p. 15 (National Electrical Manufacturers Association,, 2002).
[15] MWMA *supra* n. 10 at 16.
[16] NEMA *supra* n 14 at 16.
[17] *Id.*

In recognition of this unsolved technological challenge, the Legislature decided to exempt button cell batteries from the sales ban if they contain no more than 25 milligrams of mercury. Specifically, 38 MRSA §2165(6)(D) provides:

> "A person may not sell...[a]n alkaline manganese battery manufactured on after January 1, 1996 that contains any added mercury except that any alkaline manganese battery resembling a button or coin is size and shape, may contain no more than 25 milligrams of mercury."

The 25-milligram mercury limit under Maine law applies only to alkaline manganese button cells; the law is silent on the mercury content of silver oxide and zinc air button cell batteries. However, Minnesota law[18] applies the same limit to all battery chemistries, and NEMA reports that U.S., Japanese and European manufacturers adhere to the 25 mg limit for all chemistries.[19]

The legal status of so-called stacked button cell batteries with respect to the 25 mg limit is open to question. Most button batteries are sold individually, but several manufacturers (including Duracell, Energizer, Kodak and Panasonic) combine stacks of silver oxide or alkaline manganese button cells to produce a cylindrical battery for uses that require a higher voltage, e.g., remotes for garage door openers and dog control collars. Stacks of zinc-air button cells also are combined to make a rectangular battery used in medical devices, but this usage is very limited.

When button cells are stacked, the voltage of the individuals cells is additive and so is the mercury content. Most stacked cell batteries contain more than 25 mgs of mercury and many can exceed 50 mgs depending on the chemistry and number of individual cells. Whether the sale of these batteries violates Maine law depends on whether the 25 mg limit under section 2165 is applied to the battery or the individual cells that make up the battery.

Stacked cell batteries do not resemble "a button or coin is size and shape." Indeed, from the outside, it is difficult to distinguish stacked cell batteries from alkaline AAA and other cylindrical batteries that do not contain mercury. Nor are stacked cell batteries labeled to indicate they contain mercury. On the other hand, stacked cell batteries were available in 1992 when section 2165 was enacted,[20] and there is no clear indication in either the wording or history of the Maine law that would suggest the Legislature meant to prohibit their sale in Maine.

The status of efforts to eliminate mercury from button batteries

About a year after the 25-mg limit was enacted, the now defunct Maine Waste Management Agency issued a battery management plan that included the following statement:

> "[Battery manufacturers] have indicated that the eventual elimination of mercury use in alkaline cell construction is technically feasible and have been working towards achieving this goal."[21]

---

[18] Minnesota Statutes § 325E.125, subd. 2.
[19] Ric Erdheim to John James, personal communication, July 27, 2004.
[20] Ric Erdheim to John James, personal communication, December 9, 2004.
[21] MWMA *supra* n. 10 at 17.

The development of the zinc air technology in the early 90s allowed the industry to phase out the use of mercuric oxide button cells in hearing aids, thereby reducing mercury use in button batteries by over 90%.[22] However, although U.S. manufacturers continue to explore "no mercury" formulas,[23] they have not yet perfected the technology to eliminate mercury altogether as Table 2 below shows.

Table 2. Mercury content of button batteries sold by U.S. manufacturers in 2002

Battery technology	Average mercury content (mg)	Total amount of mercury (pounds)	Approximate sales quantity*
Zinc air	8.5	4,540.3	242 million
Silver oxide	2.5	473.6	86 million
Alkaline	10.8	269.6	11 million
Totals:		5,283.5	339 million

* The approximate sales quantity was calculated based upon data from the columns: "Average Mercury Content" and "Total Amount of Mercury".

To independently explore whether further mercury reductions are possible, the department hired the Lowell Center for Sustainable Production (LCSP). LCSP's report—*An Investigation of Alternatives to Miniature Batteries Containing Mercury*—is attached as Appendix B. Among other things, LCSP found that manufacturers are beginning to market mercury-free versions of all three button battery types that currently contain mercury, although mercury-free zinc air batteries for use in hearing aids so far have been introduced only in Europe.

According to Energizer, the manufacturer of the zero-mercury zinc air battery, they are very challenging to produce and production capability is not yet robust enough to support introduction in the United States.[24] Energizer introduced this product in Europe because it presented a manageable volume.[25] The company currently offers mercury free zinc air batteries in four models, but has given no timeline as to when these batteries will be commercially available outside Europe.

At least two companies—Sony and New Leader—now offer mercury-free silver oxide button batteries for sale on the world market. Sony claims to be among the largest producers of silver oxide batteries in the world, with sales of over 400 million annually. The company produces over 40 models of silver oxide batteries in numerous sizes, consuming about 700 pounds of mercury per year in the process. It plans to introduce 10 models of mercury free batteries in 2005, and eventually plans to eliminate mercury from its entire product line. Sony silver oxide batteries are used use mainly in watches, digital fever thermometers and game products.[26]

New Leader, a battery manufacturer located in China, currently offers mercury-free silver oxide button batteries to original equipment manufacturers (OEMs) for use in their end products. New

[22] Tozer *supra* n. 6 at 9; *see also* "Energizer and the Environment", Energizer Holdings, Inc., http://www.energizer.com/learning/environment.asp.
[23] Erdheim *supra* n. 9.
[24] Ric Erdheim to John James, personal communication, October 13, 2004.
[25] *Id.*
[26] Sony Global press release, September 29, 2004, http://www.sony.net/SonyInfo/News/Press/200409/04-051E/

Leader also offers mercury-free alkaline manganese button batteries to OEMs, and claims Burger King, Macdonald's, Kellogg's, Hallmark Cards, Kmart and Wal-Mart as customers.[27]

Konnoc and Chung Pak, two other companies known to make button batteries sold in the U.S., also claim to make mercury-free models but LSCP was unable to obtain product specifications to confirm this. At least two companies—Sony and an unidentified company based in Hong Kong (Chung Pak?)—have applied for U.S. patents related to the development of mercury-free alkaline manganese button batteries.

LCSP notes that the performance characteristics of the mercury-free button batteries, as published by Energizer, Sony and New Leader, appear to be comparable to mercury-added batteries. These manufacturers must be satisfied that they have overcome the problem of controlling the formation of internal gases without the use of mercury; they presumably would be unlikely to market a product that could undermine their reputation for quality or expose them to product liability claims.[28,29] Nevertheless, the lack of independent testing data confirming that these mercury free batteries perform reliably in the field, especially as relates to the potential for buildup of internal gases, remains a concern for potential end users.

The American Watch Association (AWA) has expressed this concern, stating that it is unknown if the mercury free batteries will work over the long run to prevent the buildup of gases that could potentially damage a watch. Some AWA members plan to use the Sony mercury-free batteries as soon as they have proven track record of reliability but feel it is too soon to risk using them in their valuable watches.[30] According to the AWA, watchmakers need to conduct extensive testing demonstrating that the new batteries will function safely and properly before they are put into watches.[31] (See Appendix C for the comments of AWA Executive Director Emilio Collado.)

The reliability of mercury-free hearing aid batteries also is of concern. (See Appendix C for the comments of Gil Poliquin, a hearing aid dealer from Lewiston.) NEMA suggests, however, that quality and performance issues with the Energizer mercury-free zinc air batteries currently being sold in Europe are unlikely,[32] and no such issues have been brought to our attention. The main issue for the U.S. markets appears to be production capacity rather than reliability.

Limited pricing information suggests that mercury-free alkaline manganese and silver oxide button batteries cost about 30% more than mercury-added models. As the market expands, this initial price differential is expected to narrow due to increased competition and economies of scale from larger production runs.[33]

Cost may be a particular issue for hearing aid users, most of whom are elderly. Hearing aid batteries have a useful life of one to four weeks once they are placed in service, meaning users

---

[27] LCSP *supra* n. 11 at 26.
[28] *Id.* at 24
[29] Erdheim *supra* n. 9.
[30] *Maine could ban mercury-containing watch batteries*, The National Jeweler, December 6, 2004
[31] Probir Mehta on behalf the AWA in personal communication to Terri Goldberg of IMERC, February 9, 2005.
[32] Erdheim *supra* n. 9.
[33] LCSP *supra* n. 11 at 24.

could go through 50 or more batteries per year depending on whether they wear one or two hearing aids. Hearing aid batteries currently can be purchased in the U.S. for less than $1 dollar each, and it is not known if manufacturers ultimately will be able to offer mercury free hearing aid batteries at comparable prices. In Europe, however, Energizer did not increase prices when it launched its line of mercury-free zinc air batteries.

IV. Is it feasible to recycle button cell batteries?

NEMA is strongly opposed to any effort that would require manufacturers to share responsibility for the recycling of mercury-added button batteries. Its position is that collection of button cells for recycling is not cost-efficient, poses a fire safety hazard and will exacerbate the swallowing hazard associated with button batteries. A copy of the NEMA paper "Button Battery Collection: Why It Does not Make Sense" is attached in Appendix C.

Battery ingestion

NEMA points out that the use of button batteries carries a small risk of injury from accidental swallowing or insertion of the battery in the ear or nose. The battery industry responsibly has addressed this risk by funding medical assistance through the National Capital Poison Control Center, by providing the Center's phone number on battery packaging, and by labeling the packaging to warn users to "keep batteries away from children."

An official at Rayovac goes further, recommending against use of "button cells of any type in children's toys, especially ones that may be dissected or chewed..."[34] This official further observes that lithium button cells, which contain no mercury, are especially problematic because they have been shown to cause serious burns in the esophagus if swallowed. Lithium batteries, moreover, are larger in diameter than other button batteries, and presumably more likely to become lodged in the esophagus.

In 2003, U.S. poison control centers logged 2,395,582 human exposure cases.[35] In 2,568 of these cases, the exposure was to a "disc battery," a category that includes six different button battery chemistries including lithium, alkaline manganese, silver oxide and zinc air. Most of these incidents involved ingestion and, in most cases, the battery passed through the digestive system without causing harm. However, 135 of these cases resulted in minor injury; 32 caused moderate injury; and four led to major injury.[36] To the extent the battery type is known, lithium batteries are implicated most often in the cases resulting in injury.

Dr. Toby Litovitz, executive director of the National Capital Poison Center, has consistently opposed efforts to collect button batteries for recycling on the premise that recycling may increase the number of battery ingestions. Her most recent comments on this issue are included in Appendix C. In these comments, Dr. Litovitz points out that at least three children have died

[34] Tim Anderson of Rayovac in personal communication to Ralph Erickson of the Madison, Wisconsin Metro Sewerage District, December 20, 2000.
[35] William Watson et al., "2003 Annual Report of the American Association of Poison Control Centers," *Amer. Joun. Toxicol.* 22:335-404, p. 336 (September 2004).
[36] *Id.* at 377.

and hundreds of other severely injured from button battery ingestions since poison control centers began tracking data in 1983, and she is concerned that number of ingestions will rise if batteries are saved for recycling rather than thrown in the trash.

These concerns have been echoed by a least one Maine audiologist. Jean Toth, an audiologist who practices in Presque Isle, writes:

> "I talk to every client about the dangers of swallowing a hearing aid battery, and safe handling of batteries. In the past twenty years, I have had one patient actually swallow a battery. That person was a ten year old child. If each person now collects the old batteries in a can or box at home, how many children will suffer the consequences of ingesting a battery? I can't help but think that the incidence of such occurrences will increase markedly." (See Appendix C for Ms. Toth email correspondence on this issue.)

Battery manufacturer Rayovac specifically recommends against recycling hearing aid batteries for this reason. On the Frequently Asked Questions page of its website, Rayovac writes:

> "Zinc air batteries used in hearing aids cannot be easily recycled and are considered general household trash when they are drained. Please [throw] these out in the trash; saving them can present a choking hazard to children."[37]

The Energizer website, on the other hand, includes the following response to Frequently Asked Questions about hearing aid batteries:

> "**Should I recycle the batteries?** If a local recycling center accepts batteries, definitely. While recycling is not required by law, Energizer encourages you to do it if you can. If you keep used batteries at home in anticipation of recycling them, remember to store them away from children and pets."[38]

Battery fires

NEMA observes that any effort to collect mercury-added button batteries for recycling inevitably will capture lithium coin-shaped batteries. Lithium batteries do not contain mercury but may pose a fire risk according to NEMA. A NEMA consultant writes:

> "Lithium electrolyte is flammable. These batteries also contain metallic lithium, highly reactive metal that, when exposed to water, liberates hydrogen, a very flammable gas. At a mercury recycling facility, batteries will be shredded or hammered. If the recycler shreds or hammers lithium batteries, they will ignite as they are opened. Ultimately, the lithium metal may ignite."[39]

According to the consultant, lithium coin cell batteries do not pose a fire hazard if disposed of individually as they are replaced, but pose a serious problem if they are placed in a combustible collection container with other lithium batteries or other types of button cell batteries. If lithium

---

[37] http://www.rayovac.com/about/environmental/e_faq2.shtml
[38] http://www.energizer.com/products/ezchange/faq.aspx
[39] Tozer *supra* n. 6 at 22.

coin cells are segregated in a separate container, their propensity to rapidly discharge increases the chances of heat generation; if they are mixed with other types of button cell batteries, those batteries can serve as bridge between the terminals of the lithium cell batteries and cause a heat-generating short-circuit.[40]

Short-circuiting can occur because many batteries are not fully discharged when disposed by consumers. Disposing of the batteries individually minimizes the risk of short-circuiting and fire. Alternately, the batteries can be protected from short-circuiting by taping the terminals or placing individual batteries in plastic bags, a time consuming process that NEMA points out adds to the cost of recycling.[41]

NEMA suggests that at least two buildings have caught fire as a result of efforts to recycle button batteries. In 2002, an 85-gallon drum of lithium batteries self-ignited at a hazardous waste facility in Clarence, New York, causing $2 million in damage. And a RadioShack store in Pennsylvania burned to the ground due to a fire that allegedly started in a battery collection container.

NEMA also points out that U.S. Department of Transportation (DOT) recently issued a new regulation prohibiting the transport of lithium batteries aboard passenger aircraft.[42] The DOT acted in the wake of several fires involving shipments of pallets of lithium batteries by manufacturers and importers. In one incident at Los Angeles International Airport, two pallets stacked with 120,000 coin cell lithium batteries caught fire when they were damaged during unloading. At Indianapolis International Airport, a fire in a shipment of lithium batteries apparently started when the batteries short circuited inside their packaging. None of the incidents mentioned in the Federal Register notice of the new rule involved the shipment of button batteries for recycling.

In a phone interview with LCSP, a representative of a company that offers button battery collection services to municipalities and other generators says that the company has never had a fire in a community collection box or during transit of button batteries. LCSP further observes:

> "[F]our elements are needed to initiate and sustain a fire: fuel, oxygen, heat and a chemical chain reaction. In general, there would be only a small amount of electrical energy left in spent miniature batteries (making the potential for heat generation minimal), the closed box will limit oxygen availability, and there would be little or no fuel to sustain a fire. Therefore it is unlikely that conditions supporting a fire would occur in a miniature battery collection box.
>
> While there is always some risk of fire in most municipal waste recycling programs, we could not find evidence of any elevated risk associated with mercury-containing battery collection and recycling programs."[43]

---

[40] *Id.*
[41] *Id.* at 24.
[42] Hazardous materials; prohibition on the transportation of primary lithium batteries and cells aboard passenger aircraft; final rule, 69 Fed. Reg. 75208-16 (December 15, 2004) (to be codified at 49 CFR Parts 171, 172, 173 and 175).
[43] LCSP *supra* n. 11 at 37-38.

Button battery recycling in the U.S.

In the U.S., no state currently bans the disposal of mercury-added button cell batteries and there are no state-sponsored programs to collect them. Some local jurisdictions in the U.S. include button cell batteries in programs targeting the collection of household hazardous waste (HHW). However, participation in these programs is voluntary and all reported a battery capture rate of less than 50%.

Hennepin County, Minnesota, and Chittenden County, Vermont, are two widely cited examples of local HHW collection programs that target button cell batteries. At our request, the LCSP examined these two programs and two others—a program run by a town in Massachusetts and program run by Wheelabrator Technologies, a company hired to operate three municipal solid waste incinerators serving 69 communities in the Northeast.

LCSP reports that, from the perspective of the program administrators, button battery recycling programs run smoothly and safely but there is an ongoing challenge to increase the recycling rate. In each of these programs, collection containers are distributed at multiple locations and the contents of the containers are periodically consolidated and shipped to a battery recycling facility. Among the locations chosen for collection containers are recycling centers, city halls, drug stores, health care facilities, hardware stores, libraries, photo stores, retail stores and senior citizen complexes.

Each of the program representatives interviewed by LCSP had heard of fire hazards associated with lithium batteries, but none have attempted to exclude lithium batteries at the button battery collection points and none have experienced a problem with heat or fire in the collection container. One of the counties, however, pays an intermediary to sort the batteries by type and tape the poles of the lithium batteries. No one was aware of a battery ingestion incident attributed to their recycling program.[44]

Although button batteries currently are not targeted for recycling in most U.S. jurisdictions, button battery collection and recycling services are well-established and readily available in this country. Several companies, including Battery Solutions, Toxco and Onyx Electronics Recycling, offer low cost battery collection containers that are easy to use. The containers are available in a number of sizes and the purchase price includes prepaid shipping labels that cover the cost of shipping, handling and recycling. If these containers are used, battery recycling generally can be expected to cost less than 1¢ per battery. Both Chittenden and Hennepin Counties report recycling costs of less than a penny per battery.[45] NEMA points out that the total costs of a button battery recycling program could be substantially higher depending on the resources and effort devoted to education and promotion.[46]

It also must be pointed out that many, if not most, silver oxide button cell batteries currently are recycled without government intervention. These batteries are collected by jewelers when they

[44] *Id.* at 62.
[45] *Id.* at 35.
[46] Tozer *supra* n. 6 at 30.

replace watch batteries and are recycled to recover the silver. About 75% of the silver oxide button cells produced by U.S. battery manufacturers are used in watches (most of the rest are used in cameras). The American Watch Association estimates that 95% of jewelers replace watch batteries and it is thought that most consumers use the services of a jeweler to change watch batteries in order not to void the watch warranty. The AWA reports that large retail jewelers like Wal-Mart replace and recycle millions of silver oxide batteries every year.

Button battery recycling in Europe

In Europe, the recycling of mercury-added button batteries is mandated by directive of the Council of the European Union. Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances, as amended by Commission Directive 98/101/EC, requires member states to, among other things:

- Mark batteries to indicate the heavy metal content and the requirement for separate collection and recycling;
- Establish programs designed to reduce the heavy metal content of batteries, promote the marketing of batteries containing smaller amounts of dangerous substances, and promote research into more benign batteries and better recycling methods; and
- Ensure efficient and separate collection systems for batteries.

The EU member states have taken divergent approaches to compliance with the directive. Twelve countries, for example, require retailers to take back batteries, including button cells, at the point of sale, with the collection costs funded by a fee on manufacturer battery sales. The European Commission reports, however, that the success of these efforts varies widely from country to country. Many mercury-added button batteries still are landfilled or incinerated in Europe, and the overall battery collection rate is thought to be low, only about 15% of estimated sales.[47]

One of the main reasons for the poor collection rate in Europe seems to be that consumers have considerable difficulty distinguishing between the batteries covered by the current directive (i.e., those containing mercury, cadmium and lead) and other batteries.[48] Fire safety and battery ingestion have not been identified as barriers to battery recycling in Europe.

[47] LCSP *supra* n. 11 at 36.

[48] Commission of the European Communities, Proposal for a Directive of the European Parliament and of the Council on Batteries and Accumulators and Spent Batteries and Accumulators, p. 17 (November 21, 2003).

IV. Conclusions

- It is not safe to throw mercury-added button batteries in the trash and the Maine Legislature did not determine that it was safe to do so in 1992 when button batteries containing less than 25 milligrams of mercury were exempted from the limitations on mercury use in batteries. Button cell batteries were exempted because, at that time, the technology did not exist to control the formation of gas in batteries of that size without using mercury.

- Some battery manufacturers recently have found ways to make button cells without the use of mercury and have introduced mercury-free models to the marketplace. The long-term reliability of these new mercury-free batteries is unproven and production capacity is limited. Maine can hasten the deployment of mercury-free button battery technology by phasing out the exemption under 38 MRSA §2165(6) that currently allows button batteries containing less than 25 mgs of mercury to be sold in Maine. This exemption, if left in place, could become a disincentive to the use of mercury free batteries.

- Labeling of button battery packaging to identify those that contain added mercury will enable consumers to shop for mercury-free replacement batteries, and could hasten the deployment of mercury-free button battery technology.

- A rapid phase-out of the use of mercury in batteries will make it unnecessary to establish a statewide program to collect and recycle button batteries. This strategy is in keeping with Maine solid waste management hierarchy under which reduction of the toxicity of waste at the source is preferred over recycling.[49]

- If the Legislature decides to prohibit the disposal of button batteries (as proposed in legislation recently referred to the Committee on Natural Resources[50]), manufacturers should share responsibility for putting an effective battery collection and recycling program in place and the program should include a strong message aimed at making the public aware of the need to keep button batteries out of the reach of children. If manufacturers are made responsible for the costs of safely collecting and recycling spent mercury-added batteries, they will have a powerful economic incentive to redesign the product to eliminate the use of this toxic substance.

Since 1998, when Maine joined the other New England states and the premiers of Eastern Canada in pledging to virtually eliminate anthropogenic sources of mercury, this state has been a

---

[49] 38 MRSA § 2101(1) reads:

1. Priorities. It is the policy of the State to plan for and implement an integrated approach to solid waste management, which shall be based on the following order of priority:

A. Reduction of waste generated at the source, including both amount and toxicity of the waste;

B. Reuse of waste;

C. Recycling of waste;

D. Composting of biodegradable waste;

E. Waste processing which reduces the volume of waste needing land disposal, including incineration; and

F. Land disposal of waste.

[50] *An Act to Regulate the Use of Batteries Containing Mercury*, LD 1058, 122nd Maine Legislature.

national leader in efforts to reduce the use of mercury in consumer products. In almost every case (the only exception being mercury manometers in dairy barn milking rooms), the targeted products account for a larger usage of mercury than button batteries.

Maine, for example, already has laws banning the sale of mercury thermostats (200 pounds of mercury per year), mercury fever thermometers (155 lbs/yr) and mercury switches in automobiles (55 lbs/yr). Maine also has banned the disposal of all mercury added lamps (125 lbs/yr) and assisted municipalities in building sheds to collect the lamps and keep them intact until they can be recycled. And two years ago, Maine passed a first-in-nation law that, effective July 1, 2006, will ban the sale all mercury switches, relays and measuring devices. If EPA's numbers in Figure 1 are correct, this law alone will reduce the amount mercury introduced into Maine commerce each year by about 1600 pounds.

The fundamental premise of each of these laws is that the use of mercury in product manufacturing should be eliminated wherever there are functional and affordable non-mercury alternatives. We now bring that same philosophy to the examination of button batteries. The initial focus on products that use larger amounts of mercury was appropriate, but should not be misinterpreted as implicitly condoning the disposal of other mercury-added products. Mercury is bio-accumulative and toxic; eliminating all unnecessary uses is a protective and prudent course of action.

V. Recommendations

Based on forgoing findings and conclusions, the department recommends that the Maine Legislature:

1. Prohibit the sale of mercury-added button batteries in non-essential products such as toys and other novelties effective January 1, 2007;
2. Require battery makers to label the packaging of button cell replacement batteries sold after January 1, 2007 to identify those batteries that contain added mercury;
3. Prohibit the sale of all mercury-added button batteries effective January 1, 2010; and
4. Direct the Department of Environmental Protection, by February 1, 2008, to submit a report to the Legislature assessing: a) the reliability of mercury-free button batteries; and b) whether mercury-free button batteries are being produced in sufficient numbers to support the phase-out of all mercury-added button batteries by 2010.

Appendix E sets forth proposed legislation to implement these recommendations.

APPENDICES

APPENDIX A

Resolve, Regarding the Sale of Batteries Containing Mercury, Resolves 2003, Chapter 125

APPENDIX B

Lowell Center for Sustainable Production, *An Investigation of Alternatives to Miniature Batteries Containing Mercury*

APPENDIX C

Request for public comment

Response to comment request

APPENDIX D

National Electrical Manufactures Association

- *Button Cell Battery Collection: Why It Does Not Make Sense*
- *Analysis of Battery Industry Sponsored Button Cell Collection Programs*

APPENDIX E

Enacted legislation on button batteries in novelties

APPENDIX F

Proposed Maine legislation to further regulate the use of mercury in batteries

APPENDIX A

Resolve, Regarding the Sale of Batteries Containing Mercury, Resolves 2003, Chapter 125

APPROVED	CHAPTER
APR 9 '04	125
BY GOVERNOR	RESOLVES

STATE OF MAINE

IN THE YEAR OF OUR LORD
TWO THOUSAND AND FOUR

H.P. 1237 - L.D. 1661

Resolve, Regarding the Sale of Batteries Containing Mercury

Sec. 1. Review. Resolved: That the Department of Environmental Protection shall review the sale of batteries containing mercury. The review must include consideration of the following:

1. The amount of mercury in foreign-made batteries sold in the State and the United States, including, but not limited to, foreign-made batteries sold with a consumer product;

2. Whether stacked button cell batteries meet the mercury content specifications of the Maine Revised Statutes, Title 38, section 2165;

3. Whether Title 38, section 2165 should be amended to include other battery chemistries;

4. Whether and how button cell batteries should be collected for recycling;

5. Whether and how button cell batteries should be labeled;

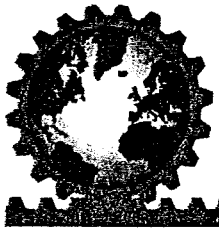
6. Whether the use of button cell batteries should be prohibited in some applications, including novelties; and

7. Whether nonmercury alternatives are available and, if so, to what extent and at what cost; and be it further

Sec. 2. Report. Resolved: That the Department of Environmental Protection shall submit a report to the joint standing committee of the Legislature having jurisdiction over natural resources matters by January 14, 2005 regarding its review of the sale of batteries containing mercury.

APPENDIX B

Lowell Center for Sustainable Production, *An Investigation of Alternatives to Miniature Batteries Containing Mercury*



Lowell Center for
Sustainable Production

University of Massachusetts Lowell

An Investigation of Alternatives to Miniature Batteries Containing Mercury

December 17, 2004

Prepared for
The Maine Department
of Environmental Protection

by
Catherine Galligan
Gregory Morose

TABLE OF CONTENTS

Executive Summary

The Maine Department of Environmental Protection (DEP) will issue a report to the Maine legislature by January 14, 2005 that will review the use of mercury in miniature batteries. To assist in gathering information for this report, the Maine DEP commissioned the Lowell Center for Sustainable Production (LCSP) of the University of Massachusetts Lowell to conduct a study of alternatives to mercury containing miniature batteries. The objectives of this study were to accomplish the following:

- Investigate miniature battery product information available in the public domain
- Estimate the total amount of mercury used annually in the manufacture of button batteries
- Identify non-mercury alternatives for miniature batteries
- Conduct a qualitative evaluation of viable alternatives
- Investigate miniature battery recycling programs in the United States and Europe

Mercury from miniature batteries can be released to the environment during various stages of the product life cycle including manufacturing, use, and disposal. Once released, the mercury can transform to toxic organic forms, and can readily disperse in the environment through the air, soil, and water. Mercury is persistent in the environment, and also accumulates in concentration as it biomagnifies within the food chain. Mercury is highly toxic to humans; exposure can damage kidneys and the central nervous system. The fetus is particularly sensitive to mercury's toxic effects. Mercury also has adverse effects on wildlife including early death, weight loss, and reproductive issues.

Miniature batteries are used in numerous products that require compact sources of electrical power. Miniature batteries are mostly used for supplying electrical power for toys, hearing aids, watches, calculators, and other portable devices. The four major technologies used for miniature batteries are: lithium, zinc air, alkaline, and silver oxide. The lithium miniature batteries contain no intentionally added mercury. However, there is typically 0.1% to 2.0% mercury content in the formulations of most zinc air, alkaline, and silver oxide miniature batteries. Based upon available data, it appears that zinc air batteries contribute the most mercury to the environment because of their high sales volumes for use in hearing aids.

The function of the mercury is to inhibit gas formation inside the miniature battery cell. Gas buildup inside the cell could cause bulging and potentially result in leakage of battery cell materials. This leakage of battery cell materials affects the ability of the battery to continue functioning. In addition, this leakage can pose a health hazard as mercury and other toxic materials are no longer encapsulated and a potential human exposure pathway is created.

Marketing data are not available to determine the total number of miniature batteries sold in the U.S. or to estimate projected future sales. However, it is clear that the use of miniature

batteries is desirable for providing electrical power for a variety of portable products. To address the negative aspects of mercury in miniature batteries, there are opportunities for source reduction and recycling. Given the demand for electrical power for portable products and the current battery technology, using fewer batteries is not a likely opportunity for source reduction. However, using different materials and technologies can reduce and or eliminate the use of added mercury in miniature batteries.

Several alternatives to mercury containing miniature batteries were identified and evaluated. The review includes lithium miniature batteries, which do not contain mercury and are sometimes considered as a potential alternative to mercury containing miniature batteries. Original equipment manufacturers (OEMs) must evaluate numerous design considerations when selecting the best miniature battery for their end product. The most important considerations for OEMs appear to be cost, nominal voltage, capacity, physical size/shape, and discharge profile. Other considerations include: type of discharge, shelf life, energy density, operating temperature, replacement availability, leakage resistance, and mercury content. The level of importance for each of these considerations can vary greatly depending upon the requirements of each particular end product (calculator, toy, watch, etc.). The suitability for replacing one miniature battery technology for another miniature battery technology must be determined on a case-by-case basis by OEMs based upon the unique requirements of their particular product.

There are mercury-free models commercially available for silver oxide, alkaline manganese dioxide, and zinc air (Europe only) miniature batteries. The performance characteristics as presented by the manufacturers appear to be comparable for the mercury and mercury-free versions. Manufacturers have taken different approaches to eliminating the mercury for each miniature battery technology. A major concern for OEMs and end-users is the capability of these mercury-free miniature batteries to perform reliably in the field, especially as relates to the potential for buildup of internal gases, which is effectively prevented by the addition of mercury. Performance testing results for buildup of internal gases for mercury free miniature batteries are not available. Also, limited pricing information suggests that mercury-free miniature batteries command a 24% - 30% premium compared to their mercury containing counterparts. This cost differential is likely to decrease as the market matures.

There are well established and readily available miniature battery recycling services offered by hazardous waste handlers in the United States as another avenue for preventing the introduction of mercury from miniature batteries into the environment. From the perspective of recycling program administrators, miniature battery recycling programs run smoothly and safely but there is an ongoing challenge to increase the recycling rate. Battery manufacturers have raised concerns about the safety of collection and recycling of miniature batteries. Our review of the data found that the use of miniature batteries, not just recycling efforts, carries a small risk of potentially harmful adverse health outcomes from ingestion or insertion of a miniature battery in the ear or nose.

Because of its nature as a persistent, bioaccumulative toxin, there is growing local and global concern about the use of mercury in products. International pressures are being applied to manufacturers to significantly reduce or eliminate the use of mercury and for responsible

recycling of mercury-containing products at the end of their useful lives. This report provides an overview of mercury-containing miniature batteries and alternatives as well as opportunities for minimizing the environmental impact of mercury from miniature batteries.

1.0 Introduction

The Maine Department of Environmental Protection (DEP) will issue a report to the Maine legislature by January 14, 2005 that will review the use of mercury in miniature batteries. To assist in gathering information for this report, the Maine DEP commissioned the Lowell Center for Sustainable Production (LCSP) of the University of Massachusetts Lowell to conduct a study of alternatives to mercury containing miniature batteries. The objectives of this study were to accomplish the following:

- Investigate miniature battery product information available in the public domain
- Estimate the total amount of mercury used annually in the manufacture of button batteries
- Identify non-mercury alternatives for miniature batteries
- Conduct a qualitative evaluation of viable alternatives
- Investigate miniature battery recycling programs in the United States and Europe

Mercury from miniature batteries can be released to the environment during various stages of the product life cycle including manufacturing, use, and disposal. Once released, the mercury can transform to toxic organic forms, and can readily disperse in the environment through the air, soil, and water. Mercury is persistent in the environment, and also accumulates in concentration as it biomagnifies within the food chain. Mercury is highly toxic to humans; exposure can damage kidneys and the central nervous system. The fetus is particularly sensitive to mercury's toxic effects. Mercury also has adverse effects on wildlife including early death, weight loss, and reproductive issues.

Miniature batteries are used in numerous products that require compact sources of electrical power. Miniature batteries are mostly used for supplying electrical power for toys, hearing aids, watches, calculators, and other portable devices. The four major technologies used for miniature batteries are: lithium, zinc air, alkaline, and silver oxide. The lithium miniature batteries contain no intentionally added mercury. However, there is typically 0.1% to 2.0% mercury content in the formulations of most zinc air, alkaline, and silver oxide miniature batteries. Based upon available data, it appears that zinc air batteries contribute the most mercury to the environment because of their high sales volumes for use in hearing aids.

The function of the mercury is to inhibit gas formation inside the miniature battery cell. Gas buildup inside the cell could cause bulging and potentially result in leakage of battery cell materials. This leakage of battery cell materials affects the ability of the battery to continue functioning. In addition, this leakage can pose a health hazard as mercury and other toxic materials are no longer encapsulated and a potential human exposure pathway is created.

The scope of this review was limited to the use of mercury in miniature, primary (non-rechargeable) batteries. Miniature batteries include batteries that are button or coin shaped.

Miniature batteries may also be combined in stacks to form a small 6- or 12-volt cylindrical battery. However, mercury generally is not used in the manufacture of other cylindrical and rectangular batteries and those batteries are not examined in this report.

There are three miniature battery technologies on the market today in the United States that use mercury:

- Zinc air
- Silver oxide
- Alkaline manganese dioxide

For each of the three miniature battery technologies listed above, this report provides a listing of applications, pricing and availability information, performance attributes (such as voltage, capacity, discharge characteristics, energy density, and operating temperature), and a representative listing of various battery models. This report also provides a description of various non-mercury alternatives to these three mercury containing miniature battery technologies. The pricing information in this report is for initial battery purchase price only, and does not include lifecycle costs such as disposal and/or recycling.

The Lowell Center for Sustainable Production (LCSP) conducted a review of publicly available information for this study. This review included the following data sources:

- Product specifications
- Material safety data sheets
- Battery manufacturer manuals
- Marketing studies
- Health and safety data
- Miscellaneous battery reports
- Mercury product information compiled by the Interstate Mercury Education and Reduction Clearinghouse (IMERC)

The Interstate Mercury Education and Reduction Clearinghouse (IMERC) is an umbrella organization designed to assist states in their implementation of laws and programs aimed at getting mercury out of consumer products, the waste stream, and the environment. Launched under the auspices of the Northeast Waste Management Officials' Association (NEWMOA), IMERC has, among other things, helped implement product notification laws. These laws

prohibit the sale of mercury-added products in the states of Connecticut, Maine, New Hampshire and Rhode Island unless the manufacturer has disclosed the amount and purpose of the mercury.

The LCSP also conducted discussions and interviews with representatives from the following types of organizations:

- Miniature battery manufacturers and distributors
- Original equipment manufacturers (OEMs)
- Battery recyclers
- State and local government officials
- Battery testing organizations
- Non-government organizations

Several states have begun to focus on reducing the use or disposal of mercury-containing miniature batteries. These efforts include notification requirements for manufacturers and distributors, as well as public awareness programs. In addition, proposed European legislation provides several strong incentives for manufacturers to eliminate mercury from miniature batteries. Manufacturers of mercury-free miniature batteries will be "promoted by" the European States. Recycling costs will be borne by the manufacturer under the new legislation, providing further incentive to reduce mercury use.

2.0 Miniature Battery Overview

Miniature batteries are used in numerous products that require miniature sources of electrical power. Miniature batteries are mostly used for supplying electrical power for toys (often for lights or noise making), hearing aids, watches, calculators, and other portable devices. Miniature batteries are also used for providing memory backup for a variety of devices such as electronic organizers, fax machines, and mobile radios. For the purposes of this report, a miniature battery is defined as a small, round battery whose diameter is greater than its height. Miniature batteries can either be "button" shaped or "coin" shaped.

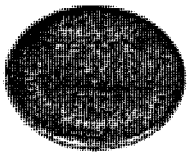
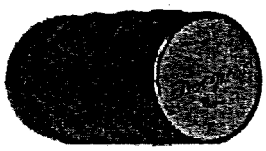
Miniature batteries power a wide range of products, from inexpensive toys with flashing lights or sounds to precision medical acoustic stethoscopes. The batteries may be used singly or in various combinations, depending on the needs of a particular product. Even within a general family of products, the power requirements can vary based on the design and features requiring power. For example, some miniature battery powered calculators use a single miniature battery, others use multiple batteries, and some use a combination of solar cells and battery power. Examples of battery configurations in products are shown in the following table, and a more detailed list of typical products is included in Appendix D.

Several battery companies make small cylindrical batteries that are a single unit comprised of a stack of individual miniature cells. From the outside of the battery, it is difficult to tell that there are multiple individual cells inside. Duracell, Energizer, Eveready, Eastman Kodak, Panasonic and Shanghai BiBa battery companies offer "button stack", "stacked cell" or "stackup" units of this type. Stacked cell batteries are offered in silver oxide and alkaline manganese. Stacked zinc air chemistries were found, but their use was very limited and solely for specialty industrial applications.

When the batteries are stacked in electrical series, the voltage of the individual cells is additive. For example, a stack of four 1.5 V cells produces a 6 V output. Stacked miniature batteries typically provide power for applications in which a higher voltage is needed, including remote controls (e.g. garage door opener remotes), dog control products (electronic training shock collar, electronic leash, bark collar) and camera applications.

In addition to the "button stack" single unit batteries, there are many products using multiple miniature batteries in series. In these products, individual batteries are dropped into the cylindrical battery compartment one on top of another. These products include flashlights, novelty strobe lights, toys that flash lights or make sounds and medical stethoscopes.

Table 2.1 Examples of Battery Configurations in Products

Single Miniature Battery	Multiple Miniature Batteries Inserted in a stack by consumer	Stacked Miniature Battery Single unit of multiple batteries over-wrapped by manufacturer
Watch Compact digital thermometers Digital tire pressure gauges Pedometers Small pocket lights (e.g. keychain light) Remote control for car door locks Hearing aids	Garage door openers LED headlamps, flashlights Novelty strobe lights WiFi locators Child's toy that makes noise or flashes lights Endoscopy capsules (medical application)	Invisible fence dog collar battery Garage door openers Vehicle locks Other remote control devices
Example: Maxell CR2016: 	Example: Vinnic L736 (multiple): 	Example: Energizer TR175S: 

The four major technologies used for miniature batteries are: lithium, zinc air, alkaline, and silver oxide. The lithium miniature batteries have no added mercury. However, there is typically 0.1% to 2.0% mercury content found in most zinc air, alkaline, and silver oxide miniature batteries. The function of the mercury is to inhibit gas formation inside the miniature battery cell.

Gas can form due to zinc corrosion. Zinc is used in silver oxide, zinc air, and alkaline manganese dioxide miniature batteries. As battery capacity is consumed, the zinc will corrode in

the alkaline electrolyte. This corrosion can cause electrolysis in the electrolyte and generate the production of hydrogen gas. This buildup of gas inside the cell could cause bulging and potentially result in leakage of battery cell materials. This leakage of battery cell materials affects the ability of the battery to continue functioning. In addition, this leakage can pose a health hazard as mercury and other toxic materials are no longer encapsulated and a pathway to human exposure exists. For these reasons, mercury is added to miniature batteries to prevent zinc corrosion and the resultant gas buildup. See Appendix B for a discussion of the components of miniature batteries.

2.1 Manufacturers

There are numerous manufacturers of miniature batteries. The following is a listing of known manufacturers, the principle location of their operations, and the status of their IMERC notification. Many of these manufacturers sell miniature batteries used for products sold in the U.S. including: Camelion, Chung Pak, Duracell, Eagle Picher, Eastman Kodak, Energizer, GP Batteries, Hitachi, New Leader, Panasonic, Rayovac, Renata, Schenzhen Konnoc, Schenzhen Jundong, Varta, and Wilson Greatbatch.

Table 2.2 Miniature Battery Manufacturers

Manufacturer	Location	IMERC Notification[1]
Camelion	China	-
Cegasa International	Spain	-
Chener Battery Works	Hong Kong	-
Chung Pak (Vinnic) (Evergreen)	Hong Kong	-
Daily Power Batteries Limited	China	-
Duracell	United States	Yes
Eagle Picher	United States	-
Eastman Kodak	United States	Yes
Energizer (Eveready)	United States	Yes – Eveready
Gloso (Novacell)	Hong Kong	-
Golden Power Industries	Hong Kong	-
GP Batteries International Limited (Gold Peak, Shanghai BiBa Batteries Co. Ltd)	Hong Kong	Yes – GPI Ltd Yes – Shanghai BiBa
Hitachi Maxell	Japan	-
IcellTech	Korea	-
Leclanche	Switzerland	-
New Leader	China	Yes
Panasonic	United States	Yes
Promax Battery Industries Limited	China	-
Rayovac	United States	Yes
Renata	Switzerland	-
Sanyo	Japan	-
Schenzhen King Kang	China	-

Manufacturer	Location	IMERC Notification[1]
Schenzhen Konnoc (Konnoc)	China	-
Schenzhen Jundong Industrial Co. (Votek)	China	-
Schenzhen Malintech Industrial Co. (Powtek)	China	-
Sony	Japan	-
Suzhou Industrial Park East Battery Co.	China	-
Tadiran	Israel	-
Toshiba	Japan	-
Tronic	Hong Kong	-
Varta	Germany	-
Wilson Greatbatch Technologies, Inc.	United States	-
Zhuhai Zhi Battery Co. Ltd. (Zenipower)	China	-

[1] IMERC database last checked on 10/14/04. A dash in the cell indicates the manufacturer was not listed in IMERC database by the name shown.

2.2 Pricing

The retail pricing information in this report is provided for the following miniature battery technologies: alkaline, silver dioxide, lithium, and zinc air. There are numerous factors that influence the retail price of miniature batteries including:

- *Battery technology* – The cathode, anode, electrolyte, and packaging materials are different for the various miniature battery technologies and some raw materials, e.g. silver, are more expensive than others.

- *Battery capacity* – The capacity of a battery varies greatly and can have an impact on pricing.

- *Battery manufacturer* – The price for batteries manufactured by different manufacturers may vary due to brand name recognition, scale of production, and other market factors.

- *Retail pricing versus OEM pricing* – The pricing available for retail customers purchasing replacement miniature batteries is often greater than the pricing provided to OEMs that incorporate miniature batteries into their end products.

- *Quantity of batteries purchased* – The price per battery often decreases as the quantity of batteries purchased increases.

- *Retailer* – The markup on battery prices may fluctuate depending on the retailer (e.g. Staples, CVS, www.batteries.com, etc.)

- *Marketing/promotional events* – Special promotional events may affect the price of miniature batteries on a short-term basis.

The miniature battery pricing information provided in this report is for retail purchases of replacement batteries. The pricing information for miniature batteries is provided in Appendix C: Cost and Availability. Pricing information is included for each miniature battery technology, including the range of retail pricing as well as a listing of the sources for pricing information. An exception to this is the pricing obtained for the New Leader mercury and non-mercury miniature batteries. New Leader non-mercury miniature batteries are only available for purchase by OEMs, and are not yet available for retail customers. Therefore, OEM pricing only was available for New Leader batteries.

2.3 Annual Sales

Miniature batteries are provided in the United States through two main markets:

1) *Original equipment market*: This includes items that are sold with miniature batteries embedded in the product. Examples include toys, watches, calculators, and hearing aids. Manufacturers of these products will be referred to as original equipment manufacturers (OEMs) in this report.

2) *After market*: This includes the purchase of miniature batteries by end-users to replace batteries in products from the original equipment market. These replacement batteries can be purchased from various retailers, mail order operators, and Internet based suppliers.

Manufacturers of mercury-added miniature batteries or products that contain mercury-added miniature batteries are required to disclose the amount of mercury in these batteries before selling their product in the following states that have mercury product notification laws: Connecticut, Maine, New Hampshire, Rhode Island and Washington. IMERC uses two forms to collect this data:

Mercury Added Product Notification Form: The term "mercury added" is used to indicate that the mercury was intentionally added to the product. This form requests manufacturer contact information, as well as information pertaining to the mercury in the product such as description of mercury added components, number of components, amount of mercury, and purpose of mercury in the product.

Total Mercury in all Mercury Added Products Form: This form requests manufacturer contact information, as well as total amount of mercury in all units sold in the United States for a particular product.

For this study, the mercury notification information in the IMERC electronic database was reviewed. This information was useful to help ascertain the total mercury sold in the United States for various products as reported by OEMs and miniature battery manufacturers. However, the reporting did not cover all the various products containing miniature batteries that are produced by domestic OEMs. In addition, most foreign battery manufacturers and foreign original equipment manufacturers have not reported this information to IMERC.

The LCSP tried to determine the total number of miniature batteries sold in the United States on an annual basis for both the original equipment and after market sales. However, the authors of this report were unable to locate any marketing information that provided comprehensive sales data for U.S. sales of all miniature batteries. In particular, we could not find meaningful data on the number of miniature batteries imported into the United States. Several marketing reports on batteries were investigated, from leading market research providers such as Mintel, Business Communications Company, and Freedonia. However, miniature batteries are often aggregated with other battery sizes and shapes for a particular battery technology (e.g. alkaline, lithium, zinc air, and silver oxide). For example, sales data is provided for total alkaline battery sales, with no breakdown for miniature batteries, cylindrical batteries, rectangular batteries, etc. Therefore, it is not possible to determine the sales quantities attributable to miniature batteries for the original equipment or after markets.

Despite the absence of definitive sales data, we were able to better understand the order of magnitude of miniature battery sales in the United States by using data from the National Electronics Manufacturer's Association (NEMA) and the 2003 European report "Impact Assessment on Selected Policy Options for Revision of the Battery Directive".

For the U.S. miniature battery market, NEMA data offered insight in miniature battery sales of its member companies, which include Duracell, Eveready Battery Company, Renata SA, Saft Inc., Eastman Kodak, Panasonic Industrial Company, Polaroid Corporation, Wilson Greatbatch Ltd., and Rayovac Corporation. Although these manufacturers represent only a subset of the manufacturers of miniature batteries sold in the U.S., the data is helpful to define a lower limit for estimated annual sales. In September 2003, NEMA conducted a survey of its members to ascertain the average mercury content and the U.S. sales quantity for silver oxide, zinc air, and alkaline miniature batteries. The results for 2002 sales are summarized in the table below:

Table 2.3 2002 Miniature Battery Sales in the U.S.

Battery Technology	Average Mercury Content (mg)	Total Amount of Mercury (Pounds)	Approximate Sales Quantity*
Zinc air	8.5	4,540.3	242 million
Silver oxide	2.5	473.6	86 million
Alkaline	10.8	269.6	11 million
Totals:		5,283.5	339 million

* The approximate sales quantity was calculated based upon data from the columns: "Average Mercury Content" and "Total Amount of Mercury".

The number of miniature batteries sold by non-NEMA companies in the United States is not known. Therefore, the 339 million miniature batteries reported by NEMA members represent only a portion of the total after market and original equipment market in the United States. In the after market, it is possible to purchase miniature batteries from numerous foreign sources of batteries through various retail and Internet-based channels. For example, we identified retail sources in the United States where one can purchase replacement batteries from companies such as Varta (Germany) and Konnoc (China).

In the original equipment market, there are several examples indicating that the quantities reported by NEMA members represents only a modest fraction of the total original equipment market. For example, the total quantity of alkaline miniature batteries reported by NEMA members was approximately 11 million units. However, millions of toys, novelties, and other products containing miniature batteries enter the United States from foreign sources. In one instance, Kellogg's provided Spidey 2 signal toys in various types of cereal boxes. The Spidey 2 toy is powered by a mercury-containing alkaline button cell. The quantity of button batteries for this one promotion alone was approximately 17 million toys. Further, China is considered the third largest battery supplier in the world after Japan and South Korea. It is estimated that China produced approximately 2.5 billion button cell batteries in 2003. (Global Sources, 2004) This output is anticipated to increase to 3 billion units in 2004, and increase to 5 billion units in 2005. It can be reasonably assumed that significant amounts of these batteries are included in original equipment manufactured in Asia and ultimately sold in the United States.

For the European miniature battery market, BIO Intelligence Service completed a report in July 2003 titled: "Impact Assessment on Selected Policy Options for Revision of the Battery Directive". In this report, the total sales of miniature batteries in Europe were estimated to weigh 373 metric tons in 2002. Miniature batteries were estimated to represent approximately 0.236% of the entire portable battery market of 158,270 metric tons in 2002. Further, it was estimated that 90% of these batteries were sold in the "after market" (replacement batteries), and 10% were sold in the original equipment market electric and electronic equipment.

Using an estimate of 640 miniature batteries per pound (this is described in more detail in Section 8 of this report), the sales in the European market for 2002 are estimated at approximately 526 million miniature batteries. This would result in approximately 473.4 million miniature batteries sold in the after market, and 52.6 million batteries sold in the original equipment market for electric and electronic equipment. This includes products such as toys, novelty items, watches, calculators, and hearing aids.

We made the assumption that most miniature batteries are used in consumer products (largely hearing aids) and that we could therefore use relative populations to estimate U.S. sales based on European sales. In 2002, the population of the European Union was approximately 380 million, while the population of the United States was 279 million. The population of the United States is 73.4% of the population of Europe, therefore we estimated that U.S. sales of miniature batteries at approximately 386.2 million. Of this, approximately 348 million are replacement batteries and approximately 39 million are sold in products. As previously stated, Kellogg's sold 17 million miniature batteries for one toy, which suggests this estimate of 39 million may significantly

underestimate the total amount of miniature batteries sold in products in the United States. While this approach does not fully take into account other important factors such as economic activity and other market factors, it provides an order of magnitude estimate.

Based on the NEMA data and the European Union study, it can be reasonably assumed that the total U.S. annual sales are a minimum of 340 million miniature batteries per year. Because of the lack of data for miniature batteries sold as a component in products, the total U.S. annual sales cannot be accurately estimated.

2.4 Battery Selection Considerations

Original equipment manufacturers (OEMs) must evaluate numerous design considerations when selecting the best miniature battery for their end product. Based on our discussion with OEMs and the review of available literature, we identified the most common factors/considerations for selection of miniature battery technologies.

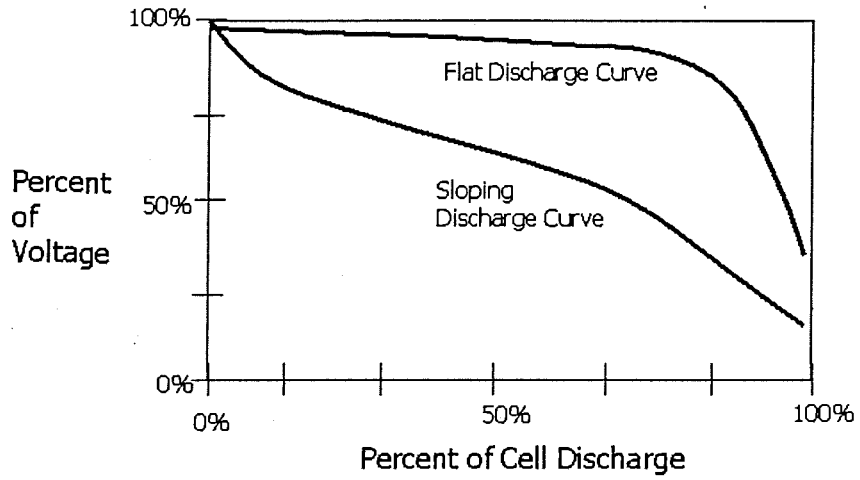
The most important considerations for OEMs appear to be cost, nominal voltage, capacity, physical size/shape, and discharge profile. Other considerations for OEMs include: type of discharge, shelf life, energy density, operating temperature, replacement availability, leakage resistance, and mercury content. For example, one original equipment manufacturer indicated that mercury content was an important consideration and therefore plans to use lithium miniature batteries for new products. The remainder of this section provides a brief description of each of the miniature battery selection considerations.

Cost – This includes the initial price to purchase the battery for the OEM product, as well as consideration for the cost of replacement batteries for the end-user.

Nominal voltage – The nominal voltage is generally accepted as typical of the operating voltage of the battery. For example, 1.4 Volts is the nominal voltage for a zinc-air battery.

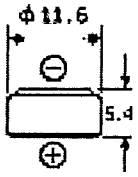
Battery capacity – This is the quantity of electricity measured in milli-Ampere-hours (mAh) that may be drawn from a fully charged miniature battery under specified conditions of discharge. In general, a 500-mAh battery will be able to provide 1 mA of current for 500 hours, provide 2 mA of current for 250 hours, etc. This information is used by some original equipment manufacturers to help calculate the Mean Time Between Failure (MTBF) for their products.

Battery discharge profile – The discharge profile for miniature batteries is typically either flat or sloping/tapered. A flat discharge profile indicates that the battery voltage remains approximately constant during the discharge of the battery energy. A sloping discharge profile indicates that the battery voltage decreases during the discharge of the battery energy.



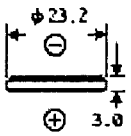
Physical size/shape – In general, a miniature battery can be defined as a small, round battery where the battery diameter is greater than the battery height. There are two shapes of miniature batteries: button and coin. For the purposes of this report, if the diameter is 1 to 6 times greater than the height then the miniature battery will be referred to as a "button" shaped batteries. In the button battery example below, the diameter is 11.6 millimeters and the height is 5.4 millimeters.

Button Shaped Battery: Side View



A variation of the miniature battery is the "coin" shaped battery. In the coin battery example below, the diameter is 23.2 millimeters and the height is 3.0 millimeters. For the purposes of this report, if the diameter is 7 or more times greater than the height the miniature battery will be referred to as a "coin" shaped battery.

Coin Shaped Battery: Side View



Type of discharge – The magnitude of the battery load/drain has a significant impact on battery performance. In addition, the energy of a miniature battery can be discharged in a continuous, intermittent, or a combination continuous/intermittent manner. For example, a digital watch may require a continuous low drain of a battery to display the time, however, there may be intermittent periods of high drain on the battery to provide alarm or backlighting functionality.

Shelf life – Miniature batteries are a perishable product and deteriorate as a result of chemical activity that occurs during storage. For certain end products, there may be a prolonged period before commencing use of the battery. Therefore, the rated shelf life can be an important consideration.

Replacement availability – The commercial availability of replacement batteries is a key consideration for OEM product designers. Ideally, the replacement battery will be available in a standard size, supplied by numerous manufacturers, and available in several on-line and physical retail outlets.

Energy density – The energy of a battery is often measured relative to its volume and/or weight. Volumetric energy density is typically measured in milli-Watt-hours per cubic centimeter. Gravimetric energy density is typically measured in milli-Watt-hours per gram.

Operating temperature – The operating temperature for the battery has a significant impact on battery performance. For example, lowering the operating temperature will reduce the level of chemical activity and increase the internal resistance of the battery. In general, lowering the operating temperature will result in a reduction of capacity and an increase in the slope of the discharge curve. At higher operating temperatures, the internal resistance decreases and the capacity may increase. However, at higher temperatures the chemical activity increases and could cause a phenomenon called self-discharge which may cause a net loss of capacity. Miniature batteries are often rated for use within a specified operating temperature range.

Mercury content – The amount of mercury contained within the miniature battery.

Leakage resistance – Miniature batteries often contain various hazardous substances. Leakage of these miniature battery materials is often undesirable from a safety standpoint, and can also adversely affect battery performance.

3.0 Zinc Air Miniature Batteries

3.1 Description

Zinc air miniature batteries are primarily used for hearing aids. Zinc air miniature batteries are the battery of choice for hearing aid applications because they have a high energy density and are excellent for continuous discharge use. Zinc air miniature batteries can also be used for wristwatch pagers, behind the ear speech processors, and cochlear (inner ear) implants. The PR2330 coin shaped zinc air battery is often used for credit card style pagers and for wireless telecom headsets. The PR2330 designation follows the battery nomenclature published by the International Electrotechnical Commission (IEC). The IEC nomenclature is described in Appendix B.

Zinc air miniature batteries use oxygen from ambient air to produce electrochemical energy. Ambient air enters through a hole on the positive terminal. This hole provides a path for oxygen to enter the cell and diffuse to the cathode catalyst site. Therefore, zinc air miniature batteries are good candidates for applications like hearing aids with access to ambient air.

The mercury content of the zinc air miniature battery is typically between 0.3% - 2.0% of total battery weight. However, Energizer offers mercury-free zinc air batteries in Europe for hearing aid users. The mercury-free Energizer battery is discussed further in the Non-Mercury Alternatives section of this report.

3.2 Performance

The zinc air miniature battery has a nominal voltage of 1.4 Volts. The zinc air battery has a flat discharge curve. Miniature zinc air batteries are mostly button shaped; however there are some commercially available coin shaped batteries (e.g. Panasonic PR2330 that has a diameter of 23.2 mm and a height of 3.0 mm). Zinc air miniature batteries are excellent for continuous, low discharge applications, and provide good leakage resistance.

For the battery models reviewed, the zinc air miniature battery offers the widest range and the highest level of capacity (33 to 1,100 mAh) compared to the other miniature battery technologies. However, the typical useful service life of a zinc air miniature battery is two to three months once the seal has been removed. Zinc air batteries also have the highest energy density compared with other battery systems. The gravimetric energy density is typically 210 to 370 mWh/g and the volumetric energy density is 770 to 1,300 mWh/cc. Therefore, the zinc air miniature batteries are excellent candidates for volume or weight critical applications.

During storage, the air access holes of the zinc air miniature battery are sealed to prevent gas transfer decay. Polyester tape is often used for sealing the battery during storage. Zinc air batteries have excellent long-term storage life if the seal remains intact. An 85% capacity retention has been measured in tests for 5-year storage periods, resulting in a self-discharge rate of approximately 3% per year.

The service life of the zinc air battery is significantly affected by pressure differences between the vapor pressure of the electrolyte and the ambient air. In low humidity environments, there can be excessive water loss that can increase the electrolyte concentration and eventually cause the cell to fail. In high humidity environments, excessive water gain dilutes the electrolyte and can reduce the electrochemical activity and eventually cause cell failure. Zinc air miniature batteries operate most effectively in the range of 0 degrees to 50 degrees C.

3.3 Manufacturers

There are numerous manufacturers of zinc air miniature batteries on a worldwide basis. The following table provides key information for some domestic and foreign manufacturers of zinc air miniature batteries:

Table 3.1 Manufacturers of Zinc Air Miniature Batteries

Manufacturer	Model	Applications	Hg Content	Capacity* (mAh)
Duracell	Models 10, 13, 312, 675	Not identified	<2%	70 - 600
Panasonic	630	Not identified	Not listed	1,100
Energizer	ACXX series	Hearing aids (eyeglass, behind the ear, in the ear), pagers	1.0 - 1.4%	33 - 635
Energizer	ACXX series	Hearing aids	None (zero mercury type)	33 - 635
GP Batteries International (Gold Peak)	ZAXX series	Hearing aids.	0.3 - 1.3%	70 - 600
Toshiba	ZAXX series and PR series	Hearing aids, BTE speech processors, cochlear implants, pagers	Not listed	75- 1,050
Varta	PXXX series	Hearing aids, implants	Not listed	35 - 650

* *Battery capacity* refers to the quantity of electricity measured in milli-Ampere-hours (mAh) that may be drawn from a fully charged miniature battery under specified conditions of discharge. See Section 2.4.

4.0 Silver Oxide Miniature Batteries

4.1 Description

Silver oxide miniature batteries can be used for numerous devices including: analog watches, digital watches, miniature clocks, calculators, electronic games, cameras, hearing aids, and electronic instruments. The cathode consists primarily of monovalent silver oxide (Ag2O), and the anode consists of powdered zinc.

The mercury content of the silver oxide miniature battery is typically between 0.2% to 1.0% of total battery weight. However, at least two manufacturers (New Leader and Sony) offer mercury-free silver oxide miniature batteries. These mercury-free batteries will be discussed further in the Non-Mercury Alternatives section of this report.

4.2 Performance

The nominal voltage of the silver oxide miniature battery is 1.55 Volts. In general, the silver oxide miniature battery has a flat discharge curve. However, there are at least two manufacturers (Chung Pak and New Leader) that provide silver oxide miniature batteries with a tapered discharge profile. In the case of New Leader, some of their silver oxide miniature batteries are manufactured with half the typical amount of silver for use in low cost applications. This reduction of silver content results in a tapered discharge profile.

For the battery models reviewed, the silver oxide miniature battery has the lowest range of capacity (5.5 to 200 mAh) compared to the other miniature battery technologies. The gravimetric energy density is typically 75 to 135 mWh/g and the volumetric energy density is 300 to 530 mWh/cc. The energy density of the silver oxide miniature battery is the third highest of the four miniature battery technologies.

The silver oxide miniature battery is capable of operation over a wide temperature range. For example, at an operating temperature of 0 degrees C the silver oxide miniature battery can deliver 70% of the capacity provided at 20 degrees C. Batteries using potassium hydroxide electrolyte are able to operate at lower temperatures than batteries with sodium hydroxide electrolyte.

Silver oxide miniature batteries are good for high or low drain applications. Potassium hydroxide is the preferred electrolyte for continuous low drain applications over long periods of time (e.g. five years). Sodium hydroxide is the preferred electrolyte for continuous low drain use with periodic high drain pulse demands. An example of this application would be an analog watch with alarm capability. Silver oxide miniature batteries exhibit long shelf and service life. Most batteries are designed to operate watches for five years without leakage. Test data indicates that storage up to ten years is possible at 21 degrees C.

Silver oxide batteries come in a variety of shapes and dimensions. For example, the SR41 is button shaped with a diameter of 7.8 mm and a height of 3.6 mm. The SR1116 is coin shaped with a diameter of 11.6 mm and a height of 1.65 mm.

4.3 Manufacturers

There are numerous manufacturers of silver oxide miniature batteries on a worldwide basis. The following table provides key information for some domestic and foreign manufacturers of silver oxide miniature batteries:

Table 4.1 Manufacturers of Silver Oxide Miniature Batteries

Manufacturer	Model	Applications	Hg Content	Capacity (mAh)
Duracell	D3X series	Not identified	< 1%	16 - 180
Eastman Kodak	KS76	Photo	< 0.6%	145
Energizer	3XX series	Watches, calculators, photoelectric exposure devices, hearing aids, and electronic instruments	0.3 - 1.0%	5 - 200
GP Batteries International (Gold Peak)	3XX series	Watch, calculator, electronic toy, hearing aid, lighter, photo	0.4 - 0.8%	7.5 - 165
Hitachi Maxell	SRXX series	Not identified	Not listed	5.5 - 165
New Leader	Hg Free SRXX series	Not identified	None	15 - 165
New Leader	SRXX series	Not identified	Not listed	15 - 165
Renata	3XX series	Watches (analog, digital), pocket calculators, electronic games, cameras, etc.	Not listed	5.5 - 190
Sony	Hg free SRXX series	Not identified	None	12.5 - 160
Sony	SRXX series	Wrist watches, small size thermometers, mobile game products	Not listed	4 - 180
Varta	V Series	Not identified	0.2 - 0.6%	6 - 180

5.0 Alkaline Manganese Dioxide Miniature Batteries

5.1 Description

Alkaline manganese dioxide miniature batteries can be used in numerous devices including: calculators, toys, key chains, tire gauges, remote controls, and photographic products. The cathode is primarily comprised of electrolytic manganese dioxide, and the anode is powdered zinc.

The mercury content of the alkaline manganese dioxide miniature battery is typically 0.1% to 0.9% of total battery weight. However, one manufacturer (New Leader) offers mercury-free alkaline manganese dioxide miniature batteries. These mercury-free batteries will be discussed further in the Non-Mercury Alternatives section of this report.

5.2 Performance

The alkaline manganese dioxide miniature battery has a nominal voltage of 1.5 Volts. The alkaline manganese dioxide miniature battery has a sloped discharge profile. The voltage starts around 1.5 Volts and gradually decreases during battery discharge. Most end products that use alkaline miniature batteries at low to moderate drains (i.e. toys, penlights, etc.) are generally able to tolerate this sloped discharge pattern.

Alkaline manganese dioxide miniature batteries are typically available in button shapes. These batteries are available in capacities ranging from 15 to 830 mAh. The alkaline manganese dioxide battery has the lowest energy density compared to other miniature battery technologies. The gravimetric energy density is typically 50 to 80 mWh/g and the volumetric energy density is 150 to 360 mWh/cc.

Alkaline manganese dioxide batteries discharge more efficiently as the operating temperature increases, up to a certain threshold. Alkaline manganese dioxide batteries can typically be operated in temperatures between –30 degrees C to 55 degrees C. In addition, these batteries also provide good leakage resistance.

Chemical reactions such as self-discharge, corrosion, and degradation of battery materials can occur during storage of an alkaline manganese dioxide battery. These chemical reactions will occur more rapidly if the battery is stored at higher temperatures and will occur more slowly at lower temperatures. Therefore, the storage temperature has a significant effect on charge retention. For example, a battery stored at 0 degrees C will have approximately 97% charge retention after four years, while a battery stored at 20 degrees C will have approximately 84% charge retention after four years.

5.3 Manufacturers

There are numerous manufacturers of alkaline miniature batteries on a worldwide basis. The following table provides key information for some domestic and foreign manufacturers of alkaline miniature batteries:

Manufacturer	Model	Applications	Hg Content	Capacity (mAh)
Eastman Kodak	K series	Photo, calculators	<0.5%	125 - 830
Energizer	1XX, AXX, E625G	Not identified	0.1 - 0.9%	31 - 200
GP Batteries International (Gold Peak)	164, A76, 18X, 19X, 625A	Watch, calculator, photo, toy, melody card, remote control	0.1 - 0.6%	8 - 190
Hitachi Maxell	LRXX series	Mini game machines, electronic calculators, electronic watches and clocks, measuring instruments, electronic lighters, electronic thermometers, cameras, compact radios, remote controllers	Not listed	26 - 60
New Leader	Hg Free LRXX series	Not identified	None	15 - 158
New Leader	LRXX series	Not identified	Not listed	15 - 160
Renata	LR4X	Calculators, electronic games, etc.	Not listed	73 - 105
Shenzhen Malintech	AG series	Not identified	Not listed	13 - 138
Varta	4XXX series	Not identified	0.2 - 0.5%	25 - 200

6.0 Non-Mercury Alternatives

6.1 Mercury-free Miniature Batteries

Silver Oxide:

In September 2004, Sony Corporation announced that it would provide mercury-free silver oxide miniature batteries. Ten models of mercury-free silver oxide batteries will be available on a worldwide basis starting in January 2005. These miniature batteries will be available in a variety of dimensions, with capacities ranging from 12.5 mAh to 160 mAh. This announcement from Sony Corporation also stated their goal to eliminate mercury from all of their silver oxide batteries. Sony's silver oxide miniature batteries are used mainly for watches, miniature thermometers, and mobile game products.

In a silver oxide miniature battery, the zinc anode will corrode in the presence of an alkaline electrolyte. The zinc corrosion causes electrolysis in the electrolyte that initiates the formation of hydrogen gas. The buildup of hydrogen gas in the miniature battery cell causes an increase in internal pressure that may lead to bulging and even rupture of the cell. Mercury is intentionally added to silver oxide miniature batteries to suppress the zinc corrosion and resultant formation of hydrogen gas.

To provide mercury-free silver oxide miniature batteries, Sony has utilized the following techniques:

- Use of a high quality zinc alloy powder that reduces the corrosion rate by a factor of ten compared to conventional powders.
- Use of an anti-corrosion additive material in the anode. The composition of this additive material has not been disclosed by Sony.
- Use of a unique surface process technology for the cathode material. This process technology is claimed to further suppress zinc corrosion.
- Use of a proprietary active cathode material. This material has high hydrogen absorption capacity.

New Leader, a battery manufacturer located in China, also provides mercury-free silver oxide miniature batteries. Currently, this mercury-free battery is available to original equipment manufacturers for use in their end products, but is not yet commercially available in the United States for purchase by end-consumers as replacement batteries. However, New Leader appears to be interested in selling the mercury-free silver oxide battery to the U.S. retail market in the near future.

The New Leader product specifications for mercury and mercury-free silver oxide miniature batteries were compared for the following three models: SG3/SR41, SG13/SR44, and

SG4/SR626. The specifications provide information for the following performance attributes: voltage, capacity, weight, diameter, height, and estimated average hours of service. The performance was found to be identical for each of these attributes for the mercury and mercury-free versions of the same model.

Currently, there is a price differential between the New Leader mercury and mercury-free models. The mercury-free models cost approximately 30% more than the similar models containing mercury. As the market for mercury-free miniature batteries expands, there will be increased competition as well as greater economies of scale for larger production runs. Therefore, it is reasonable to anticipate that the cost differential between mercury and mercury-free miniature batteries will decrease over time. The method that New Leader uses to achieve the mercury-free silver oxide battery is not publicly available.

No performance test results were found for the Sony and New Leader mercury-free batteries to demonstrate that formation of hydrogen gas and the resultant cell bulging and rupture is not an issue for these batteries. Presumably, these manufacturers are satisfied that they have overcome this problem as they are unlikely to market a product that could undermine their reputation for delivering quality products or expose them to product liability claims.

Alkaline Manganese Dioxide:

New Leader also offers mercury-free alkaline miniature batteries. Currently, this battery is available only to original equipment manufacturers for use in their end products such as toys. The mercury-free alkaline miniature battery from New Leader is not yet commercially available in the United States for purchase by end-consumers as replacement batteries. However, New Leader appears to be interested in selling it to the U.S. retail market in the near future. (Reference: Ivan Kong of New Leader) Specialized Technology Resources (STR) conducted mercury testing for the New Leader LR44 mercury-free alkaline button battery. The test results indicate that the mercury content is below detection levels of 0.0001 mg per battery.

New Leader has registered for a patent in China to use indium instead of mercury in alkaline manganese dioxide miniature batteries. Indium is a soft silver-white metal that is used in applications such as electronic components. The indium is pre-electroplated on the inside of the cathode cap by using a single face electro-plating technique. In addition, the zinc powder is pre-treated with an indium compound.

The New Leader performance specifications were compared for the mercury-containing and mercury-free versions for various alkaline manganese dioxide models. The performance attributes were similar between the mercury and mercury-free versions for AG1/LR621 and AG8/LR1120 as illustrated in the table below.

Table 6.1 New Leader Mercury and Mercury-free Miniature Batteries

Attribute	New Leader AG1/LR621 With Mercury	New Leader AG1/LR621 Without Mercury	New Leader AG8/LR1120 With Mercury	New Leader AG8/LR1120 Without Mercury
Voltage (V)	1.55	1.55	1.5	1.5
Capacity (mAh)	15	15	44	44
Weight (g)	0.3	0.3	0.86	0.86
Diameter (mm)	6.75	6.75	11.5	11.5
Height (mm)	2.15	2.15	2.1	2.1
Estimated Average Hours Service	Approx. 540	Approx. 540	Approx. 504	Approx. 504

Some differences in performance attributes can be identified for the New Leader mercury-containing and mercury-free models AG12/LR43 and AG13/LR44. The differences identified for capacity and estimated average hours service are highlighted in the tables below. The tables below also include data for comparable Energizer miniature batteries.

Table 6.2 Mercury and Mercury-free Miniature Batteries

Attribute	New Leader AG13/LR44 With Mercury	New Leader AG13/LR44 Without Mercury	Energizer A76 With Mercury
Voltage (V)	1.5	1.5	1.5
Capacity (mAh)	160	158	150
Weight (g)	2.0	2.0	2.3
Diameter (mm)	11.53	11.53	11.6
Height (mm)	5.43	5.43	5.4
Estimated Average Hours Service*	624	612	900

* A load of 5,000 ohms was used for the New Leader battery and a load of 7,500 ohms was used for the Energizer battery.

Table 6.3 Mercury and Mercury-free Miniature Batteries

Attribute	AG12/LR43 With Mercury	AG12/LR43 Without Mercury	Energizer 186 With Mercury
Voltage (V)	1.5	1.5	1.5
Capacity (mAh)	115	110	80
Weight (g)	1.6	1.6	1.4
Diameter (mm)	11.53	11.53	11.6
Height (mm)	4.2	4.2	4.2

Attribute	AG12/LR43 With Mercury	AG12/LR43 * Without Mercury	Energizer 186 With Mercury
Estimated Average Hours Service	456	480	924

* A load of 5,000 ohms was used for the New Leader battery and a load of 15,000 ohms was used for the Energizer battery.

Currently, there is a price differential between the New Leader mercury and mercury-free models. The mercury-free models cost approximately 24% to 30% more than the similar models containing mercury.

New Leader has stated that these mercury-free batteries are being used for toys, electronic gifts, and products for the following customers: McDonalds, Hallmark Cards, Wal-mart, Chicco, Burger King, K-Mart, and Kellogg's. Several other companies are in the process of evaluating these batteries including Hasbro, Mattel, and Red Box. (Reference: Ivan Kong of New Leader)

There is no performance testing available for the New Leader mercury-free batteries to demonstrate that formation of hydrogen gas and the resultant cell bulging and rupture is not an issue for these batteries.

Zinc Air:

One battery manufacturer, Energizer, sells mercury-free zinc air miniature batteries in Europe for hearing aid applications. Energizer offers mercury containing and mercury-free miniature batteries for the following four models: AC10/230, AC13, AC312, and AC675. The Energizer engineering data sheets for the mercury containing zinc air miniature battery and the mercury-free zinc air miniature battery were compared for each of these four models. The performance data for the following parameters show no differences between the mercury containing and mercury-free models.

- Diameter
- Height
- Voltage
- Volume
- Average capacity
- Typical discharge characteristics
- Estimated average service
- Impedance
- Impedance vs. Frequency
- Impedance vs. Depth of Discharge

An exact timeline as to when these zinc air mercury-free miniature batteries will be commercially available in regions outside of Europe is not yet known. The price differential between the Energizer mercury and mercury-free zinc air models was not available. The method

that Energizer uses to achieve the mercury-free zinc air miniature battery is not publicly available.

Other Mercury-free Batteries

The following companies indicate either on their website or elsewhere on the Internet that they have mercury-free miniature batteries:

- Schenzhen Konnoc (China)
- Chung Pak (Hong Kong)
- Gloso (Hong Kong)
- Promax Battery (China)

However, the LCSP was not able to obtain product specifications or datasheets for these batteries.

Stacked Batteries

There were no mercury-free alternatives identified for stacked silver oxide or stacked alkaline manganese batteries. (Recall that these stacked batteries are a single unit comprised of multiple individual miniature cells in electrical series, to provide a higher voltage).

A possible alternative for mercury containing stacked miniature batteries is to stack mercury free versions of the alkaline and silver oxide miniature batteries. It appears that this would provide similar performance characteristics. However, we did not find a non-mercury stacked miniature battery product that was commercially available at this time.

6.2 Lithium Miniature Batteries

Lithium miniature batteries do not contain mercury, and are sometimes considered a potential alternative to mercury containing miniature batteries. As stated previously, there are numerous design considerations for OEMs in selecting a miniature battery technology for their end products. The requirements for each end product vary greatly, and consequently the level of importance for each of the design considerations will vary as well. Therefore, depending on the end product, the lithium miniature battery may or may not be a suitable alternative for mercury containing miniature batteries. For example, nominal voltage and physical size/shape may be important design considerations for a particular end product. Since lithium miniature batteries have a much higher nominal voltage and a different physical shape (typically flatter and wider - coin shaped) than the other three miniature battery technologies, they cannot easily be substituted in existing products. In one situation, a toy manufacturer investigated the replacement of a mercury-containing button battery with a lithium miniature battery. However, the requirement to retool the plastic mold for this toy product to accommodate the lithium battery was determined to be cost prohibitive.

Description:

Lithium miniature batteries are used as the main power source for devices such as electronic games, watches, calculators, car lock systems, and garage door openers. They are also used in

memory backup for telecommunications devices such as cordless telephones and mobile radios, as well as for office automation equipment such as printers, fax machines, and electronic typewriters. In addition, lithium miniature batteries can be used as the main power and the memory back up for the same device, such as an electronic organizer.

Lithium is an excellent candidate for use as a battery anode material because of its desirable properties such as: low density, high voltage, and good conductivity. Therefore, lithium is used as anode material for numerous battery chemistries in a variety of configurations (i.e. miniature, cylindrical, prismatic, etc.). Lithium metal reacts vigorously with water, and consequently must be used with non-aqueous electrolytes. There is a concern about the potential for fire when lithium batteries are collected. This issue is further discussed in Section 8 of this report.

The two primary lithium miniature battery chemistries are: 1) lithium/manganese dioxide, and 2) lithium/carbon monofluoride.

Performance:

The lithium/carbon monofluoride and lithium/manganese dioxide miniature batteries do not contain mercury. They each have a nominal voltage of 3.0 Volts, and have a flat discharge curve. The lithium batteries are commercially available in a wide range of capacities, from 25 to 1,000 mAh, and are mostly available in coin shaped batteries. However, there are also some models available in button shapes (e.g. Eastman Kodak model K58L, Sony model CR2477, and Varta model 6131 which has a 11.6 mm diameter and a 10.8 mm height).

Lithium miniature batteries have the second highest energy density compared to other miniature battery technologies. The gravimetric energy density is typically 200 to 230 mWh/g and the volumetric energy density is 400 to 545 mWh/cc. These batteries have excellent storage characteristics. The self-discharge rate for both lithium batteries is approximately 1% per year for up to ten years. This is the lowest self-discharge rate of the four miniature battery technologies. They also provide excellent leakage resistance.

Both lithium miniature batteries are ideal for applications requiring low current drain over an extended period of time. The maximum continuous drain recommended for these batteries is usually between 2 to 5 mA. They can accommodate current pulses up to 5 to 20 mA depending upon battery size.

Both lithium battery types can be used for a wide range of operating temperatures, from about –20 degrees C to 55 degrees C. Furthermore, lithium carbon monofluoride miniature batteries are also available in high operating temperature models. These batteries can be operated in a temperature range from –40 degrees C to 150 degrees C. They can be mounted on printed circuit boards and used for long term, low drain applications. The high operating temperature models offer the greatest range of operating temperatures compared to the other miniature battery technologies.

Manufacturers:

There are numerous manufacturers of lithium miniature batteries. The following table provides key information for some domestic and foreign manufacturers of lithium miniature batteries:

Table 6.4 Manufacturers of Lithium Miniature Batteries

Manufacturer	Model	Applications	Hg Content	Capacity (mAh)
Duracell	DL2X series	Not listed	None	(DL 2025) 150
Eastman Kodak	KCR series	Date book	None	80 - 230
Eastman Kodak	K58L	Photo	None	160
Energizer	CRX series	Audio equipment, calculators, cameras & light meters, data acquisition systems, electronic communication devices, electronic games, electronic wristwatches and clocks, hearing aids, industrial monitors/controls, medical equipment, memory retention, micro cassette recorders, military electronics, switchboards, transceivers & radios, security devices, small electronic instruments, remote keyless entry	None	29 - 575
GP Batteries International (Gold Peak)	CR1XXX, CR2XXX Series	Watch, computer memory backup, remote control, photo	None	36 - 270
Hitachi Maxell	CR2XXX series	Timepieces, calculators, cameras, medical instruments, office equipment, backup power for integrated circuits (ICs) and real time clocks (RTCs), home electronic instruments, automobile keyless entry, PC boards	None	50 - 610
Panasonic	BR series - High Operating Temperature	Automotive electric systems, toll way transponders, radio frequency identification products	None	48 - 1,000
Panasonic	CR series	Calculators, cameras, cordless applications, electronic translators, watches, memory backup in all types of devices (with tab terminals)	None	30 - 1,000
Panasonic	VL series	Memory back-up in facsimiles, memory cards, personal computers, sequencers, telephones, tuners, video cameras	None	1.5 - 100
Sanyo	CRXXXX series	Not listed	None	38 - 1,000

Manufacturer	Model	Applications	Hg Content	Capacity (mAh)
Shenzhen Malintech	CRXXXX series	Not listed	None	30 - 1,000
Varta	CRX series	Car keys/remote controls, alarm systems, watches (digital & analog), electronic databases/calculators, memory back-up, real-time clock, medical equipment, mini-flashlights	None	27 - 560
Varta	MC6XX Series	Cellular phones, personal digital assistants (PDAs), pagers, consumer devices	None	1.5 - 3

6.3 Cylindrical Alkaline Batteries

There are non-miniature cylindrical alkaline batteries ("cylindrical alkaline") that could be considered as alternatives to silver oxide, zinc air, and alkaline miniature technologies. The cylindrical alkaline batteries do not have added mercury. The smaller batteries of this type include:

Common Designation	IEC Designation	Voltage	Diameter (mm)	Height (mm)	Weight [Note 1]	Capacity
N	R1	1.5 V	12.0	30.2	9 g	1000 mAh [Note 2]
AAAA	N/A	1.5 V	8.3	42.5	6.5 g	625 mAh [Note 3]
AAA	R03	1.5 V	10.5	44.5	11.5 g	1250-1375 mAh [Note 4]
AA	R6	1.5 V	14.5	50.5	23 g	2850-3135 mAh [Note 5]

Notes:
[1] As a reference, miniature batteries typically fall in the 0.3-3.0 gram range
[2] Energizer e90 alkaline battery
[3] Energizer e96 E2 alkaline battery
[4] Energizer e92 alkaline battery & Energizer X92 alkaline battery
[5] Energizer e91 alkaline battery & Energizer X91 alkaline battery

The cylindrical alkaline batteries require considerably more battery compartment space and weigh much more than miniature batteries. Therefore cylindrical batteries would not be ideal candidates for applications that are either volume or weight sensitive, such as hearing aids. On the plus side, a typical cylindrical alkaline battery offers far greater capacity and significantly lower cost than most miniature batteries so their use would be favorable for consumers.

6.4 Secondary (Rechargeable) Batteries

There are several miniature battery technologies available for secondary batteries. These include the following technologies:

- Nickel Metal Hydride
- Lithium Ion
- Titanium Carbon Lithium Ion

- Lithium Manganese Dioxide

Nickel metal hydride miniature batteries typically contain less than 0.0005% mercury. The other technologies listed above for rechargeable batteries do not have any mercury content.

6.5 Other alternatives

Capacitors: Some OEMs have used capacitors instead of miniature batteries to provide memory backup power for certain electronic devices. Capacitors are non-mercury electronic components that store and release electrical charge. In some instances, the use of capacitors instead of miniature batteries can increase product reliability and reduce product costs. However, the technical and economic feasibility of using capacitors instead of miniature batteries should be evaluated by the OEM based upon the memory backup requirements for each particular application.

Solar Powered: Photovoltaic powered consumer products use amorphous silicon to capture sunlight and artificial light. Existing consumer products that use photovoltaic cells include watches, calculators, radios, cameras, cellular phones, headphones, flashlights, garden lamps, and dust busters. The disadvantages of this alternative include: need sunlight to power, output is directly related to light intensity, not appropriate for shaded areas, cost, and difficult to store electricity for later use.

Mechanically Powered: Mechanical energy can sometimes be used as an energy source for portable devices. Examples of sources of mechanical power include:

- Hand cranks/manual wind-up
- Self-winding
- Finger power from keyboard usage
- Trackball movement
- Watches powered by wrist motion

7.0 Alternatives - Summary and Conclusions

The following table summarizes key battery performance data from the preceding sections:

Consideration	Alkaline (Hg Containing)	Silver Oxide (Hg Containing)	Zinc Air (Hg Containing)	Lithium (No Hg)
Typical Mercury Content	0.1 – 0.9 %	0.2 – 1.0 %	0.3 – 2.0 %	None
Cost	$0.33/battery (min) $6.99/battery (max) $2.29/battery (median)	$1.20/battery (min) $18.99/battery (max) $3.19/battery (median)	$0.62/battery (min) $1.35/battery (max) $1.08/battery (median)	$0.33/battery (min) $5.09/battery (max) $2.99/battery (median)
Nominal Voltage (V)	1.5	1.55	1.4	3.0
Capacity (mAh)	15 - 830	5.5 - 200	33 – 1,100	25 – 1,000
Discharge profile	Tapered	Mostly flat, Tapered for reduced silver	Flat	Flat
Physical shape	Button	Mostly button, Some coin	Mostly button, Some coin	Mostly coin, Some button
Energy density: Gravimetric (mWh/g)	50 - 80	75 – 135	210 – 370	200 – 230
Energy density: Volumetric (mWh/cc)	150 - 360	300 - 530	770 – 1,300	400 - 545
Operating temperature (degrees C)	-20 to 55	0 to 55	0 to 50	Typical: -20 to 55, High temp. version: –40 to 150
Shelf life (self discharge rate at 20 degrees C, loss per year	Approximately 4%	Approximately 6%	Approximately 3%	Approximately 1%
Replacement Availability	Numerous retail and on-line options available	Numerous retail and on-line options available	Numerous retail and on-line options available	Numerous retail and on-line options available
Leakage resistance	Good	Good	Good	Excellent
Type of discharge	Good for high or low drainage applications.	Good for low drainage applications. KOH electrolyte preferred for high drainage.	Most effective for medium to high drain applications that use up capacity in a short period.	Excellent for low drainage, or high drainage, intermittent pulse applications.
Other key factors	Good resistance to shock and vibration.	High recycling rate due to silver content.	Requires access to ambient air. Short service life.	Excellent for memory backup applications.

Several alternatives to mercury containing miniature batteries were identified and evaluated. Lithium miniature batteries do not contain mercury, and are sometimes considered as

a potential alternative to mercury containing miniature batteries. Original equipment manufacturers (OEMs) must evaluate numerous design considerations when selecting the best miniature battery for their end product. The most important considerations for OEMs appear to be cost, nominal voltage, capacity, physical size/shape, and discharge profile. Other considerations include: type of discharge, shelf life, energy density, operating temperature, replacement availability, leakage resistance, and mercury content. The level of importance for each of these considerations can vary greatly depending upon the requirements of each particular end product (calculator, toy, watch, etc.). The suitability for replacing one miniature battery technology for another miniature battery technology must be determined on a case-by-case basis by OEMs based upon the unique requirements of their particular product. Therefore, depending on the end product, the lithium miniature battery may or may not be a suitable alternative for mercury containing miniature batteries.

Manufacturers are beginning to market mercury-free versions of silver oxide, alkaline manganese dioxide, and zinc air miniature batteries. Some of these batteries are targeted for the European market, but most are intended for worldwide use. The performance characteristics as published by the manufacturers appear to be comparable for the mercury and mercury-free versions. The costs of the mercury and mercury-free versions of these batteries were not available from some manufacturers. Based on pricing provided by one manufacturer, there is a 24% - 30% premium for their mercury-free miniature batteries compared to their mercury containing batteries. It is likely that this cost differential will close as sales volumes increase for mercury-free miniature batteries.

Manufacturers have taken different approaches to eliminating the mercury for the three mercury-containing miniature battery technologies. Since mercury is added to prevent the buildup of internal gases that can lead to battery cell bulging and rupture, it is important to assure that mercury-free miniature batteries will be reliable and comparable in performance to mercury-added miniature batteries with respect to leakage and rupture. Although the manufacturers of mercury-free batteries appear confidant that their batteries will not rupture and leak, there are no data currently available on the long-term performance of the mercury-free miniature batteries in this area.

8.0 Recycling

The most effective strategy for reducing the environmental emissions and potential health hazards of mercury from miniature batteries involves substituting mercury-containing batteries with mercury-free batteries. As noted in the previous sections, there are numerous mercury-free miniature batteries available today, although the feasibility of each substitution will depend on the specific application and the particular design considerations of each OEM. While new directives in Europe may be encouraging OEMs to convert to mercury-free miniature batteries, there will continue to be mercury-containing batteries on the market for the immediate future. To address the mercury-containing batteries currently on the market and the legacy of mercury-containing batteries still in use, it is useful to consider the use of battery recycling programs to manage potential environmental and health hazards of mercury in miniature batteries.

A recent European proposal notes that recycling miniature batteries provides the opportunity to avoid external costs that are usually paid for by society in the form of cleanup costs, environmental deterioration, or adverse health effects. Metals in the spent batteries that might normally be lost to disposal can be recycled and put back into products. Other substances such as acids, salts, and plastics will be diverted from the waste stream and managed appropriately. Potential air and water pollution and other environmental impacts from incinerating or landfilling the spent batteries can be avoided, ultimately translating to reduced human exposures and abatement costs. (Reference: Commission of the European Communities, 2003, p.22 and discussion in Appendix E)

Recycling programs for miniature batteries are currently available and carried out throughout the United States. There are multiple vendors and options for recycling miniature batteries. Although some in the business community have raised concerns about the safety and cost effectiveness of miniature battery recycling, the existing evidence suggests that most of these concerns can be effectively addressed.

8.1 Battery Recycling Programs in The United States

Four recycling programs in the United States were interviewed by phone and their costs and recovery rates are shown in the following Table 8.1. The programs represented two counties in the United States, a town in Massachusetts and a municipal waste provider serving 69 communities in the Northeast, all of which offer recycling programs that include miniature batteries. The four programs were selected for interviews because of the ability to provide data, longevity or breadth of the program, and/or the ability to provide a cogent overview of their experience. (More details from these interviews are included in Appendix F).

The town and counties represented in our interviews have collection sites or containers set up in multiple areas in the town or regions. A major city in one of the counties also provides curbside pickup of miniature and other dry cell batteries. Miniature battery collection containers (typically cardboard boxes) fall under the universal waste rule and are collected within 1 year. Batteries from the boxes are often consolidated into a pail or larger container and then shipped for sorting and recycling.

Batteries fall under the Universal Waste Rules of the Environmental Protection Agency. These rules reduce the administrative and regulatory burdens associated with hazardous waste. As a result, battery collection containers may be left in place for 1 year and then shipped by a common transport system such as United Parcel Service. (That is, it is not considered hazardous waste and does not require special documentation or handling).

These local battery-recycling programs are voluntary. While each of these programs has had some success with local merchants or with aggressive promotional campaigns, those interviewed suggested that the actual recycling rate for miniature battery recycling appeared lower than they could be.

Different cost structures make it difficult to compare recycling costs from program to program, although the recycling costs from these communities appear to fall in the $2.50-$5.00 per pound range. However, in most recycling programs, miniature batteries are not the sole waste being collected or the only container being transported. Miniature battery recycling typically takes place in the context of larger recycling programs that aggregate the costs.

Table 8.1

Location	Population Served	Miniature Battery Recycling Cost/Pound	Average Cost/Year (N/A – not available)	Pounds (Lbs) Batteries Recycled	Population-based Recycling Level
County in Midwest	1,112,259	$5.05/pound	$4424/year	876 lbs/year	7.8×10^{-4} lb/person
County in Northeast	150,000	$2.50/pound	$150/year	60 lbs/year	2.2×10^{-4} lb/person
Massachusetts Town	17,000	State contracted price for recycling applies: $0.65/lb for alkaline batteries, $3.50/lb for Hg batteries, $2.50/lb for silver oxide, $3.50/lb for lithium batteries, $.20/lb for sorting	N/A; combined with other recycling costs in Waste Contract	N/A	
Wheelabrator; Operator of 3 Municipal Waste Combustors in Northeast	1,428,856	N/A; mercury reduction programs are funded by $0.50/ton set aside from tipping fees charged to communities	N/A	67.5 lbs/year (2003) or approximately 43,200 batteries/yr[1]	0.5×10^{-4} lb/person

[1] Wheelabrator Program Coordinator estimates 640 miniature batteries/pound

In the interviews with representatives of four U.S. recycling programs, it was found that some recycling programs rely on contracts established directly with recycling firms, other programs are tied into municipal waste contracts, and some other programs are pay as you go, using pre-paid boxes or paying a sum based on the weight of small individual recycling containers.

Representatives of two battery-recycling companies were interviewed about their options for small-scale miniature battery recycling in communities. Each offers a user-friendly system for

collecting and recycling button batteries, briefly outlined in the following Table. According to the representatives, their containers are commonly found in public locations (e.g. town hall, library, senior center).

Table 8.2 Recycling Services

Company	Program Offered	Costs
Battery Solutions Http://www.batteryrecycling.com/pailmail.html	Pail Mail® program: Customer purchases a plastic bucket that serves as a collection and shipping container. When a customer calls in with a full container, Battery Solutions will send a shipping label and arrange for a FedEx Ground battery pickup on the following business day.	Reusable Bucket - $8 Recycling charge - $2.50/lb Shipping charge – approximately $13 (estimate for ground shipping 30 lb)
Toxco Http://www.biggreenbox.com/	Big Green Box program: Customer purchases box that is self-contained collection & shipping unit. Purchase price of $58 includes collection box, return shipping cost and battery recycling cost. Box includes plastic baggies for batteries and return shipping label. (Note: Box capacity 43 pounds)	Big Green Box - $58 total

8.2 Battery Recycling in Europe

Recycling data were also available for miniature battery recycling in European Union-15 (EU-15) states (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom) and Norway and the Swiss Confederation and are included in Table 8.3. (Reference: BIO Intelligence Service). Unlike the United States where miniature battery recycling is voluntary, recycling of mercury-containing miniature batteries in the European Union is influenced by existing battery legislation under "Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances, as amended by Commission Directive 98/101/EC". The key points of this legislation are summarized in Appendix G.

The Member States of the European Union have taken divergent approaches to battery recycling. Therefore, results vary widely from state to state and the overall collection efficiency of spent batteries in the Member States is low. Many batteries are still landfilled or incinerated instead of being collected and recycled. In a report commissioned by the European Commission Directorate General Environment, BIO Intelligence Service estimated the current recycling level of button batteries in Europe in 2002 at 15%. That is, 15% of the spent batteries available for collection enter a recycling plant.

Table 8.3 Recycling in Europe (2002)

Location	Population Served	Miniature Battery Recycling Cost/Pound	Average Cost/Year (N/A – not available)	Pounds (Lbs) Batteries Recycled	Population-based Recycling Level
EU-15, Norway and Swiss Confederation	Approximately 380,000,000	France – approximately $1.49/pound[1] Belgium – approximately $2.29/pound[1]	N/A	83,752 pounds/year[2] This is equivalent to 15% of batteries available for collection, or 10% of annual sales	4×10^{-4} lb/person

[1] Based on 10/22/04 conversion rate of $1.2639/Euro (Reference: Federal Reserve)
[2] (38 tonnes/year x 2204 lbs/tonne) = 83,752 lbs/year

8.3 Fire Hazards

There is some concern that the collection of miniature batteries for recycling could raise the risk of fire. There is a widely held perception that discarded lithium miniature batteries (an alternative to mercury-containing miniature batteries) have the potential for smoldering or causing fires in collection containers. One can understand the concern about battery fires when reading information available online. These statements and others raise the specter of fires occurring at local collection sites. In our phone interview with David Miller of Toxco, many concerns about collecting lithium miniature batteries for recycling were allayed. According to Miller:

- His company has never had a fire in a community collection box or during transit of miniature batteries.
- Lithium metal is the dangerous form associated with fires. As a miniature battery is consumed, the lithium is converted to lithium manganese dioxide, which is a stable form.
- Any recycler who handles lithium is going to have a fire sooner or later. However those fires are from much more potent forms of lithium: scrap lithium anode, government and industrial batteries, lithium boilers that contain ~15 pounds of elemental lithium, for example.

The National Fire Protection Association (NFPA) was contacted and they stated that there are no NFPA codes or standards that apply to miniature batteries. The NFPA representative noted that NFPA writes codes, including fire codes and electrical codes. While a code might specify requirements such as use of smoke detectors, for example, it is up to others to determine the necessary standards and/or functionality of a device or its components. NFPA does not conduct research, nor does it have lab or testing facilities.

Underwriters Laboratories (UL) is an independent, not-for-profit product-safety testing and certification organization was also contacted. UL has no voluntary safety standards for zinc air, silver oxide, alkaline, or lithium miniature batteries.

There is no evidence that mercury-containing miniature batteries pose a significant fire hazard. For a fire to occur, four elements are needed to initiate and sustain a fire: fuel, oxygen, heat, and a chemical chain reaction. In general, there would be only as small amount of electrical energy left in spent miniature batteries (making the potential for heat generation minimal), the

closed box will limit oxygen availability, and there would be little or no fuel to sustain a fire. Therefore it is unlikely that conditions supporting a fire would occur in a miniature battery collection box.

While there is always some risk of fire in most municipal waste recycling programs, we could not find evidence of any elevated risk associated with mercury-containing battery collection and recycling programs.

8.4 Human Ingestion Hazards

Additional concern has focused on the risks of human ingestion of miniature batteries or insertion of a miniature battery in the ear or nose when they are removed from products or stored prior to collection. Our review of the data found that the use of miniature batteries carries a small risk of ingestion, especially by children and the elderly.

Data show that miniature battery ingestions represent 0.1% of exposures reported to poison control centers in the United States. (Reference: Annual Reports of the AAPCC, 1998-2002 and Appendix H). Although most miniature battery ingestions result in no long-term adverse medical outcomes, a very small percentage will have more serious outcomes. In 2002, about 10 people reported a major medical outcome (life-threatening or significant residual disability or disfigurement) from ingesting miniature batteries. (Annual Report of the AAPCC, 2002)

Risk of ingestion is associated with the use of miniature batteries, not just conditions that might occur with battery recycling. Approximately 60% of battery ingestions occur immediately after removal from a product or with batteries taken directly from the package, while the remaining battery ingestions (40%) involve batteries lying loose, sitting out or discarded. (Reference: Litovitz and Schmitz, 1992). More complete data on battery ingestions are included in Appendix H.

Our research did not reveal any specific miniature battery standards promulgated by consumer product safety agencies, packaging organizations or advocacy groups. The Consumer Product Safety Commission (CPSC), for example, does not have specific input or regulations for miniature batteries. Some of the CPSC regulations, however, such as regulations pertaining to small parts on children's toys, might indirectly pertain to miniature batteries.

The mishandling of miniature batteries that leads to ingestion or insertion of the battery into the human body does occur. Removing a miniature battery from a product such as a hearing aid to replace it presents an opportunity for such ingestion. However, once the battery is removed, the difference in risk of ingestion between setting it aside for disposal or for recycling is determined by where and how the battery is stored prior to collection. Further research is needed to determine the degree to which this is significant.

8.5 Recycling - Results and Conclusions

Recycling programs for miniature batteries are available throughout the United States and there are private vendors who have demonstrated capacities in battery recycling. Different cost

structures make it difficult to compare recycling costs from program to program, however the recycling costs appear to fall in the $2.50-$5.00 per pound range. This is higher than recycling costs of approximately $1.50 - $2.30 per pound reported in two European Union countries, but still amounts to less than 1¢ per battery assuming 640 batteries per pound.

Although there is not enough information to establish recycling rates, by comparing the U.S. recycling levels with the European levels (estimated at 15% of batteries available for collection) the evidence from the local programs reviewed suggests that the U.S. rates are low and could be significantly improved. A comparison with Europe also suggests that if miniature battery recycling becomes more widespread and recycling volumes increase, economies of scale will be reflected in more efficient, cost effective options for collection, transportation and recovery processes.

Mercury-containing miniature batteries (as individual units) do not have any applicable codes, standards or certifications to measure or control their inherent safety or safe use and there are no standards or regulations specific to recycling miniature batteries. While there is no evidence that the batteries pose an elevated fire hazard during recycling, data that shows a risk of human ingestion associated with the use of miniature batteries should be considered in promoting domestic battery recycling programs. However, this factor should be considered at any time for the safe use of replacement miniature batteries and any products that contain miniature batteries.

9.0 Sources

American Association of Poison Control Centers (AAPCC), (1998, 1999, 2000, 2001 and 2002). *Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System.* http://www.aapcc.org/annual.htm (Accessed various dates, June-August, 2004)

American Association of Poison Control Centers (AAPCC) *1998 Pediatric Exposures,* http://www.aapcc.org/poison1.htm (Accessed various dates, June-August, 2004)

Alvi, Aijiz, MD; Bereliani, Arash MS; Gerald D. Zahtz, MD; (1997), Miniature Disc Battery in the Nose: A Dangerous Foreign Body, *Clinical Pediatrics*, July 1997; 36: 427-429

Ansley, John F., Cunningham, Michael J., (1998), Treatment of aural foreign bodies in children, *Pediatrics*, April 1998 v101 n4 p638(4)

Battery Benelux B.V.
www.batterybenelux.nl
info@batterybenelux.nl
Brenda Veenhoff

BIO Intelligence Service, (July 2003), *Impact Assessment on Selected Policy Options for Revision of the Battery Directive*, commissioned by the European Commission Directorate General Environment

Brown, Lance, Dannenberg, Bernard, (2002), A literature-based approach to the identification and management of pediatric foreign bodies. *Pediatric Emergency Medicine Reports*, September 2002 v7 i9 p93(12).

Chung Pak Battery Works, Ltd
www.vinnic.com
www.evergreencpusa.com
sales@evergreencpusa.com
Product Specifications
Cheryl Cheung, Account Executive

Commission of the European Communities, (2003), *Proposal for a Directive of the European Parliament and of the Council on Batteries & Accumulators and Spent Batteries and Accumulators, Commission of the European Communities*, [SEC(2003)1343] http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0723en01.pdf (Accessed various dates June-August 2004)

The Council of European Communities, Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances, as amended by Commission Directive

98/101/EC, http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991L0157_do_001.pdf (accessed October 20, 2004)

Duracell
www.duracell.com
Product Data Sheets
Material Safety Data Sheets
Ni-MH Technical Bulletin Chapter: 5

Eastman Kodak Co.
www.kodak.com
Product Data Sheets
Material Safety Data Sheets

Energizer
www.energizer.com
Engineering Data Sheets
Product Safety Data Sheets
Energizer Manganese Dioxide Application Manual 11/06/01
Energizer Silver Oxide Application Manual 11/06/01
Energizer Zinc Air Application Manual 11/06/01
Energizer Lithium Miniature Application Manual 11/06/01
BatteryInfo@Energizersales.com

Environmental Resources Management, (November 2000), *Analysis of the Environmental Impact and Financial Costs of a Possible New European Directive on Batteries*, commissioned by the (UK) Department of Trade and Industry, http://www.dti.gov.uk/sustainability/pdfs/EUBatteries.pdf, (accessed October 19, 2004)

European Portable Battery Association, Portable Energy!, www.epbaeurope.org/recycling

European Union, More Facts and Figures on the European Union and the United States, www.eurunion.org/profile/EUUSStats.htm

The Federal Reserve Board, *Federal Reserve Statistical Release H.10; Foreign Exchange Rates*, Release Date: October 22, 2004, http://www.federalreserve.gov/releases/h10/update (Accessed October 26, 2004)

Global Sources, Excerpts from "Market Intelligence Report – Batteries: Supplier Capability in China", July 2004. www.globalsources.com.

Gold Peak
www.gpbatteries.com.hk
Product Data Sheets
Material Safety Data Sheets

J.T. Baker Material Safety Data Sheet, Lithium Perchlorate, Anhydrous (CAS # 7791-03-9), Silver Oxide (CAS # 20667-12-3), Sodium Hydroxide (CAS # 1310-73-2), Propylene Carbonate (CAS # 108-32-7), Manganese Dioxide (CAS # 1313-13-9), 1,2-Dimethoxyethane (CAS # 110-71-4), Potassium Hydroxide (CAS # 1310-58-3)

Kronos Incorporated
www.kronos.com
Cynthia Hickey, Senior New Products Purchasing
Bob McIntosh, Component Engineer

Lin, Vincent Y.W., S.J. Daniel, and B.C. Papsin, Case Report: Button batteries in the ear, nose and upper aerodigestive tract, *International Journal of Pediatric Otorhinolaryngology* (2004) 68, 473-479

Linden, D., Reddy T.B., Handbook of Batteries (3rd Edition), McGraw-Hill, 2002.

Litovitz, T, and Schmitz, B.F., Ingestion of Cylindrical and Button Batteries: An Analysis of 2382 Cases, *Pediatrics* 1992; 89:747-757

National Electrical Manufacturer's Association, Testimony on LD 1661/HB 1237 Before the Joint Committee on Natural Resources, Ric Erdheim, January 20, 2004.

New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, Nickel Hydroxide (CAS # 12054-48-7)

New Leader
www.newleader.com.hk
Engineering Data Sheets
Ivan Kong, Assistant Sales Manager
Sunny Chow, Customer Service Manager

National Institute for Occupational Safety and Health (NIOSH), The Registry of Toxic Effects of Chemical Substances, Sodium Hydroxide (CAS # 1310-73-2), 2(3H)-Furanone, dihydro (CAS # 96-48-0),

New Jersey Department of Health and Senior Services, Indium: Hazardous Substance Fact Sheet, August 1999.

Panasonic
www.panasonic.com
Product Information Sheets
Lithium Handbook, August 2003, Rechargeable Lithium Coin Batteries: Overview
Lithium Batteries Handbook, December 1998
Panasonic Safety Note on Lithium Batteries (Recycling)

http://www.panasonic.com/industrial/battery/oem/images/pdf/Panasonic_LithiumCR_Info.pdf
http://www.panasonic.com/industrial/battery/oem/images/pdf/Panasonic_LithiumBR_Info.pdf

Radica
Gary Jones, Director of Quality and Safety

Renata
www.renata.com
Technical Data Sheets

Reuters, UPDATE – Kellogg says new toy batteries to be mercury-free, July 15, 2004, http://biz.yahoo.com

Schenzen Konnoc Battery Industrial Co.
www.konnoc.com
Melody Ma, Sales & Marketing

Sony Press Release, "World's First Commercialization of Mercury-Free Silver Oxide Battery", September 29, 2004

Specialized Technology Resources (STR)
Test Report Number A20790457 (May 6, 2004)
Susan DeRagon

The Steel Recycling Institute, *A Few Facts About Steel – North America's #1 Recycled Material*; a fact sheet of the Steel Recycling Institute, http://www.recycle-steel.org/fact/main.html, accessed 10/15/04)

Strachan, David R., Kenny, Helen, Hope, G.A., "The hearing-aid battery: a hazard to elderly patients", Age and Ageing, Sept 1994 v23 n5 p425(2)

Tozer, Richard F., *Analysis of Battery Industry Sponsored Button Cell Collection Programs*, December 19, 2003.

Ultralife Batteries, Inc.
Material Safety Data Sheet – Ultralife Lithium Power Cell

United States Environmental Protection Agency, EPA Sector Notebook; Profile of the Metal Mining Industry, (1995) Publication Number EPA/310-R-95-008, http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/metminsn.pdf

United States Environmental Protection Agency, Agency for Toxic Substances and Disease Registry, Medical Management Guidelines for Sodium Hydroxide, http://www.atsdr.cdc.gov/MHMI/mmg178.html

University of Oxford, Physical and Theoretical Chemistry Laboratory, Safety (MSDS) Data for Nickel Hydroxide, http://physchem.ox.ac.uk/MSDS/NI/nickel_hydroxide.html

Varta
www.varta.com
Technical data sheets, Material data sheets
Varta Microbattery: Sales Program and Technical Handbook – Primary Lithium Cells
Varta Microbattery: Sales Program and Technical Handbook – High Performance Nickel-Hydride Rechargeable Button Cells

Appendices

Appendix A: Miniature Battery Components

The following figure illustrates the basic components of a miniature battery.

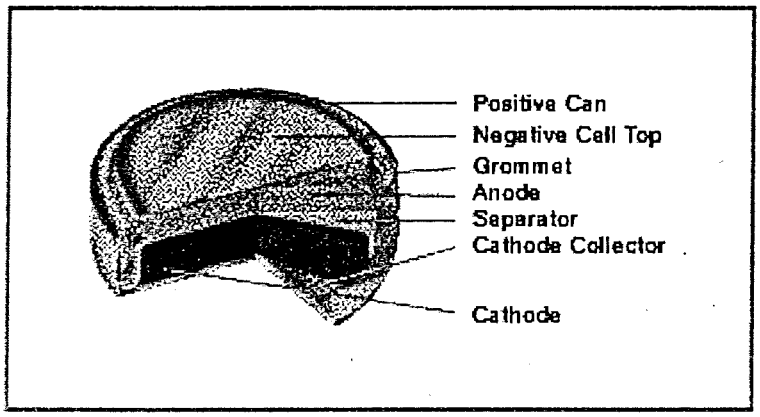


Figure 1: Miniature Battery Components

In general, the primary components of the primary miniature battery technologies are as follows:

Cathode: The electrode in an electrochemical cell where reduction occurs. During discharge, the positive electrode of the electrochemical cell is the cathode.

Anode: The electrode in an electrochemical cell where oxidation occurs. During discharge, the negative electrode of the electrochemical cell is the anode.

Electrolyte: The medium that provides the ion transport mechanism between the positive and negative electrodes of a cell.

Packaging: The cathode, anode, and electrolyte are typically housed in two metal cans that are crimped together to form the miniature battery. The metal cans are often plated with a protective layer of nickel. There is often a gasket used to seal the cell and prevent leakage of battery cell materials.

Zinc Air

The major components of the zinc air miniature battery are as follows:

Cathode: Oxygen from ambient air

Electrolyte: The aqueous electrolyte typically consists of 20 to 40% potassium hydroxide (KOH) or sodium hydroxide (NaOH).

Anode: Granulated zinc powder mixed with the electrolyte.

Packaging: The metal can houses the cathode and anode active materials and acts as the positive and negative terminals. A plastic gasket provides insulation between the two cans.

Silver Oxide
The major components of the silver oxide miniature battery are as follows:

Cathode: The cathode consists primarily of monovalent silver oxide (Ag2O) blended with 1% to 5% powered graphite. The cathode may also contain manganese dioxide (MnO2) or silver nickel oxyhydroxide (AgNiO2)

Electrolyte: The aqueous electrolyte typically consists of 20% to 45% potassium hydroxide (KOH) or sodium hydroxide (NaOH). Potassium hydroxide has higher electrical conductivity and allows cells to discharge over a wide range of current levels. Sodium hydroxide is used mostly for long life cells not requiring a high discharge rate.

Anode: A powdered zinc metal.

Packaging: The outer surface is steel with a protective layer of nickel, and the inner surface is high purity copper or tin. The gasket used to seal the cell is made from an electrolyte resistant plastic such as nylon.

Alkaline Manganese Dioxide
The major components of the alkaline-manganese dioxide miniature cell are as follows:

Cathode: The cathode is primarily comprised of electrolytic manganese dioxide. Carbon, usually in the form of graphite, is used as an electronic conductor.

Electrolyte: The aqueous electrolyte typically contains 35 – 52% potassium hydroxide (KOH).

Anode: Powered zinc metal. The anode may also contain mercury used as a gassing suppressor, electronic conductor, or discharge accelerator.

Packaging: The can is made of steel plated on both sides with nickel. The seal is a thin plastic gasket.

Lithium Manganese Dioxide
The major components of the lithium manganese dioxide miniature batteries are as follows:

Cathode: Heat-treated form of manganese dioxide (MnO_2)

Electrolyte: Lithium salts in a mixed organic solvent such as propylene carbonate and 1,2-dimethoxyethane.

Anode: Lithium

Packaging: A non-woven polypropylene separator is used to separate the manganese dioxide pellet and the lithium anode disk. The battery cell is crimp sealed, with the can providing the positive terminal and the cap providing the negative terminal.

Lithium Carbon Monofluoride

The major components of the lithium carbon monofluoride miniature cell are as follows:

Cathode: Polycarbon monofluoride $(CF)_n$, where n is typically between 0.9 to 1.2. The carbon monofluoride is formed by the reaction between carbon powder and fluorine gas.

Electrolyte: Common electrolytes used are 1) lithium hexafluoroarsenate ($LiAsF_6$) in gamma-butyrolactone, or 2) lithium tetrafluoroborate ($LiBF_4$) in propylene carbonate and dimethoxyethane.

Anode: Lithium

Packaging: Nickel plated steel or stainless steel is often used for the case material. The battery cells are crimp sealed using a polypropylene gasket.

Appendix B: Miniature Battery Nomenclature

The International Electrotechnical Commission (IEC) has published standards for primary batteries. The IEC nomenclature scheme for primary batteries is based on the electrochemical system as well as the size and shape of the battery. The following table indicates the IEC nomenclature for electrochemical systems relevant to this study.

IEC Letter Code	Negative Electrode	Positive Electrode	Nominal Voltage
B	Lithium	Carbon monofluoride	3
C	Lithium	Manganese dioxide	3
L	Zinc	Manganese dioxide	1.5
P	Zinc	Oxygen (air)	1.4
S	Zinc	Silver oxide	1.55

The IEC uses the letter "R" to designate round batteries. The IEC uses many numerical designations to indicate the acceptable range for battery diameter and height. The following table provides some examples:

IEC Designation	Maximum Diameter (mm)	Minimum Diameter (mm)	Maximum Height (mm)	Minimum Height (mm)
R44	11.6	11.25	5.4	5.0
R64	5.8	5.55	2.7	2.4
R1620	16	15.7	2.0	1.8
R2032	20	19.7	3.2	2.9

Many manufacturers base the model numbers for their miniature batteries on the IEC nomenclature. The following two examples are provided to illustrate the IEC nomenclature for miniature batteries:

- The IEC nomenclature for a lithium manganese dioxide miniature battery with a diameter of 20 mm and a height of 3.2 mm would be: CR2032.

- The IEC nomenclature for a silver oxide miniature battery with a diameter of 11.6 mm and a height of 5.4 mm would be: SR44.

Appendix C: Miniature Battery Cost and Availability

Hearing Aid Batteries
Chemistry: Zinc Air

Battery Size	Date	Vendor	Description	price	qty/pkg	$/unit
10	7/22/04	Walgreens.com	Walgreens Size 10	14.99	24	$0.62
10	10/23/04	www.radioshack.com	Part number 23-776	10.99	16	$0.69
10	10/23/04	www.radioshack.com	Part number 23-076	5.99	8	$0.75
10	7/22/04	Walgreens.com	Walgreens Size 10	8.99	12	$0.75
10	7/22/04	Walgreens.com	Walgreens Size 10	4.99	6	$0.83
10	7/26/04	Walgreens Pharmacy	Duracell	12.99	12	$1.08
10	7/22/04	Walgreens.com	Duracell Size 10	12.99	12	$1.08
10	7/22/04	CVS.com	Duracell Easy-Tab DA 10B8	8.99	8	$1.12
10	7/26/04	Walgreens Pharmacy	Duracell	8.99	8	$1.12
10	7/26/04	Walgreens Pharmacy	Rayovac	8.99	8	$1.12
10	7/26/04	Walgreens Pharmacy	Energizer EZ Change	8.99	8	$1.12
10	7/22/04	Walgreens.com	Duracell Size 10	8.99	8	$1.12
RS 10	10/23/04	www.radioshack.com	Part number 23-056	5.99	8	$0.75
13	7/22/04	Walgreens.com	Walgreens Size 13	14.99	24	$0.62
13	10/23/04	www.radioshack.com	Part number 23-778	10.99	16	$0.69
13	10/23/04	www.radioshack.com	Part number 23-078	5.99	8	$0.75
13	7/22/04	Walgreens.com	Walgreens Size 13	8.99	12	$0.75
13	7/22/04	Walgreens.com	Walgreens Size 13	4.99	6	$0.83
13	7/26/04	Walgreens Pharmacy	Rayovac	14.99	16	$0.94
13	7/26/04	Walgreens Pharmacy	Duracell	12.99	12	$1.08
13	7/22/04	Walgreens.com	Duracell Size 13	12.99	12	$1.08
13	7/22/04	CVS.com	Duracell Easy-Tab DA 13B8	8.99	8	$1.12
13	7/26/04	Walgreens Pharmacy	Duracell	8.99	8	$1.12
13	7/26/04	Walgreens Pharmacy	Rayovac	8.99	8	$1.12
13	7/26/04	Walgreens Pharmacy	Energizer EZ Change	8.99	8	$1.12
13	7/22/04	Walgreens.com	Duracell Size 13	8.99	8	$1.12
RS 13	10/23/04	www.radioshack.com	Part number 23-058	5.99	8	$0.75
312	7/22/04	Walgreens.com	Walgreens Size 312	14.99	24	$0.62
312	10/23/04	www.radioshack.com	Part number 23-779	10.99	16	$0.69
312	10/23/04	www.radioshack.com	Part number 23-079	5.99	8	$0.75
312	7/22/04	Walgreens.com	Walgreens Size 312	8.99	12	$0.75
312	7/22/04	Walgreens.com	Walgreens Size 312	4.99	6	$0.83
312	7/26/04	Walgreens Pharmacy	Rayovac	14.99	16	$0.94
312	7/22/04	Walgreens.com	Duracell Size 312	12.99	12	$1.08
312	7/22/04	CVS.com	Duracell Easy-Tab 312B8	8.99	8	$1.12
312	7/26/04	Walgreens Pharmacy	Rayovac	8.99	8	$1.12
312	7/26/04	Walgreens Pharmacy	Energizer EZ Change	8.99	8	$1.12
312	7/22/04	Walgreens.com	Duracell Size 312	8.99	8	$1.12
675	7/22/04	Walgreens.com	Walgreens Size 675	14.99	24	$0.62
675	10/23/04	www.radioshack.com	Part number 23-077	5.99	8	$0.75

675	7/22/04	Walgreens.com	Walgreens Size 675	8.99	12	$0.75
675	7/22/04	Walgreens.com	Walgreens Size 675	4.99	6	$0.83
675	7/26/04	Walgreens Pharmacy	Duracell	12.99	12	$1.08
675	7/26/04	Walgreens Pharmacy	Rayovac	8.99	8	$1.12
675	7/22/04	CVS.com	Duracell Easy-Tab DA 675B6	6.99	6	$1.17
675	7/26/04	Walgreens Pharmacy	Duracell	6.99	6	$1.17
675	7/26/04	Walgreens Pharmacy	Energizer EZ Change	6.99	6	$1.17
675P	10/24/04	RadioShack stores & online	Model 675HP Zinc-Air Pager/Hearing Aid Battery 2-Pack. Cat. No. 23-150	2.69	2	$1.35
675	7/22/04	Walgreens.com	Duracell Size 675	6.99	6	$1.17

Minimum	$0.62
Maximum	$1.35
Median	$1.08

Silver Oxide Batteries

Battery Size	Date	Vendor	Description	price	qty/pkg	$/unit
76	10/24/04	Radio Shack stores & online	Model 76 1.55V/165mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
301	7/25/04	www.batteries.com	Renata	$3.47	1	$3.47
301	7/25/04	www.batteries.com	Energizer	$4.39	1	$4.39
303	10/24/04	Radio Shack stores & online	Model 303 1.55V/170mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
303	7/25/04	www.batteries.com	Renata 303R	$4.39	1	$4.39
303	7/25/04	www.batteries.com	Energizer 303	$5.09	1	$5.09
309	7/25/04	www.batteries.com	Energizer	$4.84	1	$4.84
315	7/25/04	www.batteries.com	Renata 5-Pack 315 Coincell Batteries	$5.99	5	$1.20
317	10/24/04	Radio Shack stores & online	Model 317 1.55V/8mAh S-O Button-Watch/Calculator Battery	$3.19	1	$3.19
317	7/25/04	www.batteries.com	Energizer Button Cell	$4.29	1	$4.29
319	7/25/04	www.batteries.com	Renata 5-pack 319 Coincell Batteries	$5.99	5	$1.20
319	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
319	10/24/04	Radio Shack stores & online	Model 319 1.5V/16mAh Silver-Oxide Battery 1 Pack	$3.19	1	$3.19
319	7/25/04	www.batteries.com	Energizer Button Cell	$4.59	1	$4.59
321	7/25/04	www.batteries.com	Renata 5-pack 321 Coincell Batteries	$5.99	5	$1.20
321	10/14/04	www.radioshack.com	1.55V/13mAh S-O Button Battery, Catalog # 23-515	$3.19	1	$3.19
321	7/25/04	www.batteries.com	Energizer Button Cell	$3.29	1	$3.29
329	7/25/04	www.batteries.com	Renata 329R Button Cell Battery	$3.09	1	$3.09
335	10/24/04	www.radioshack.com	Model 335 1.55V/5mAh Renata Silver-Oxide Battery 1-Pack	$2.99	1	$2.99
335	7/25/04	www.batteries.com	Renata 335R Button Cell Battery	$3.72	1	$3.72
335	7/25/04	www.batteries.com	Energizer Button Cell	$4.29	1	$4.29
337	7/25/04	www.batteries.com	Renata 337R Button Cell	$4.20	1	$4.20
339	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
341	10/24/04	www.radioshack.com	Model 341 1.55V/13.5mAh Silver-Oxide Battery 1-Pack	$2.99	1	$2.99
341	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
344	10/24/04	www.radioshack.com	Model 344 1.55V/105mAh Renata Silver Oxide Battery 1-pack	$2.99	1	$2.99
344	7/25/04	www.batteries.com	Renata 344R Button Cell Battery	$3.09	1	$3.09
344	7/25/04	www.batteries.com	Energizer Button Cell	$3.99	1	$3.99
346	10/24/04	www.radioshack.com	Model 346 1.55V 10mAh Renata Silver Oxide Battery	$2.99	1	$2.99
346	7/25/04	www.batteries.com	Renata 346R Button Cell Battery	$3.82	1	$3.82
346	7/25/04	www.batteries.com	Energizer Button Cell	$4.29	1	$4.29
350	10/24/04	www.radioshack.com	Model 350 1.55V 105mAh Renata Silver Oxide Battery - 1 Pack	$2.99	1	$2.99
350	7/25/04	www.batteries.com	Renata 350R Button Cell Battery	$3.73	1	$3.73
350	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
357	7/26/04	Walgreen's Pharmacy	Energizer 357	$6.99	3	$2.33
357	7/25/04	www.batteries.com	Renata 357R	$3.09	1	$3.09
357	10/24/04	Radio Shack stores & online	Model 357 1.55V/165mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19

357	7/25/04	www.batteries.com	Energizer Button Cell	$3.89	1	$3.89
361	7/25/04	www.batteries.com	Renata 361R Button Cell Battery	$3.09	1	$3.09
361	7/25/04	www.batteries.com	Energizer Button Cell	$3.69	1	$3.69
362	7/25/04	www.batteries.com	Renata 5-pack 362 Coincell Batteries	$5.99	5	$1.20
362	7/25/04	www.batteries.com	Renata 362R Button Cell Battery	$3.09	1	$3.09
362	10/24/04	Radio Shack stores & online	Model 362 1.55V/21mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
362	7/25/04	www.batteries.com	Energizer Button Cell	$3.79	1	$3.79
364	7/25/04	www.batteries.com	Renata 5-pack 364 Coincell Batteries	$5.99	5	$1.20
364	7/26/04	Walgreen's Pharmacy	Energizer 364	$2.99	1	$2.99
364	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
364	10/24/04	Radio Shack stores & online	Model 364 1.55V/20mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
364	7/25/04	www.batteries.com	Energizer Button Cell	$3.29	1	$3.29
365	10/24/04	www.radioshack.com	365 1.55V 40mAh Renata Silver Oxide Battery 1 Pack	$2.99	1	$2.99
365	7/25/04	www.batteries.com	Energizer Button Cell	$3.79	1	$3.79
366	10/24/04	www.radioshack.com	Model 366 - 1-pack 1.55V/33mAh Renata Silver Oxide Battery	$2.99	1	$2.99
366	7/25/04	www.batteries.com	Renata 366R Button Cell Battery	$3.62	1	$3.62
366	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
370	7/25/04	www.batteries.com	Renata 5-pack 370 Coincell Batteries	$5.99	5	$1.20
370	7/25/04	www.batteries.com	Renata 370R Button Cell Battery	$3.34	1	$3.34
370	7/25/04	www.batteries.com	Energizer Button Cell	$3.99	1	$3.99
371	7/25/04	www.batteries.com	Renata 5-Pack 371 Coincell Batteries	$5.99	5	$1.20
371	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
373	7/25/04	www.batteries.com	Renata 5-Pack 373 Coincell Batteries	$5.99	5	$1.20
373	10/24/04	Radio Shack stores & online	Model 373 1.55V/23mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
373	7/25/04	www.batteries.com	Energizer Button Cell	$4.29	1	$4.29
376	10/24/04	Radio Shack stores & online	Model 376 1.55V/26mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
376	7/25/04	www.batteries.com	Energizer Button Cell	$3.39	1	$3.39
376	7/25/04	www.batteries.com	Renata 376R Button Cell Battery	$3.46	1	$3.46
377	7/25/04	www.batteries.com	Renata 5-Pack 377 Coincell Batteries	$5.99	5	$1.20
377	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
377	7/25/04	www.batteries.com	Energizer Button Cell	$3.09	1	$3.09
377	10/24/04	Radio Shack stores & online	Model 377 1.55V/26mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
379	7/25/04	www.batteries.com	Renata 5-pack 379 Coincell Batteries	$5.99	5	$1.20
379	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
379	7/25/04	www.batteries.com	Energizer Button Cell	$3.09	1	$3.09
379	10/24/04	Radio Shack stores & online	Model 379 1.55V/14mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
380	7/25/04	www.batteries.com	Renata 380R Button Cell Battery	$3.99	1	$3.99
381	7/25/04	www.batteries.com	Renata 381R Button Cell Battery	$3.43	1	$3.43
381	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
384	10/24/04	Radio Shack stores & online	Model 384 1.55V/42mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
384	7/25/04	www.batteries.com	Renate 384R Button Cell Battery	$3.32	1	$3.32
384	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09

386	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
386	7/25/04	www.batteries.com	Renata 386R Button Cell Battery	$3.09	1	$3.09
386	10/24/04	Radio Shack stores & online	Model 386 1.55V/120mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
386	7/25/04	www.batteries.com	Energizer Button Cell	$3.79	1	$3.79
387	10/24/04	www.radioshack.com	Model 387S Energizer 1.5V/80mAh Silver-Oxide Button Battery	$2.99	1	$2.99
387	7/25/04	www.batteries.com	Renata 387R Button Cell Battery	$4.39	1	$4.39
389	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
389	7/25/04	www.batteries.com	Renata 389R Button Cell Battery	$3.09	1	$3.09
389	10/24/04	Radio Shack stores & online	Model 389 1.5V/85mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
389	7/25/04	www.batteries.com	Energizer Button Cell	$4.39	1	$4.39
390	10/24/04	Radio Shack stores & online	Model 390 1.55V/85mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
390	7/25/04	www.batteries.com	Energizer Button Cell	$3.99	1	$3.99
391	10/24/04	Radio Shack stores & online	Model 391 1.5V/24mAH Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
391	7/25/04	www.batteries.com	Renata 391R Button Cell Battery	$3.35	1	$3.35
391	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
392	7/25/04	www.batteries.com	Renata 5-Pack 392 Coincell Batteries	$5.99	5	$1.20
392	7/25/04	www.batteries.com	Energizer Button Cell	$3.09	1	$3.09
392	10/24/04	Radio Shack stores & online	Model 392 1.55V/42mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
393	10/24/04	Radio Shack stores & online	Model 393 1.55V/70mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
393	7/25/04	www.batteries.com	Energizer Button Cell	$3.29	1	$3.29
394	7/25/04	www.batteries.com	Renata 5-Pack 394 Coincell Batteries	$5.99	5	$1.20
394	10/24/04	Radio Shack stores & online	Model 394 1.5V/67mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
394	7/25/04	www.batteries.com	Energizer Button Cell	$3.99	1	$3.99
395	7/25/04	www.batteries.com	Renata 395R 5-pack Button Cell Batteries	$5.99	5	$1.20
395	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
395	10/24/04	Radio Shack stores & online	Model 395 1.55V/42mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
395	7/25/04	www.batteries.com	Energizer Button Cell	$3.29	1	$3.29
396	10/24/04	Radio Shack stores & online	Model 396 1.55V/25mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
396	7/25/04	www.batteries.com	Energizer Button Cell	$3.19	1	$3.19
397	7/25/04	www.batteries.com	Renata 5-Pack 397 Coincell Batteries	$5.99	5	$1.20
397	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
397	10/24/04	Radio Shack stores & online	Model 397 1.55V/30mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
397	7/25/04	www.batteries.com	Energizer Button Cell	$4.09	1	$4.09
399	7/25/04	www.batteries.com	Renata 5-Pack 399 Coincell Batteries	$5.99	5	$1.20
399	10/24/04	Radio Shack stores & online	Model 399 1.55V/55mAh Silver-Oxide Battery 1-Pack	$3.19	1	$3.19
399	7/25/04	www.batteries.com	Energizer Button Cell	$3.99	1	$3.99
23-221	10/24/04	Radio Shack stores & online	Pet Collar Replacement Battery; 7.5 V, Silver Oxide. Catalog #: 23-221. Appears to be stacked.	$18.99	1	$18.99
357/303	7/26/04	Walgreen's Pharmacy	Energizer 357/303	$2.99	1	$2.99

387S	7/25/04	www.batteries.com	Energizer Button Cell	$4.49	1	$4.49
PX28S	7/29/04	www.zbattery.com	(Stack) PX28S Silver Oxide 6V Battery (Note 2)	$4.27	1	$4.27
RFA-16-11	10/19/04	www.petsafestore.com	6 Volt Silver oxide battery for Pet pager Receiver, Electronic Leash or Receiver. (Appears to be stacked miniature cells)	$6.95	1	$6.95
S76	7/29/04	www.zbattery.com	Duracell MS76B Photo Battery	$2.69	1	$2.69
TR175S	7/29/04	www.zbattery.com	(Stack) Energizer TR175S (Silver Oxide) Dog Collar Battery (Note 1)	$5.93	1	$5.93
	10/24/04	www.radioshack.com	1.55V/45mAh Vinnic S-O Button-Watch/Calculator	$2.99	1	$2.99
	10/24/04	www.radioshack.com	1.5V Button Vinnic (S-O) Battery	$2.99	1	$2.99
	10/24/04	www.radioshack.com	1.5V Button Vinnic (S-O) Battery	$2.99	1	$2.99
	10/24/04	www.radioshack.com	1.5V Button Varta (S-O) Battery	$2.99	1	$2.99
	10/24/04	www.radioshack.com	1.5V Renata Button (S-O) Battery	$2.99	1	$2.99
	10/24/04	www.radioshack.com	1.55V/7.5mAh Maxell Button S-O Battery 1-Pack	$2.99	1	$2.99

minimum	$1.20
maximum	$18.99
median	$3.19

Alkaline Manganese Dioxide Batteries

Battery Size	Date	Vendor	Description	price	qty/pkg	$/unit
See descrip.	6/16/04	Ocean State Job Lot	Konnoc Alkaline MicroCell AG1/LR621/364	$0.99	3	$0.33
See descrip.	6/16/04	Ocean State Job Lot	Konnoc Alkaline MicroCell AG3/LR41/392	$0.99	3	$0.33
See descrip.	6/16/04	Ocean State Job Lot	Konnoc Alkaline MicroCell LR44/357	$0.99	3	$0.33
See descrip.	6/16/04	Ocean State Job Lot	Konnoc Alkaline MicroCell LR521/379	$0.99	3	$0.33
See descrip.	6/16/04	Ocean State Job Lot	Konnoc Alkaline MicroCell LR626/AG4/377	$0.99	3	$0.33
LR44	7/29/04	www.zbattery.com	Renata	$195.00	500	$0.39
LR44	7/29/04	www.zbattery.com	Renata	$50.00	100	$0.50
76A	7/29/04	www.zbattery.com	Duracell 76A Medical Battery	$9.50	12	$0.79
76A	7/29/04	www.zbattery.com	Duracell PX76A/675AB	$0.89	1	$0.89
6V Stack	10/24/04	www.radioshack.com	6V Vinnic Alkaline Remote Control Battery. Appears to be stacked. Catalog #: 960-0363	$1.79	1	$1.79
9V Stack	10/24/04	www.radioshack.com	9V/33mAh Vinnic Alkaline Battery. Catalog #: 960-0362. Appears to be stacked	$1.79	1	$1.79
76A	7/26/04	Walgreen's Pharmacy	Duracell	$2.79	1	$2.79
TR175A	7/29/04	www.zbattery.com	(Stack) Exell A175 Alkaline Dog Collar Battery (Note 1)	$2.98	1	$2.98
12V Stack	10/24/04	Radio Shack stores & online	New 12V GP27A Alkaline Battery; Cat. No. 23-279. Appears to be stacked	$3.19	1	$3.19
12V Stack	10/24/04	Radio Shack stores & online	2-pack 12V Radio Shack Alkaline Battery; for remote controls. Appears to be stacked. Cat. No. 23-154	$6.59	2	$3.30
23-1504		Radio Shack stores & online	1.5V Alkaline Photo/Miscellaneous. Catalog #: 23-1504	$3.39	1	$3.39
12V Stack	10/24/04	Radio Shack stores & online	12V Alkaline Pager/Remote Battery (Pkg. 1); Cat. No. 23-144. Appears to be stacked	$3.59	1	$3.59
RFA-35	10/19/04	www.petsafestore.com	6 Volt Alkaline battery. Used for Pet pager receiver, electronic leash, bark collar, receiver. Appears to be stacked miniature cells	$4.95	1	$4.95
960-0357	10/24/04	www.radioshack.com	1.5V Exell Photo (Alkaline) Battery. Catalog #: 960-0374	$4.99	1	$4.99
E625G	7/25/04	www.batteries.com	Energizer E625G Button Cell Battery	$6.39	1	$6.39
4.5V Stack	10/24/04	www.radioshack.com	4.5V Photo (Alkaline) Battery; Catalog #: 960-0357. Appears to be stacked	$6.99	1	$6.99
175	10/24/04	www.radioshack.com	7.5V 120mAh Excel Alkaline #175 Camera Battery.	$6.99	1	$6.99
					Minimum	$0.33
					Maximum	$6.99
					Median	$2.29

Lithium Batteries

Battery Size	Date	Vendor	Description	price	qty/pk	$/unit
CR1/3N	7/29/04	www.zbattery.com	Sanyo CR113N (Note 1)	$2.54	1	$2.54
CR1025	7/29/04	www.zbattery.com	Duracell DL1025B	$1.05	1	$1.05
CR1025	7/25/04	www.batteries.com	Energizer ECR1025 Lithium Coin Cell Battery	$2.85	1	$2.85
CR1025	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
CR1025	7/25/04	www.batteries.com	Renata CR1025 Coin Cell Battery	$3.09	1	$3.09
CR1216	7/29/04	www.zbattery.com	Duracell DL1216B	$1.05	1	$1.05
CR1216	7/25/04	www.batteries.com	Energizer ECR1216 Lithium Coin Cell Battery	$4.09	1	$4.09
CR1220	7/25/04	www.batteries.com	Energizer ECR1220 Button Cell Battery	$5.09	1	$5.09
CR1225	7/25/04	www.batteries.com	Energizer ECR1225 Coin Cell Battery	$4.29	1	$4.29
CR1616	7/29/04	www.zbattery.com	Duracell DL 1616B	$1.42	1	$1.42
CR1616	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
CR1616	7/25/04	www.batteries.com	Energizer ECR1616 Coin Cell Battery	$4.29	1	$4.29
CR1620	7/29/04	www.zbattery.com	Duracell DL1620B	$1.19	1	$1.19
CR1620	7/25/04	www.batteries.com	Energizer ECR 1620 Button Cell Battery	$4.39	1	$4.39
CR1632	7/25/04	www.batteries.com	Energizer ECR1632 Lithium Coin Cell	$3.39	1	$3.39
CR2012	7/25/04	www.batteries.com	Energizer ECR2012 Coin Cell Battery	$5.09	1	$5.09
CR2016	6/16/04	Ocean State Job Lot	Konnoc MicroCell Lithium	$0.99	3	$0.33
CR2016	7/29/04	www.zbattery.com	Duracell DL2016B	$1.19	1	$1.19
CR2016	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
CR2016	7/25/04	www.batteries.com	Renata CR2016R Coin Cell Battery	$4.09	1	$4.09
CR2016	7/25/04	www.batteries.com	Energizer ECR2016 Coin Cell Battery	$5.09	1	$5.09
CR2025	6/16/04	Ocean State Job Lot	Konnoc MicroCell Lithium	$0.99	3	$0.33
CR2025	7/29/04	www.zbattery.com	Duracell DL2025B	$1.19	1	$1.19
CR2025	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
CR2025	7/25/04	www.batteries.com	Energizer ECR2025 Coin Cell Battery	$3.39	1	$3.39
CR2025	7/25/04	www.batteries.com	Renata CR2025R Coin Cell Battery	$4.09	1	$4.09
CR2032	7/29/04	www.zbattery.com	Renata CR2032-25	$22.25	25	$0.89
CR2032	7/29/04	www.zbattery.com	Renata CR2032	$0.99	1	$0.99
CR2032	7/29/04	www.zbattery.com	Duracell DL2032B	$1.19	1	$1.19
CR2032	7/26/04	Walgreen's Pharmacy	Duracell "Medical"	$4.99	2	$2.50
CR2032	7/25/04	www.batteries.com	Energizer ECR2032 Coin Cell Battery	$5.09	1	$5.09
CR2320	7/25/04	www.batteries.com	Renata CR2320R Coin Cell Battery	$3.61	1	$3.61
CR2320	7/25/04	www.batteries.com	Energizer ECR2320 Coin Cell Battery	$5.09	1	$5.09
CR2325	7/25/04	www.batteries.com	Renata CR2325 Coin Cell Battery	$2.89	1	$2.89
CR2430	7/29/04	Www.zbattery.com	Duracell DL2430B	$1.29	1	$1.29
CR2430	7/25/04	Www.batteries.com	Energizer ECR2430 Coin Cell Battery	$3.89	1	$3.89
CR2450	7/29/04	Www.zbattery.com	Duracell DL2450B	$2.42	1	$2.42
CR2450	7/26/04	Walgreen's Pharmacy	Energizer	$2.99	1	$2.99
CR2450N	7/29/04	Www.zbattery.com	Renata	$1.50	1	$1.50
DL1/3N	7/29/04	Www.zbattery.com	Duracell (Note 1)	$3.73	1	$3.73
					Minimum	$0.33
					Maximum	$5.09
					Median	$2.99

1. DL1/3N 3V Li Button Battery used in Invisible Fence® brand Powercap® dog collars

Appendix D – Miniature (Non-Lithium) Batteries in Products

Note: The following list of products is a complement to the products reported to the Interstate Mercury Education and Reduction Clearinghouse (IMERC) Mercury-Added Products Database. [IMERC is a resource of the Northeast Waste Management Officials' Association (NEWMOA)]. Because the Maine DEP maintains a complete and updated summary of the IMERC data, the intent here is to use other sources to identify products using mercury-containing miniature batteries and perhaps identify products not captured in the IMERC database.

Tables:
Compact Fever Thermometers
Flashlights
Toys, Party Favors
Medical Products

Compact Fever Thermometers

Product	Mfr (or Source)	Product Description	Cost	*Batteries*
Omron 20 Second Flexible Digital Thermometer	Omron http://www.freemedicineprogram.com/category/Home+Diagnostics+%3E+Thermometers	Fast measurement in just 20 seconds. Flexible tip for added comfort and safety. Jumbo display for easy reading. Memory recalls last temperature. Measures Fahrenheit and Celsius. Automatic shut-off after 10 minutes. Battery included	$10.16	One 1.5V Button-type battery
TIMEX Accu-Curve Digital Thermometer Item/Pkg:MPT80002-EA	Mfr: Medport www.carepathways.com	Includes 1.5V button-type battery. TIMEX™ Accu-Curve Thermometer. Results in 30 seconds. Extra large digital display with INDIGLO® nightlight. Compact and lightweight. Mercury-free. Displays last temperature taken when Thermometer is turned on. Fahrenheit or Celsius. Unit comes with long-life battery, travel case, 5 disposable probe covers and instructions. Lifetime warranty.	$11.99	One 1.5V button-type battery

Flashlights

Product	Mfr (or Source)	Product Description	Cost	*Batteries*
Flashlight	Pelican www.pelican.com Pricing from http://hardinoptical.com	LED Flashlight #1930 L1 L1 LED Light provides a concentrated close quarter beam. Available in white, red or blue/green. Provides up to 50,000 hours of usage. Four replaceable LR 44 alkaline coin	14.95	4 LR44 batteries

		cells (included) offer up to 130 hours of battery life. Equipped with a neck lanyard and a handy push button on/off switch that can be used with only one hand. Water resistant (not for diving applications). You break it, we Replace it... forever.		
Mini-flasher	Pelican www.pelican.com Pricing from www.rei.com	Mini Flasher with red LED #2130 MINI FLASHER keeps track of joggers, hikers, children, pets and can identify equipment and campsites at night. Flashing LED lamp produces a light so powerful that is visible up to a .50 mile (800 m) for 130 hours. Submersible to 300 feet, the Mini Flasher is ideal for warning or emergency light. Small .56 oz (16 gr). Includes 2 coin cell batteries. You break it, we replace it... forever.	$10.95	2 alkaline coin

Toys, Party Favors

Note: Miniature batteries were typically found in novelty items that made noise or flashed lights.

Product	Mfr (or Source)	Product Description	Cost	*Batteries*
Dream Capsule Key Chain	Team Products, Inc. Phone: 877-227-5832 Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Key chain that lights up, bright changing colors. Includes 3 spare AG3 batteries.	$1.99	Uses 3 AG3 batteries (1.5V Energizer 392 or Duracell 392)
Sqooshy keychain Flashlight	Team Products, Inc. 877-227-5832 Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Flexible, gel-like translucent flower with what appeared to be a single LED Light, e.g. to illuminate keyhole at night. Battery must have been button.	$1.99	Did not specify battery. (Because of size & shape, had to be button or coin)
Glo-Wand ($1.99) Flashing Strobe Light	Team Products, Inc. 877-227-5832 Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Glo-Wand) Flashing Strobe Light keychain uses 3 batteries and includes 3 extra batteries	$1.99	3 LR 44 batteries
NeoGlo Light Show Strobe	Team Products, Inc. 877-227-5832 Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Strobe light on keychain uses 3 batteries and includes 3 extra batteries.	$1.99	3 LR 44 batteries
Pocket Strobe	Team Products, Inc. 877-227-5832 Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Keychain strobe light	$1.99	3 LR44 batteries
Milton Bradley "Perfection" electronic race car game	Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Compact electronic game uses 1 button cell battery	$12.99	1 button cell battery (type not specified)
Little Muscle	Seen at: Ocean State Job Lot,	Toy car uses 3 button cell	$3.99	3 button cell

Chevrolet	Marlboro, MA, 07/09/04	batteries to move eyes, mouth and make sounds, by Racing Champions Ertl (Plastic car ~8" long x 4"wx 6" h)		batteries (type not specified)
Light up gyroscope	Seen at: Ocean State Job Lot, Marlboro, MA, 07/09/04	Uses 2 button cell batteries for lights	$1.29	2 button cell batteries (type not specified)

Medical Products

Product	**Mfr (or Source)**	**Product Description**	*Batteries*
Electronic Stethoscope	ST3 (Starkey Laboratories, Minneapolis, Minnesota).	The ST3 (Starkey) is a Classic II (Littmann) stethoscope modified for people with hearing problems. The amplification system, powered by a 1.5-V button cell, is integrated into the tubing of the Littmann stethoscope. (Grenier et al)	1
Electronic Stethoscope	Labtron (Graham Field, Hauppage, New York	The amplification system of the Labtron is integrated into a large chest piece and the amplified sounds are transmitted into the acoustic tubing. It is powered by 4 1.5-V button cells (Grenier et al)	4
M2A Endoscopy capsule produced by Given Imaging Ltd.		http://batteriesdigest.com/id243.htm: One of these new devices is a battery powered diagnostic capsule which, after being swallowed, maps the human small intestine with a video camera. The views are transmitted to a belt mounted receiver carried by the patient. A second battery pack powers the data recorder worn by the patient as a belt pack. While ultra miniature semiconductors are heralded as the backbone of this unique investigational device, batteries in both the capsule and belt data recorder provide the power which makes the product possible. The capsule is shown being held in the fingers to illustrate its small size. It is swallowed to obtain detailed photos and streaming video of the small intestine. Equipped with illuminating light source, camera, processing electronics and data radio transmitter, the capsule is powered by two silver oxide primary batteries during its eight hour journey through the digestive system to provide pictures for medical diagnostics.	2 Silver oxide for capsule

Reference:
Grenier, Marie-Claude MSc; Gagnon, Katerie ID; Genest, Jacques Jr. MD; Durand, Jocelyn BEng; Durand, Louis-Gilles PhD, Clinical Comparison of Acoustic and Electronic Stethoscopes and Design of a New Electronic Stethoscope, The American Journal of Cardiology, Volume 81(5) 1 March 1998 pp 653-656

Appendix E: Description of Proposed European Battery Legislation

Reference: Proposal for a Directive of the European Parliament and of the Council on Batteries and Accumulators and Spent Batteries and Accumulators, Commission of the European Communities [SEC(2003)1343]
http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0723en01.pdf

In its "Proposal for a Directive of the European Parliament and of the Council on Batteries and Accumulators and Spent Batteries and Accumulators" (Proposal), the Commission of the European Communities outlines a plan for a major revision of its current battery recycling legislation. The Proposal is now making its way through the legislative approval process.

The European Communities' existing battery legislation, often referred to as the Battery Directives (Directive 91/157/EEC, amended by Commission Directives 98/101/EC and 93/86/EEC), includes batteries containing mercury, cadmium and lead. The Commission reports that the goal of the Directive, to reduce the use and environmental impact of these dangerous metals, has not been met.

The impetus for changing the legislation addressing the way batteries are handled came from the EU Sixth Community Environment Action Program (6EAP), which outlined environmental objectives and priorities for the decade starting in July 2002. The 6EAP identified the four specific objectives shown below and stipulated that the battery legislation would be one avenue used for supporting those objectives. The objectives include:

1. Reduce the overall quantity of waste generated, including both hazardous and non-hazardous categories (source reduction),
2. Encourage re-use of wastes,
3. Give preference to options for recovery and recycling over disposal, and
4. Minimize the quantity of waste for disposal and safely dispose of it.

(Reference: Proposal, p. 6)
The four objectives are consistent with the solid waste reduction hierarchy model, which prioritizes the environmentally sound strategies for municipal solid waste as:
Source Reduction – Reuse - Recycle & Compost – Dispose
(Reference: EPA Region 7, http://www.epa.gov/Region7/waste/solidwaste/index.htm).

In developing the Proposal, the Commission considered the following points:

- All batteries contain substances which are more or less harmful to the environment
- "All battery" collection schemes are more efficient than schemes that collect only specific battery types. In the European States a low collection rate is attributed to consumers having difficulty distinguishing between batteries covered by the current Directive (batteries with mercury, lead, and cadmium) and other general purpose batteries. (Proposal, page 17)
- All batteries contain metals that are recyclable, so recycling helps save resources.
- For consumer batteries, producers should finance the costs of the collection and treatment obligations at least from the collection point onwards.

To support the desired objectives, the Commission's Proposal lays out policy measures to divert all spent batteries from landfill and incineration and to ensure that member states adopt environmentally sound waste management practices that foster efficient collection and recycling of spent batteries and a proper function of the internal market. Member states are required to set up schemes to ensure that all batteries are collected for recycling and thus ensure a closed loop system for all batteries. The articles specify that within 4 years, member states shall achieve a minimum average collection rate equivalent to 160 grams per inhabitant per year for all spent portable batteries and accumulators (rechargeable batteries), including portable nickel-cadmium batteries.

Some key points of the Proposal:

- The Directive will apply to all batteries, excluding military batteries or batteries for equipment protecting essential interests of security of Member states, regardless of their shape, volume, weight, material composition or use.
- It is prohibited to market batteries which contain >0.0005% mercury by weight, except for button cells and batteries made up of button cells with a mercury content of no more than 2% by weight.
- Member States will promote research and development into increasing overall environmental performance of batteries throughout their entire lifecycle and will promote the marketing of batteries that contain smaller amounts of dangerous substance or contain less polluting substances, in particular as substitutes for mercury, cadmium and lead.
- The Commission shall establish detailed rules for monitoring the municipal solid waste stream and Member States shall report annually on waste statistics.
- Member States shall take the necessary measures to prevent the final disposal of spent batteries and to aim at achieving a closed loop system for all batteries.
- Member States shall ensure that schemes are set up under which spent batteries can be returned free of charge and collection facilities are available and accessible. When setting up collection schemes, the negative external impacts of transport will be taken into account.
- Within four years of implementing the legislation, Member States shall achieve a minimum average collection rate equivalent to 160 grams per inhabitant per year for all spent portable batteries and accumulators (rechargeable batteries), including portable nickel-cadmium batteries. (Portable means a battery used in household applications, cordless power tools, emergency lighting and electrical and electronic equipment or other applications by either consumers or professional users).
- Member States shall ensure producers or third parties acting on their behalf achieve recycling efficiencies of 55% by average weight of the materials contained in batteries, other than lead-acid batteries (65% efficiency) and nickel-cadmium batteries (75% efficiency).
- Member States shall ensure that producers or third parties acting on their behalf arrange the financing for at least the treatment, recycling, and sound disposal of all spent portable batteries deposited at collection facilities.

Appendix F – Interviews With Representatives of United States Recycling Programs

A sampling of four recycling programs in the United States was identified for phone interviews. The interviews were held with representatives of two counties in the United States, a town in Massachusetts and a municipal waste provider serving 69 communities in the Northeast, all of which oversee recycling programs that include miniature batteries. The four programs were selected because of some combination of their ability to provide data, longevity and/or breadth of the program, and ability to provide a cogent overview of their experience.

Each representative was asked about how his or her program operates, the amount of miniature batteries collected, recycling costs, and safety concerns. The following paragraphs discuss the findings and a summary is shown in Tables F.1 and F.2.

2 Counties and 1 Town - The town and counties represented in our interviews have collection sites or containers set up in multiple areas in the town or regions. A major city in one of the counties also provides curbside pickup of miniature and other dry cell batteries. Miniature battery collection containers (typically cardboard boxes) fall under the universal waste rule and are collected within 1 year. Batteries from the boxes are often consolidated into a pail or larger container and then shipped for sorting and recycling.

Safety concerns - While each of the representatives had heard of fire hazards associated with lithium battery collection, no one systematically addresses this concern at the community collection points. One of the counties has an intermediary sort and consolidate miniature batteries, and the poles of the lithium batteries are taped (electrically insulated) at that stage prior to shipment to the recycler. None had experienced a problem with heat, smoldering or fire in the community collection containers. No one was aware of any safety problems that had arisen in his or her miniature battery collection programs, either related to electrical safety or the potential for batteries being mishandled, such as children removing batteries from collection containers.

Recycling effectiveness – Miniature cell battery recycling is voluntary. Each of the representatives cited the difficulty in getting the target population engaged in recycling miniature batteries. One county representative has perceived a leveling or even a slight decrease in recycling volumes, which is counterintuitive to her perception that more products contain miniature batteries and hence volumes should be increasing. She noted that this may reflect a need for renewed outreach to the public. The Recycling Coordinator in the town interviewed has had very favorable results working with merchants on recycling programs, so that when a product (such as a miniature battery or fluorescent bulb) is brought in for replacement, the merchant takes the spent product for recycling. The Recycling Coordinator has engaged the local camera shop on recycling batteries and she estimated that the camera shop was the source of approximately 80% of the miniature batteries collected. The coordinator calls the camera shop about a month before a battery pickup and the camera shop turns the batteries in to the town.

Table F.1. Summary of Interviews

Location	Comments	Cost for Recycling Miniature Batteries
County in Midwest Population of 1,112,259 in county	Mixed button batteries are collected in small cardboard boxes provided by the County at 176 locations throughout the county and there are an additional 166 locations with larger 30-gallon containers that collect mixed button batteries and larger dry cell batteries. There is curbside battery recycling in one city, and batteries are also removed from electronics collected via the consumer electronics program. Battery collection sites include public and private sites, such as city halls, county buildings, drug stores, health care facilities, hardware stores, jewelers, libraries, photo stores, retail stores, senior apartment complexes and senior organizations. A courier collects and replaces the recycling boxes and delivers full box to a business that sorts and consolidates batteries. Sorted batteries are shipped to a recycling contractor. The program is funded by the county.	$5.05/pound ~876 pounds/year recycled = $4424/year This is estimated to be ~560,640 miniature batteries. [Note]
County in Northeast ~150,000 people covered by County Solid Waste District	Batteries are collected by the District at a permanent hazardous waste facility, 8 drop off centers, and a mobile facility called the Rover that visits rural towns and cities from March-October. A truck collects batteries from each site and brings it to the main hazardous waste facility where the collected batteries are aggregated for shipment to the recycler. Recycling is paid for by a tax on the trash.	$2.50/pound ~60 pounds/year recycled = $150/year This is estimated to be approximately 38,400 miniature batteries, of which ~22% are lithium. [Note]
Massachusetts Town Town population of 17,000	Containers are scattered around the town, e.g. library, town house, Council on Aging. The Town Recycling Coordinator collects the batteries and they are taken with the fluorescent bulbs pickup by Onyx (formerly Superior Special Services). Onyx subsequently sorts the batteries and tapes the Lithium miniature batteries. Note: Onyx/Superior Special Services is the state-contracted mercury material recycling firm and they will accept mixed batteries from Massachusetts municipalities and businesses for recycling and/or safe management at the state negotiated price. (per State contract number ST7J211). State contract cost for recycling: $0.65/pound for alkaline batteries, $3.50/pound for mercury batteries, $2.50/pound for silver oxide, $3.50/pound for lithium batteries, and $0.20/pound for sorting.	Town contract with solid waste hauler includes $2000/year in their contract allocated for all recycling. (Contract applies to households only; businesses arrange their own waste removal).

[Note] This is based on the estimate of 640 miniature batteries/pound, described in the next section.

Municipal Waste Combustor (MWC) – Wheelabrator runs three municipal waste combustion facilities in the state of Massachusetts that currently serve 69 communities under long term waste contracts. The Massachusetts Department of Environmental Protection (DEP) requires that owners and operators of MWCs submit a material separation plan (MSP) and run a program for the diversion of mercury-bearing products from municipal solid waste. Wheelabrator's mercury effort is subcontracted to and run by Pat Scanlon of Scanlon Associates, who was interviewed for this report.

The goal of the Wheelabrator MSP is to attempt to divert mercury-containing products from the municipal solid waste stream and to provide its communities with resources for proper disposal and recycling of mercury-containing products. To fund the mercury effort, $0.50/ton is

set aside from the contracted tipping fees charged to the communities. One of the programs offered to the Wheelabrator communities is miniature battery recycling; participation is voluntary. The operation is similar to the town and counties described above, with battery collection boxes provided and placed around the communities that have chosen to participate in the program. Wheelabrator provides collection boxes to participating communities and it is a community's responsibility to distribute and monitor the boxes, then place batteries with other mercury devices for collection. A Wheelabrator service provider picks up and sorts a full bucket of mercury products. Batteries are weighed and consolidated in a 55 gallon drum that is sent for recycling. Scanlon noted that he has collected hundreds of thousands of miniature batteries over the past decade and that he uses an estimate of 640 miniature batteries per pound to convert from pounds collected to number of batteries.

Safety concerns - Scanlon has never observed or received feedback about safety concerns related to miniature battery collection in communities.

Recycling effectiveness – Although all of the towns contracting with Wheelabrator pay for the mercury programs, very few take advantage of miniature battery recycling. Successful recycling requires a strong volunteer base to manage and champion the program locally. It was noted that one city stands out for its high participation relative to other Wheelabrator communities, and Scanlon attributes this to the high visibility the miniature battery recycling program receives. For example, the city has a guess-the-number contest at the library, in which visitors can guess the number of miniature batteries collected and displayed in a fish bowl. Prizes are given out at the mayor's office and the contest receives good press. Without high visibility and a strong local effort, however, miniature battery recycling lacks vitality.

Table F.2. Summary of Interview with Mercury Program Coordinator

Wheelabrator, Owns and operates 3 municipal waste combustors in Massachusetts	Wheelabrator contracts with Pat Scanlon of Scanlon Associates to manage their mercury control efforts. Scanlon develops and administers the Material Separation Plan for mercury, which includes voluntary programs for miniature battery recycling. Scanlon estimates there are approximately 640 miniature batteries per pound.	**Wheelabrator North Andover Inc.** [Note 1] FY 2002 –2003 budget of $6000 for Miniature Battery Collection. 2003: collected 31,360 miniature batteries from 4 participating communities (of 23 communities in consortium, representing a total population of 454,222) **Wheelabrator Millbury** [Note 2] FY 2002-2004 budget of $6000 for Miniature Battery Collection 2003: Collected 1920 batteries [Note 3] from 1 participating community (of 36 communities in consortium, representing a total population of 663,598) **Wheelabrator Saugus J.V.** [Note 4] FY 2004-2006 budget of $1000 for a Miniature Battery Collection 2003: Collected 9920 batteries from 3 participating communities (8 communities in consortium, representing a total population of 311,036)

Notes:

[1]*Reference: Material Separation Plan for the Diversion of Mercury (MSP2) July 1, 2002-June 30, 2004, Wheelabrator North Andover Inc., North Andover, MA (March 2002)*

[2]*Reference: Material Separation Plan for the Diversion of Mercury (MSP2) July 1, 2002 – June 30, 2004, Wheelabrator Millbury Inc., Millbury, MA. (March 2002)*

[3]*Scanlon noted the need to average battery collection over several years. For example, this town presently has ~20,000 miniature batteries queued up for collection.*

[4]*Reference: Material Separation Plan for the Diversion of Mercury (MSP3) July 1, 2004 – June 30, 2006, Wheelabrator, Saugus J.V., Saugus, MA (March 2004)*

Appendix G - Recycling in Europe

A web search was conducted and information was sought from the Commission of European Communities and ChinaBattery Online (Chinese battery industry web site) about miniature battery recycling programs in their regions, environmental legislation related to miniature batteries and disposal, and any associated health and safety concerns. The Commission responded to the request for information by directing us to existing and pending environmental legislation and informative support documentation. They did not offer any insight on health and safety concerns. No response was received from ChinaBattery Online and other searches did not yield additional substantive information about recycling outside the U.S. Our discussion therefore is limited to the European Union (EU) and its member states.

The Commission of European Communities uses terminology slightly different from the terminology of this report. In the following paragraphs, the Commission's term "button cell" is equivalent to the term miniature battery used in the rest of this report: "'button cell'... means a small round battery... whose diameter is greater than its height and which is used to special purposes such as hearing aids, watches and small portable equipment." (Reference: Commission of the European Communities, 2003, page 38). Button cells, per the Commission's description, are mainly zinc air, silver oxide, manganese oxide and lithium batteries.

The Commission of European Communities is cognizant of the adverse environmental impact of button cell batteries: "The biggest part of current mercury emissions from batteries in the EU originates from special purpose mercury button cells". (Reference: Commission of the European Communities, 2003, page 10). The EU's existing battery legislation is "Council Directive 91/157/EEC on batteries and accumulators containing certain dangerous substances, as amended by Commission Directive 98/101/EC". (Reference: The Council of European Communities, Council Directive 91/157/EEC, as amended by commission Directive 98/101/EC).
Key points of this legislation include:

- There is a prohibition on marketing batteries containing more than 0.0005% mercury from January 2000 onwards. Button cells with a mercury content of no more than 2% by weight and batteries composed of multiple button cells are exempted from this marketing restriction but all other requirements of the Directive still pertain to the button cells.
- Member States must ensure the collection separate from household waste of the batteries covered by the Directive, with a view to their recovery or disposal;
- Batteries covered by the Directive must be marked to indicate the heavy metal content, requirement for separate collection, and recycling, where appropriate
- Member States must establish four-yearly programs (programs over four years) designed to 1) reduce the heavy metal content of batteries, 2) promote the marketing of batteries containing smaller amounts of dangerous substances and/or less polluting substances, 3) foster a gradual reduction of spent batteries in household waste, 4) promote research into more benign batteries and better recycling methods, and 5) achieve separate disposal of spent batteries.
- Member States shall ensure efficient and separate collection systems for batteries.

The Commission reports that in practice the Directive has had limited success because it does not delineate clear, measurable guidelines for preventing uncontrolled disposal into the

environment. As a result States have taken divergent approaches, results vary widely from state to state and the overall collection efficiency of spent batteries in the Member States is low. Many batteries are still landfilled or incinerated, instead of being collected and recycled. In a report commissioned by the European Commission Directorate General Environment, BIO Intelligence Service estimated the current situation for sales and recycling of button batteries in Europe in 2002 at 15%, as shown in the following Table G.1. (Reference: BIO Intelligence Service, 2003).

Table G.1: European Sales and Recycling of Button Batteries
Europe, including EU-15, CH, N (Note 1)

Year	*2002*
Button Battery Sales	373 tonnes (Note 2)
% of portable battery market(Note 3)	0.2%
Average annual growth rate	1%
Spent batteries available for collection(Note 4)	
Entering a recycling plant	**38 tonnes (15%)**
Disposed with municipal solid waste	215 tonnes (85%)
Total	253 tonnes (100%)

Notes
[1] European Union-15 (EU-15): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
Norway (N) and Swiss Confederation (abbreviated CH, for Confederatio Helvetica, the Latin version of the official name)
[2] 10% of this total is estimated to be sold in Electrical and Electronic Equipment (EEE)
(Ref: BIO Intelligence Service, "Impact Assessment on Selected Policy Options for Revision of the Battery Directive, Final Report, July 2003, page 50)
[3] "Portable battery..." means a battery... used in household applications, cordless power tools, emergency lighting and electrical and electronic equipment or other applications by either consumers or professional users. (Proposal, page 38)
[4] Reference: BIO Intelligence Service, 2003, page 54

Estimates of recycling costs for button cell battery recycling in 2002 are available for France and Belgium:

Table G.2: Recycling Costs

Country	Recycling Cost	Equivalent cost in U.S. units
France	2600 Euros/tonne	~$1.45/lb
Belgium	4000 Euros/tonne	~$2.25/lb

Note: 2204 lbs/metric tonne
Reference: (BIO Intelligence Service, 2003, p. 65, 201, 200)

The Commission currently has a proposal for a major restructuring of its battery legislation that is making its way through the legislative approval process. If approved, this will have a significant impact on many miniature battery aspects including manufacturer responsibility, battery design/composition, pricing and recycling. A description and discussion of the proposed legislation is included in Appendix E.

Appendix H – Data on Battery Ingestions

Data show that miniature battery ingestions represent 0.1% of exposures reported to poison control centers. In 2002 about 10 people had a major medical outcome (life-threatening or significant residual disability or disfigurement) from ingesting miniature batteries. It is estimated that approximately 60% of battery ingestions occur immediately after removal from a product or with batteries taken directly from the package. The remaining battery ingestions involve batteries lying loose, sitting out or discarded.

Data related to battery mishandling are shown below. One valuable source of information is the Toxic Exposure Surveillance System (TESS) data, compiled annually by the American Association of Poison Control Centers (AAPCC), in cooperation with the majority of US poison centers. Another source of information is from Georgetown University Hospital's National Capital Poison Center and its National Button Battery Ingestion Hotline and Registry.

TESS data represents human exposure cases reported to a central registry by participating poison control centers. AAPCC uses the term "disc batteries" for miniature batteries. The following table shows the contribution of disc battery ingestions to the total for the past 5 years.

Table H.1. Exposures Reported to Poison Control Centers

Year	All Exposures	All ingestions	Disc Battery Ingestions	Disc batteries as % of all exposures	Disc batteries as % of all ingestions
2002	2,380,028	1,900,816	2611	0.11%	0.14%
2001	2,267,979	1,807,448	2005	0.09%	0.11%
2000	2,168,248	1,729,950	1804	0.08%	0.10%
1999	2,201,156	1,731,553	1939	0.09%	0.11%
1998	2,241,082	1,749,792	2063	0.09%	0.12%

Reference: Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System for 1998, 1999, 2000, 2001 and 2002

The 1998 TESS data was also analyzed and presented as Pediatric Exposures to Non-pharmaceuticals and Pharmaceuticals. The following table shows the relative contribution of disc batteries to the pediatric exposures; also at 0.1% of all exposures.

Table H.2. 1998 Pediatric Exposures (< 6 yrs) Reported to Poison Control Center

Year	Pediatric Exposures (<6 yrs) category	Exposures	Disc Battery Exposures	Disc batteries as % of exposures
1998	Non-pharmaceuticals	731,407	1252	0.2% of non-pharmaceuticals
	Pharmaceuticals	477,452		
	Total pediatric exposures	1,208,859		0.1% of all pediatric exposures

1998 Pediatric Exposures, http://www.aapcc.org/poison1.htm

The TESS reports also show that for most cases of disc battery ingestions the medical outcomes were reported as "none", but each year there are a small number of ingestions with serious outcomes

Table H.3. Medical Outcomes of Disc Battery Ingestions[Note]

Year	Outcome reported as "none"	Outcome reported as "minor"	Outcome reported as "moderate"	Outcome reported as "major"	Outcome reported as "death"
2002	86.8%	10.1%	2.7%	0.4%	0%
2001	88.3%	8.6%	2.9%	0.2%	0%
2000	88.8%	8.1%	2.6%	0.6%	0%
1999	90.1%	7.7%	1.9%	0.3%	0%
1998	90.2%	7.1%	2.1%	0.5%	0.1%
1998 Pediatric Expos.	92.7%	5.3%	1.3%	0.7%	0%

Medical Outcome Categories

No effect: The patient developed no signs or symptoms as a result of the exposure.

Minor effect: The patient developed some signs or symptoms as a result of the exposure, but they were minimally bothersome and generally resolved rapidly with no residual disability or disfigurement. A minor effect is often limited to the skin or mucous membranes.

Moderate effect: The patient exhibited signs or symptoms as a result of the exposure that were more pronounced, more prolonged, or more systemic in nature than minor symptoms. Usually some form of treatment is indicated. Symptoms were not life-threatening and the patient had no residual disability or disfigurement.

Major effect: The patient exhibited signs or symptoms as a result of the exposure that were life-threatening or resulted in significant residual disability or disfigurement.

Death: The patient dies as a result of the exposure or as a direct complication of the exposure.

Note: This represents the percentage of known outcomes

References:

Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System for 1998, 1999, 2000, 2001 and 2002

1998 Pediatric Exposures, http://www.aapcc.org/poison1.htm

In another perspective on battery ingestions, Dr. Toby Litovitz and Barbara Schmitz analyzed 2382 cases of battery ingestions reported to the National Button Battery Ingestion Hotline during the 7 year period of July 1983 through June 1990. (Litovitz and Schmitz) (Note: The National Button Battery Ingestion Hotline and Registry was established in 1982 at Georgetown University Hospital's National Capital Poison Center. This is one of the Poison Centers that participates in the AAPCC TESS program described above. It services areas of Washington, DC, Virginia, and Maryland). Of the 2383 cases, 62 were standard cylindrical cells (e.g. AAA, AA, A, etc.) and the remaining 2320 were miniature cells. For 2034 cases where the battery ingestion scenario and source were determined, Litovitz and Schmitz found the following trends:

Table H.4. Ingestion Timing & Battery Discharge State

%	When Ingestion Occurred (n=2034)
52.5%	Immediately following removal
41.4%	Involved batteries which were loose, sitting out, or discarded

5.4%	Batteries obtained directly from packaging
Battery Discharge State (n=1800)	
66.4%	Partially Spent
17.8%	Spent
15.8%	New cells

Table H.5. Common Uses of Batteries that were Ingested

%	Use
44.6%	Hearing Aids
16.1%	Watches
13.6%	Games and Toys
9.3%	Calculators
3.7%	Camera Equipment
3.2%	Beeping or lighted key chains
2.5%	Clocks
1.4%	Remote Control Devices

They also found that in 312 (32.8%) of the 952 cases where the battery was intended for use in a hearing aid, the battery was actually removed by the child from the child's own hearing aid. (These 312 cases represent 15% of overall ingestions). In 8.5% of the battery ingestions, more than one battery was ingested (table below). Suicidal intent was implicated in 1.3% of battery ingestions (31 cases) and nine individuals ingested batteries while in prison or to avoid incarceration.

Table H.6. Number of Batteries Ingested

# Batteries Ingested	# Patients
2 batteries	153 patients
3 batteries	20 patients
4-6 batteries	19 patients
7-9 batteries	5 patients
11-36 batteries	5 patients

The National Capital Poison Center (where this study was done) has an online fact sheet "Swallowed a Button Battery?" (http://www.poison.org/prevent/battery.asp) that describes what to do and presents facts about miniature battery ingestions.

In addition to ingestion of miniature batteries, the literature also describes cases in which miniature batteries have been placed in the ear or nose. All of these data points attest to the fact that the choice to use miniature battery powered devices comes with the need to manage the associated risk of battery mishandling. (Lin et al, Strachan et al, Alvi et al, Ansley et al, Brown and Dannenberg)

Appendix I - Adverse Environmental Impact of Collecting and Transporting Batteries for Recycling

The business community has raised concerns that collecting and transporting batteries may have greater detrimental environmental impacts than benefits gained from recycling batteries. It is beyond the scope of this report to assess the net effect (positive or negative) of all upstream and downstream environmental costs associated with miniature battery recycling, however it is worth noting the following points.

- In most recycling programs, miniature batteries are not the sole waste being collected or the only container being transported. Miniature battery recycling typically takes place in the context of larger recycling programs, to the advantage of the overall effort. For example, Wheelabrator collects and transports miniature batteries with other mercury containing devices (e.g. thermostats, thermometers, barometers) from its participating towns. For the miniature battery collection in dedicated boxes or buckets, shipping is by United Parcel Service or common package carriers to the recycling center thus utilizing existing efficient methods of transportation.
- As recycling becomes more widespread and recycling volumes increase, economies of scale will be reflected in more efficient, cost effective options for collection, transportation and recovery processes.
- Recycling provides the opportunity to avoid external costs that are usually paid for by society in the form of cleanup costs, environmental deterioration, or adverse health effects. Metals in the spent batteries that might normally be lost to disposal can be recycled and put back into products. Other substances such as acids, salts, and plastics will be diverted from the waste stream and managed appropriately. Potential air and water pollution and other environmental impacts from incinerating or landfilling the spent batteries can be avoided, ultimately translating to reduced human exposures and abatement costs. (Reference: Commission of the European Communities, 2003, page 22)
- A major component of miniature batteries is metal, including steel, nickel, tin and zinc. Recycling of miniature batteries can put metals back into the supply chain and potentially offset the mining of virgin metals. According to the Environmental Protection Agency (EPA), extraction and refining of metals produces significant amounts of waste and byproducts. Environmental impacts are extensive, including: erosion, vehicle exhaust, dust, acid rock drainage, loss of habitat, loss of fish, plant, and water fowl population, and structural damage from blasting. (Reference: EPA Sector Notebook; Profile of the Metal Mining Industry). The North American Steel Recycling Institute estimates that "every ton of steel recycled saves 2,500 pounds of iron ore, 1,400 pounds of coal, and 120 pounds of limestone." (Reference: The Steel Recycling Institute, Fact sheet)

Our study also included the review of two European documents that consider adverse environmental impacts of battery recycling: the Commission of the European Communities "Proposal for a Directive of the European Parliament and of the Council on Batteries and Accumulators and Spent Batteries and Accumulators" [SEC(2003) 1343)] and the United Kingdom (UK) Department of Trade and Industry (DTI)-commissioned report "Analysis of the Environmental Impact and Financial Costs of a Possible New European Directive on Batteries"

(Reference: Environmental Resources Management, 2000). The first document, which is discussed in Appendix E, outlines proposed legislation for member states of the European Economic Community and the latter document was prepared in anticipation of the proposed legislation to help the UK prepare its response to the legislation when it was unveiled. (Note: The DTI is a government group that works to create an environment for business success and to champion UK business at home and abroad.)

The Commission Proposal outlines a rationale for amending legislation and heightening control of waste batteries. The Commission's assessment is that recycling all batteries will have an overall favorable effect on the environment. The Proposal specifically aims to: 1) manage the risks of the hazardous materials used in batteries and their contribution to air emissions, polluting incinerator residues, and landfills and 2) contribute to resource savings by re-introducing battery metals into the economic cycle. These are strategic points because environmental concerns of batteries are mainly due to the materials they contain, and the main environmental impacts occur during the production and waste management phases. Batteries are viewed as an ore of secondary raw materials, and the Proposal notes that the metallic content of a zinc ore (15%) is comparable to the zinc content of some batteries (20%). (Reference: Commission of the European Communities, 2003, page 15) The positive environmental impacts of recycled metals versus virgin metals can be seen in reduced energy use and reduced pollution related to the avoidance of mining of the virgin metal. An example is cited for zinc, showing that the relation of energy needed for recycling and energy needed for extraction from primary sources is 2.2 to 8. Use of recycled metals is particularly significant because primary production of metals is the source of approximately 10% of the global CO_2 emissions. (Reference: Commission of the European Communities, 2003, page 15)

The November 2000 report "Analysis of the Environmental Impact and Financial Costs of a Possible New European Directive on Batteries" was commissioned by the Department of Trade and Industry to assist the Department in preparing a Regulatory Impact Assessment and to support the UK's negotiating stance during the passage of the proposed Directive. (Reference: Environmental Resources Management, 2000) At the time the report was done, the Directive had not been made public and the researchers speculated on its likely content in order to conduct their study. This study concluded that the environmental impact of battery recycling outweighed the benefits of material recovery, but it did not substantiate its conclusion. Instead there was merely a very general statement that adverse environmental impacts (due to collection, transportation and recycling processes) associated with increased recycling "are offset only to a limited extent by the avoided impacts associated with the recovery of materials through recycling". (Reference: Environmental Resources Management, 2000, page 14)

APPENDIX C

Request for Public Comment

Responses to Comment Request

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JOHN ELIAS BALDACCI
GOVERNOR

DAWN R. GALLAGHER
COMMISSIONER

November 24, 2004

Request for Comment on Mercury Use in Batteries

Dear Reviewer:

Manufacturers have eliminated the use of mercury in most household batteries but mercury still is used in button cell batteries. U.S. battery manufacturers report they used over 5000 pounds of mercury in button cells sold in the U.S. in 2002, about 1000 pounds more than reported for 2001. We do not know how much mercury enters U.S. commerce in foreign-made button batteries, but the total could be high given the large number of foreign-made products that contain button batteries.

Earlier this year, the Maine Legislature passed a law that requires this department to review the use of mercury in button batteries and report back by January 14, 2005. To assist in preparation of the report, we retained the services of the Lowell Center for Sustainable Production (LCSP). The LCSP was asked to:

- Estimate the amount of mercury used annually in the manufacture of button batteries;
- Identify and evaluate nonmercury alternatives; and
- Investigate button battery recycling programs.

LCSP has completed its draft report "An Investigation of Alternatives to Miniature Batteries Containing Mercury." A copy is enclosed for your review and comment.

Among other things, LCSP found that manufacturers are beginning to introduce mercury-free versions of the three miniature battery types in which mercury currently is used, including the zinc-air batteries used in hearing aids. Hearing aid batteries accounted for over 85% of the mercury in button batteries sold by US manufacturers in 2002.

The LCSP findings also suggest that collection of button cell batteries for recycling is feasible and affordable, and will become more efficient and cost effective if recycling becomes more widespread. LCSP examined alleged fire safety and ingestion concerns associated with collecting spent button batteries for recycling but found no evidence of an elevated fire or swallowing hazards in the few jurisdictions that currently have programs to recycle batteries.

Based on the LCSP findings, our report to the Maine Legislature likely will recommend one of

AUGUSTA
17 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0017
(207) 287-7688
RAY BLDG., HOSPITAL ST.

BANGOR
106 HOGAN ROAD
BANGOR, MAINE 04401
(207) 941-4570 FAX: (207) 941-4584

PORTLAND
312 CANCO ROAD
PORTLAND, MAINE 04103
(207) 822-6300 FAX: (207) 822-6303

PRESQUE ISLE
1235 CENTRAL DRIVE, SKYWAY PARK
PRESQUE ISLE, MAINE 04769-2094
(207) 764-0477 FAX: 764-1507

web site: www.maine.gov/dep

two strategies to reduce mercury emissions from batteries: 1) a ban on the sale of mercury-added batteries; or 2) a ban on their disposal.

- A ban on the sale of mercury-added batteries. The most effective strategy for eliminating mercury emissions from batteries is to use mercury-free batteries. The LCSP report shows that several mercury-free miniature batteries are commercially available. Perhaps most encouraging is the recent introduction of mercury-free models for all three miniature battery formulations--zinc air, silver oxide and alkaline manganese--that currently use mercury. Because these mercury-free models are new to the marketplace, data on their long-term performance is lacking. Manufacturers are confident, however, that the performance characteristics of the mercury free batteries will prove to be comparable to mercury-added models.

  While production currently is limited, the mercury-free technology can be expected to quickly become the worldwide standard. Maine and other states could hasten the transition by banning the sale of mercury-added batteries as has been done previously with mercury switches, relays, thermostats, thermometers and other mercury-added measuring devices. The effective date of the ban should be set to give the industry time to develop sufficient production capacity and to ensure that hearing aid users in particular will have access to mercury free replacement batteries. An effective date of January 1, 2008 would provide almost three years for battery manufacturers to make production adjustments.

- A ban on the disposal of mercury-added batteries. As an alternative to an outright ban on the sale of mercury-added batteries, the Maine Legislature could add batteries to the definition of mercury-added product under 38 MRSA § 1661. This would have the effect of making batteries subject to the ban on disposal of mercury-added products under section 1663 and the labeling requirement under section 1662.

  While labeling of the button cell itself may not be practical because of its small size, labeling of the battery packaging and stacked button cell batteries will help consumers identify which batteries contain mercury so they can be kept out of the trash and recycled. A stacked button cell battery is a cylindrical battery comprised of a stack of button cells. Stacked cell batteries are used in applications that require a higher voltage such as remotes for garage door openers.

  A disposal ban will require that provision be made to collect the batteries for recycling, raising the issue of how this should be done and who should be responsible. Municipalities traditionally have provided most waste disposal and recycling services, but policy makers increasingly are turning to manufacturers to share the cost of handling wastes that have toxic components like mercury. This approach is attractive because it shifts costs from municipal solid waste budgets to the marketplace. If manufacturers must pay the costs of safely managing any mercury in the product, they have a powerful incentive to redesign the product to eliminate the use of this toxic substance.

  We likely will recommend that manufacturers share responsibility for putting an effective collection system in place if the Maine Legislature decides to ban the disposal of mercury-

added batteries. Maine law at 38 MRSA §2166(3) provides one possible approach. That law requires manufacturers of mercuric oxide or rechargeable batteries to do the following:

- Establish and maintain a system for the proper collection, transportation and processing of the batteries for purchasers in this State;
- Clearly inform purchasers of the batteries of the prohibition on disposal and the available systems for proper collection, transportation and processing; and
- Include the cost of collection, transportation and processing of the waste batteries in the battery sales price.

Through this letter, the department seeks your comment on the findings and conclusions in the enclosed draft report by LCSP. In addition, we seek your input regarding the two mercury reduction strategies outlined above, including whether either strategy would result in hardships or consequences for particular users and your ideas about how the proposed strategies could be improved.

To ensure we have time to fully consider your comments in preparing our final report to the Legislature, we must receive them by December 10, 2004. Our final report is due by January 14, 2005.

I look forward to hearing from you on this important matter. If you have any questions about the report, please feel free to contact me at 207 287-7866.

Sincerely,

John James

John James

Mail list for comment request on button battery report

Michael Anderson
Eastman Kodak Company
1669 Lake Ave
Rochester, NY 14652

Michael H. Babiak
Eveready Battery Company
25225 Detroit Rd
Westlake, OH 44145

Michael Belliveau
EHSC
PO Box 2217
Bangor ME 04402-2217

Michael Bender
Mercury Policy Project
1420 North St.
Montpelier VT 05602

Jeffery Blauner
Mary Meyers
P.O. Box 275
Townshend VT 05353

Jennifer Burns
Maine Audubon Society
20 Gilsland Farm Rd.
Falmouth, ME 04105

Ellie Clark
1200 Pennsylvania Ave, NW
MC-7404T
Washington DC 20460

Emilio G. Collardo III
American Watch Association
P.O. Box 464
Washington DC 20044

Bruce Connor
JA-RU Inc. and JA-RU (HK) Limited
4030 Philips Highway
Jacksonville FL 32207

Senator Scott Cowger
RR1, Box 1145
Hallowell ME 04347

Stephanie D'Agostino
Department of Environmental Services
6 Hazen Drive
Concord NH 03301

Representative Robert A. Daigle
197 Mountain Rd
Arundel ME 04046

Jan DeVinney
Division of Deafness
SHS 105
Augusta ME

Kevin Domack
Rayovac Corporation
601 Rayovac Dr
Madison, WI 53744

Ric Erdheim
NEMA
1300 17th Street, Suite 1847
Rosslyn VA 22209

Carol Fuller
AVCOG
125 Manley Rd
Auburn ME 04210

John Gilkeson
MOEA
520 Lafayette Road North
St Paul MN 55144-4100

Robert Jay Glickman
K'NEX Industries, Inc.
2990 Bergey Rd
Hatfield PA 19440

Freddy Gochuico
TMX Philippines, Inc (Timex)
Mactan Export Processing Zone 1
Lapu-Lapu City, Cebu
Philippines, 6015

Terri Goldberg
NEWMOA
129 Portland Street, 6th floor
Boston, MA 02114

Linda Greer
NRDC
1200 New York Ave NW, Suite 400
Washington DC 2005

Jon Hinck
Natural Resources Council
3 Wade Street
Augusta ME 04330-6351

John W. Holzwarth
The Little Tikes Company
2180 Barlow Rd
Hudson OH 44236

Gary Jones
Radica China Ltd.
13628-A Beta Rd
Dallas TX 75244

Henry Kessler
Renata Consumer Batteries
10455 Olympic Dr
Dallas TX 75220

Karen Knaebel
Department of Environmental Conservation
103 South Main Street, Laundry Building
Waterbury, VT 05671-0411

Mr. Fergus Lea
AVCOG
125 Manley Rd.
Auburn ME 04210

David Lennett
PO Box 71
Litchfield ME 04350

Dr. Toby Litovitz
National Capital Poison Center
3201 New Mexico Ave, Suite 310
Washington DC 20016

Pat Loehr
RadioShack Corporation
300 RadioShack Circle, Mailstop EF3-337
Fort Worth, TX 76102-1964

George MacDonald
State Planning Office
38 SHS
Augusta ME 04333

Senator John Martin
Church St.
PO Box 250
Eagle Lake ME 04739

Rob McLerran
Selco Custom Time Corp.
8909 East 21st Street
Tulsa, OK 74129

Tom Metzner
Department of Environmental Protection
79 Elm Street
Hartford CN 06106-5127

Beverly Migliore
Department of Environmental Management
235 Promenade Street
Providence RI 02908

Gerry Mirabile
358 Jones Hill Rd.
Appleton ME 04862

Charles Monahan
Panasonic Industrial Co.
2 Panasonic Way, 7A-2
Secaucus NJ 07094

Anthony Paolo
The First Years
1 Kiddie Dr
Avon MA 02322

Dana Peck
Hussey Seating
631 Curtis Rd.
Arundel, ME 04046

David B. Perlman, Esq.
Citizen Watch Company of America
1200 Wall Street West
Lyndhurst, NJ 07071

Robert W. Phelps
Conservation Lighting
84D Warren Ave.
Westbrook Me. 04092

Amy Roering
Hennepin County
417 North Fifth St, Suite 200
Minneapolis MN 55401

Monica Roll
Duracell
Berkshire Corporate Park
Bethel CT 06801

Thomas F. Rossiter
Seiko Corporation of America
1111 Macarthur Blvd.
Mahwah NJ 07430

Dr. Sydney R. Sewall
Box 229
Hallowell, ME 04347

Robert A. Shapiro
Casio, Inc.
570 Mt. Pleasant Ave.
Dover NJ 07801

Karen Simone
NNE Poison Center
190 Park Avenue
Portland ME 04102

Douglas Smith
Sony Electronics Inc.
16450 West Bernardo Dr
San Diego, CA 92127

Richard F. Tozer
2911 Turtle Creek Blvd, Suite 300
Dallas TX 75219

Kim Vandermeulen
Route 5, Box 1800
Augusta Me 04330

Brian Wong
Gold Peak International Limited (GP)
8/F Gold Peak Bldg, 30 Kwai Wing Rd
Kwai Chung N.T.
Hong Kong

VIA FACSIMILE AND ELECTRONIC MAIL

December 9, 2004

John James
Policy and Procedures
Department of Environmental Protection
17 State House Station, Augusta, ME 04333

RE: Letter to Maine DEP regarding the Lowell Center's November 2004 report entitled "Investigation of Alternatives to Miniature Batteries Containing Mercury."

Dear John,

Thank you for the opportunity to comment on the merits of the Lowell Center Report. We have thoroughly reviewed it and would like to provide the Department with the following comments:

Overall, this report is a very thorough and clear presentation of current information on the subject of miniature (mini) (including "button cell") mercury batteries. Among other things, the report sets forth essential information regarding mini mercury battery safety and specifications. It is particularly helpful in reviewing the different types of mini batteries and comparing the advantages and disadvantages, both with respect to performance and safety, of each.

Overall, the data presented provides support for state legislation to do the following:

1. By 1/1/06 make all mercury-added miniature batteries sold in Maine subject to provisions of existing law on mercury products, including specifically (a) the labeling requirements and (b) the ban on disposal. In addition, require that all manufacturers of mercury-added miniature batteries establish and maintain a system for the proper collection, transportation and processing of such batteries for purchasers in this state

2. By 1/1/07 ban the sale of "novelty items" containing mercury-added miniature batteries; and

3. By 1/1/07 or 1/1/08 ban the sale of all mercury-added miniature batteries, with a provision that allows for an exemption from this prohibition if the manufacturer or user of the product can demonstrate to the Commissioner that the mercury-added battery provides a net benefit to the environment, public health or public safety when compared to available non-mercury alternatives.

<u>Mercury-Added Novelty Products</u>
With regard to the issue of mercury-added novelty products, the report explains that while

> "...the function of the mercury is to inhibit gas formation inside the miniature battery cell. Gas buildup inside the cell could cause bulging and potentially result in leakage of battery cell materials. This leakage of battery cell materials affects the ability of the battery to continue functioning. In addition, this leakage can pose a health hazard as mercury and other toxic materials are no longer encapsulated and a potential human exposure pathway is created." (p.4)

it is also clear that

> There are mercury-free models commercially available for silver oxide, alkaline manganese dioxide, and zinc air (Europe only) miniature batteries. [and lithium batteries contain no added mercury and widely available (pp. 27-29)]. The performance characteristics as presented by the manufacturers appear to be comparable for the mercury and mercury-free versions. Manufacturers have taken different approaches to eliminating the mercury for each miniature battery technology. A major concern for OEMs and end-users is the capability of these mercury-free miniature batteries to perform reliably in the field, especially as relates to the potential for buildup of internal gases, which is effectively prevented by the addition of mercury. Performance testing results for buildup of internal gases for mercury free miniature batteries is not available. Also, limited pricing information suggests that mercury-free miniature batteries command a 24% - 30% premium compared to their mercury containing counterparts. This cost differential is likely to decrease as the market matures. [emphasis added] (p.1)

These conclusions are extensively documented throughout the body of the report, as well as in Appendixes A-D. At worst, these novelty items would have the battery-cost component of the novelty item marginally increased. Since "the performance characteristics as presented by the manufacturers appear to be comparable for the mercury and mercury-free versions," there is no justification for the continued sale of mercury-added novelty products in Maine.

Mercury-Added Miniature Batteries For Other Purposes

With regard to the issue of using mercury-added miniature batteries for other purposes, the report points out that most miniature batteries are used in the U.S. in hearing aids. (p.13). For this reason,

> "Based upon available data, it appears that zinc air batteries contribute the most mercury to the environment because of their high sales volumes for use in hearing aids." (p. 4)

The report further confirms that, with regard to the safety and effectiveness issues regarding hearing aids (i.e., a battery placed in or near the human ear):

- Lithium batteries have no leakage issues and can be used for hearing aids. (Energizer CRX, table 6.4)

- Energizer sells mercury-free zinc air miniature batteries in Europe for hearing aid applications. Energizer offers mercury-containing and mercury-free miniature batteries for the following four models: AC10/230, AC13, AC312, and AC675. The Energizer engineering data sheets for the mercury-containing zinc air miniature battery and the mercury-free zinc air miniature battery were compared for each of these four models. The performance data for all relevant parameters

show no differences between the mercury-containing and mercury-free models." (p.26)

Nevertheless, we understand that there may be some lag time in a transition from mercury to non-mercury alternatives for the Maine market. For this reason, we would understand that a prohibition on the sale of mercury-added miniature batteries might be delayed for two to three years to allow for a smooth transition. Even after that date, the exemption procedure suggested above could remain in effect.

Recycling

The report (p 34) supports the concept of recycling miniature mercury-added batteries, and suggest that in Europe and some communities in the U.S., such programs have been effective. In Maine, such a system is now in place for certain full size batteries, and manufacturers of such batteries are required to "establish and maintain a system for the proper collection, transportation and processing of waste dry cell mercuric oxide and rechargeable batteries for purchasers in this State" 38 MSRA 2165(4)(a). However, according to the January 2003 National Electrical Manufacturers Association (NEMA) article entitled "Button Cell Battery Collection: Why It Does Not Make Sense":

> "Collection of button cells is not cost-efficient....Collection and storage can create a safety hazard....Environmental costs of collection and transportation are likely to exceed the small environmental benefits".

Our review of the NEMA article and the report leads us to conclude that the better approach is to phase out all mini mercury battery sales in Maine as set out above. Nevertheless, both during the phase-out period and with regard to any mini mercury batteries that secure an exemption, we agree with the report that they should be subject to mandatory recycling.

If we can be of any assistance, please contact us at any time. We would be pleased to meet with you to further discuss the issue. Again, thank you for the opportunity to comment on the important findings of this report.

Best Regards,

Jon Hinck,
Staff Attorney
Natural Resources Council of Maine
3 Wade Street, Augusta, Maine 04330
(207) 622-3101

Minnesota Office of Environmental Assistance

December 10, 2004

Mr. John James
Maine Dept. of Environmental Protection
State House Station
Augusta, Maine 04333-0017

[transmitted electronically as e-mail attachment to John.James@state.me.us]

Dear Mr. James,

Thank you for sending our agency a copy of the Maine DEP Report "An Investigation of Alternatives to Miniature Batteries Containing Mercury" and requesting review and comment.

You requested comment on two strategies for addressing mercury in miniature batteries. One, the sale of mercury-added miniature batteries could be banned. Two, the disposal of such batteries could be banned, with manufacturers required to develop and operate an end of life collection and management system.

In 1991, the Minnesota Legislature addressed these issues as they related to mercury-containing dry cell batteries. The position of the Legislature was that manufacturers must either eliminate mercury from dry cell batteries or establish a collection and management system for end of life batteries. Battery manufacturers opposed both options, the former on technical grounds and the latter on economic and political grounds. However, one manufacturer, Eveready, was producing mercury-free dry cell batteries in Europe and finally agreed to eliminate mercury from new batteries sold in the US. As a result, Minnesota enacted a P2-based battery mercury content law that was the first in the nation to require the phase-out of mercury in dry cell batteries, set maximum mercury levels of 25 mg or 0.025% in alkaline manganese miniature batteries, and prohibited the sale of mercuric oxide batteries except for essential uses with a manufacturer-based end of life management system. The Minnesota law does not restrict the mercury content of zinc air or silver oxide miniature batteries.

It is the remaining mercury in miniature batteries that we are dealing with today, some 13 years after the passage of Minnesota's landmark law. We have better information about the mercury content of miniature batteries and the total amount of mercury in the batteries sold each year. Some zinc air and silver oxide miniature batteries contain 1-2% mercury. Overall, miniature batteries contain a significant amount of mercury, partly due to the huge increase in miniature battery use since 1991. However, your report makes the critical finding that some manufacturers have made significant technical advances and are now making miniature batteries of all three chemistries without added mercury, just as some manufacturers were making dry cell batteries without mercury 13 years ago.

With those technical advances, it is now time to move forward with a rapid phaseout of mercury in miniature batteries. This is the only environmentally and economically sustainable choice. End of life collection systems are more expensive and less protective of manufacturing employees and the environment than simply eliminating the use of a toxic substance.

However, two important questions remain: One, should there be some type of collection system for the mercury-containing miniature batteries that are currently in use and that will be sold until industry conversion is complete? Two, are there other economic or environmental reasons to collect mercury-free miniature batteries, for example, to recover silver in silver oxide batteries? We are not able to provide guidance on these questions at this time.

A comment on mercuric oxide miniature batteries:
The conventional wisdom is that no one in the world is manufacturing or selling mercuric oxide batteries (40-plus percent mercury by weight), except possibly for a few specialty or military/ defense applications. However, the Eveready Battery Company's US website holds a current "Mercuric Oxide Battery Product Safety Data Sheet," dated 8/12/04, which states that these batteries are not available in the US (copy attached). This information suggests that mercuric oxide batteries may be manufactured by Eveready and available outside of the US as of 8/12/04. The same website holds several mercuric oxide battery spec sheets and they are all marked "Obsolete" or "Discontinued;" however these notations could be for the US market only. This should be clarified with Eveready and other manufacturers.

On the other hand, the website http://www.px625.com, which has offered two sizes of mercuric oxide battery for photographic equipment applications since 1998, notes that worldwide production of those sizes ceased in 2001.

Battery identification:
Table 2.2 Miniature Battery Manufacturers would be enhanced by the addition of a column of identifying marks or logos for each manufacturer, if such things exist. For example, Varta, Eveready, and GP batteries generally bear the manufacturer's name. Other manufacturers use names, initials, and/or logos.

Thank you for the opportunity to comment on this valuable study and the policy options you are considering in Maine.

Sincerely,

[transmitted electronically]

John Gilkeson
Principal Planner

Attachment

American Watch Association • P.O. Box 464 • Washington, DC 20044 • (703) 759-3377 • Fax: (703) 759-1639

December 15, 2004

Dawn R. Gallagher
Commissioner
Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Attn: John James

Dear Ms. Gallagher:

Your department has requested public comments regarding the use of mercury in batteries and "likely" recommendations to the Maine Legislature calling for either "a ban on the sale of mercury-added batteries" or "a ban on their disposal."

The American Watch Association (AWA), whose members constitute the great majority of leading watch brands in the United States, (1) opposes a ban on the sale of mercury-added button cell batteries and (2) seeks an exemption from battery collection proposals for the reasons stated below.

It is premature to ban mercury-added batteries

The proposal to ban the sale of mercury-added batteries appears to be based on two assumptions: (1) that eliminating mercury products is good for the environment, and (2) that reliable mercury-free batteries are a commercial alternative. The watch industry wholeheartedly endorses the first principle. Watch companies want to use mercury-free batteries in their products. However, these companies must use batteries that are assured of being reliable and non-corrosive.

To date, we are aware of no button cell batteries manufactured without the addition of mercury that have a proven track record of

reliability. The November 9, 2004, report of the Lowell Center for Sustainable Production describes the very recent introduction of such batteries by Sony (Japan) and New Leader (China). AWA members applaud the news but are naturally cautious about using those batteries until their reliability has been established.

Watch movements are precise instruments that cannot work properly in a contaminated environment. They are sealed in water resistant cases to protect them from moisture, dirt and dust that can damage their fine-tuned mechanisms.

Watches use silver-oxide button-cell batteries that contain on average well less than 3 mg. of mercury to prevent electrolytic "gassing," which would corrode and destroy the watch mechanism. Often, a single watch movement costs more than $100 to manufacture, with such "complications" as day-date and moon-phase demanding pristine cleanliness in the mechanism. All watches require a contaminant-free environment in order to tell time accurately.

Will the new Sony and New Leader mercury-free batteries provide such an environment over the full life of the battery? We certainly hope so, but it is clearly too soon to know. It is our understanding that major battery manufacturers have developed mercury-free products over the past decade but so far none has proved reliable over the long run. Perhaps Sony and New Leader will be the first to succeed where others have failed. However, even Sony has had "false starts" with its 8-track tape and Betamax technologies.

It would be a major mistake for Maine to impose an artificial ban on the sale of mercury-added batteries on the slender hope – one our members share – which the new batteries will prove to be the answer. Nor would it be sound policy to propose a specific sunset date for the use of mercury-added batteries – 2008 has been mentioned. It is impossible to legislate technological development.

Watch companies would be placed in an untenable position were Maine to ban the sale of mercury-added batteries before a proven alternative technology were in place. AWA companies are not prepared to risk the use of the new batteries – with as yet an unproven track record – in their precision instruments. That may be an acceptable risk for the makers of novelties but not for our members which shoulder long-term warranty obligations. If Maine were to impose such a premature ban on sales, watch companies would have no alternative but to avoid sales in Maine to the detriment of retailers in your state.

Maine should continue to press battery manufacturers to expedite mercury-free technology development as much as possible. But the state should not try to legislate such development by means of a ban on sales.

Maine should exempt watches from disposal/recycling requirements

Unique among consumer products, battery-powered watches are part of a closed-loop system that assures that virtually all spent batteries are recycled properly.

Watches Use Silver-oxide Batteries

Quartz watches – whether digitals or analogs – require a minimum constant voltage of 1.50v in order to operate accurately over an extended period of time. These watches depend on the piezoelectric properties of a quartz crystal. When placed in the proper alternating electric current circuit such crystals vibrate at a specific frequency so that the frequency of the circuit becomes that of the crystal. In turn, that frequency is electronically reduced and converted into intervals of precise seconds to actuate the watch.

Silver-oxide button-cell batteries provide the constant 1.50v of electric current required in quartz watches and are used extensively in luxury and fashion models where a thin profile is required and where non-mercury batteries (e.g. lithium batteries) are too bulky. Other batteries, such as aluminum manganese button cells, have a lesser voltage ranging up to 1.35v.

Watch Construction Deters Consumer Maintenance

Unlike other consumer products, watches by their very nature must be sealed compartments that protect their internal movements and batteries from exposure to water and pollution.

Today, virtually all watches require specialized equipment to open the watch and replace the battery. A watch's case back can easily be damaged by household tools and the water-resistant gaskets may often need replacing once the back is removed, particularly if it is removed by someone other than a professional. Typically, watch warranties are voided if the watch is damaged when the consumer opens it instead of using a professional (in some cases, the warranty is

voided merely by opening). As a result, consumers rarely come into contact with the button cell batteries in their watches.

Retailers Encourage Consumers to Replace Batteries Professionally

Consumers want to know where they can obtain service on their watches; consequently, retailers view battery replacement as a service that helps make the sale. Such encouragement helps to foster a continuing relationship with the consumer and thus generate future sales. The retailer who changes the battery will be less likely to damage the water resistant gasket and thus avoid much subsequent consumer complaints. The retailer will sell the used battery to a recycler.

Virtually all retail jewelers – more than 95 percent – replace used watch batteries or arrange for the replacement. Among major retailers, Wal-Mart replaces millions of watch batteries every year and sells them for recycling. Wal-Mart touts its "Green Coordinators," specially-trained associates who "coordinate efforts to make an environmentally responsible store." Target, Sears and others also change and recycle batteries. While Kmart and Kohl's do not, they typically refer customers to local jewelers or other retailers that provide the service.

Recycling Programs Already Exist

The Connecticut Department of Environmental Protection, in its letter of July 14, 2003, approving the AWA's watch battery collection plan, has recognized that more than 95% of watch batteries are already being recycled by the watch industry by the watch industry.

For the reasons given above, consumers typically return their watches to local retailers to replace the battery.

Retailers profit from recycling the silver content of these batteries. Watches use silver-oxide button-cell batteries that contain on average less than 3 mg. of mercury to prevent electrolytic "gassing," which would destroy the watch mechanism. The silver content has an economic value that guarantees that the batteries will be recycled.

Currently, there are two avenues for recycling silver-oxide batteries. The American Watchmakers and Clockmakers Institute Education, Library and Museum Trust (AWI") accepts donations of used batteries nationwide and enables retailers and watch manufacturers to write off

the value of the silver content for tax purposes. AWI promotes the program through its state chapters and conducts an annual competition rewarding the chapter whose members collect the most. Secondly, waste management companies contact retailers and purchase silver-oxide batteries directly.

Conclusion

Watch companies could not comply with Maine's contemplated ban on disposal and requirement for collection and recycling of used watch batteries. That is because the batteries are rarely returned to the manufacturer or distributor. Instead, the market place has devised its own mechanism to ensure that more than 95% of used watch batteries are recycled. The profit motive works and Maine should not disturb it.

Sincerely yours,

Emilio G. Collado
Executive Director

POISON Help
1-800-222-1222

National Capital Poison Center
3201 New Mexico Ave, Suite 310
Washington, DC 20016
Admin 202-362-3867
Fax 202-362-8377

December 15, 2004

John James
State of Maine
DEP-DRWM
17SHS
Augusta, ME 04330

Dear Mr. James:

Thank you for providing an opportunity to comment on Maine's proposal to ban the sale or the disposal of mercury-added batteries. As a board-certified medical toxicologist, I have directed the National Button Battery Ingestion Hotline and Study for more than two decades. This service has provided consultations for more than 8,500 battery ingestions and conducted clinical and animal research to optimize treatment recommendations. In addition, in 1980 I founded then subsequently directed the National Capital Poison Center, served as Executive Director of the American Association of Poison Control Centers from 1994-2004, and served as a past president of the American Association of Poison Control Centers. I have directed the nation's poison exposure database (TESS) since 1984, compiling in real-time more than 2.4 million poison exposures annually from all 60 US poison centers. As a tenured Professor of Emergency Medicine at Georgetown University and a Clinical Professor of Emergency Medicine at The George Washington University, I have served on the editorial boards of three medical journals and authored more than 150 publications in clinical toxicology, including 20 scientific journal articles and medical textbook chapters which focus on the clinical complications associated with button batteries.

Based on my experience, I do not believe that the possible acute health risks posed by battery recycling or use of mercury-free batteries are justified. My concerns are outlined, below.

Battery recycling may increase the risk of battery ingestion. At present, there is inadequate US battery ingestion data to demonstrate that battery recycling is safe, and there is every reason to believe that recycling is associated with behaviors that put children at risk. Over a recent two year period (July 2002 through June 2004), 51% of ingested batteries from known sources were sitting out, discarded or loose; 40% were removed directly from the product; 7% were obtained from the battery package; and 3% were ingested in a hearing aid. Batteries that are not discarded immediately but that are saved for residential recycling or carried to a recycling center may be more accessible to small children. While the majority of button battery ingestions do not cause serious clinical effects, at least three children have died following button cell ingestions, and hundreds of children have experienced permanent esophageal injury after a battery lodged in the esophagus. These tragic stories of children whose lives are marred by feeding tubes, frequent surgical or endoscopic procedures, impaired swallowing, or restricted intake are heart-wrenching. Just as worrisome, batteries placed in the ear or

nose by small children lead to facial deformities, destruction of the middle ear, hearing loss and serious infections. Until there are well-studied models for safe button battery recycling, I do not believe that mandatory battery recycling programs can be justified.

The stability of mercury-free button cells has not been established. Mercury serves an important role, inhibiting gas formation and preventing bulging of button cells. Other additives may effectively substitute for mercury in the future, but these technologies are in their infancy, and there is inadequate experience with these alternatives. Before mercury-free button cells are mandated, there should be adequate consumer and market experience conclusively demonstrating that these cells do *not* have a higher incidence of associated leakage. Leakage of strong alkali from button cells or exploding cells could lead to more frequent or more serious dermal, ocular, otic, nasal or ingestion effects associated with button battery use or exposure.

I believe that both of the options under consideration are premature. Neither recycling of button cells or use of mercury-free cells has been shown to be safe, thus neither should be implemented at this time. While these safety data may emerge in the future, until then, the State of Maine must weigh the minimal impact of button cells on overall mercury emissions against the possible increase in the number of children with immediate, serious and permanent esophageal damage. Trading a minimal environmental improvement for potentially serious acute health effects is irrational public health policy.

Sincerely,

Toby Litovitz, MD
Executive & Medical Director
National Capital Poison Center

cc. Anthony J. Tomassoni, MD
Medical Director, Northern New England Poison Center

Setting Standards for Excellence

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209
703-841-3249
Fax: 703-841-3349
Ric_Erdheim@nema.org

December 17, 2004

Mr. John James
Maine Department of Environmental Protection
DEP-DRWM
17SHS
Augusta, Maine 04330

Dear John:

The National Electrical Manufacturers Association (NEMA) represents manufacturers of dry cell batteries including button cells. NEMA has had an opportunity to review your cover letter and a report prepared by the Lowell Center for Sustainable Production, "An Investigation of Alternatives to Miniature Batteries Containing Mercury."

These documents are significantly flawed and would mislead policy makers. The attached document describes in detail the flaws in the report as well as the significant omissions of data contained in our report, "Analysis of Battery Industry Sponsored Button Cell Collection Programs" as well as my email to you of October 13, 2004.

The analysis in the report and in your cover letter contain the following major flaws:

1. The elimination of button cells containing small amounts of mercury from the Maine waste stream will result in no measurable reduction of mercury levels in Maine.

2. The data presented in the Lowell Center report regarding mercury-free alternatives does not support the conclusion in the report and in the cover letter that there are available commercially available mercury-free button cells. It also identifies lithium coin cells as a potential substitute in some products but never mentions the regulatory hurdles of shipping lithium coin cells including an emergency rule issued this week banning the shipment of lithium batteries on passenger aircraft except for personal use.

3. The data presented in the Lowell Center report not only fails to support its conclusion that "miniature battery recycling systems are well-established and readily available in the United States," but also actually shows the opposite that there are virtually no such programs. It also ignores the costs of such a program

4. The report fails to properly evaluate the safety and regulatory issues involved with collection.

As a result NEMA strongly opposes both alternatives suggested in your letter. In fact your letter fails to propose the most logical option, the no action alternative. This alternative makes the most sense because of the miniscule benefit from your alternative proposals, the lack of mercury-free options and the potential harm to product users from establishing an arbitrary deadline, the long proactive record of the battery industry to successfully address environmental problems, and the safety, ingestion and cost concerns of collection. Such an alternative is, despite what is incorrectly said in the Lowell Center report, consistent with the actions of all other states.

In addition, NEMA opposes button cell labeling suggested in your cover letter. Such labeling would provide no useful information. No other state that has any labeling provision provides requires labeling for button cells.

We hope you will rethink your proposals and fully consider all of the facts that are not discussed in the Lowell Center report.

Sincerely,

Ric Erdheim

Ric Erdheim
Senior Manager

1. The elimination of button cells containing small amounts of mercury from the Maine waste stream will result in no measurable reduction of mercury in Maine.

a. **Almost all mercury deposition in Maine is coming from outside the state.**

Deposition of mercury is coming largely from out of region/state. The NESCAUM (Northeast States for Coordinated Air Use Management) 1998 report, "Mercury Study, A Framework for Action," using 1995 data, estimated that 53% of mercury deposition in the northeast (New York, New Jersey and the six New England states), came from outside the region (Page VI-16). In 1995 the largest source of mercury emissions in the region came from municipal solid waste incinerators. The report estimated that 42% of all mercury deposition from anthropogenic sources in the Northeast came from municipal solid waste and sewage sludge incinerators in the northeast (Page VI-24). Municipal solid waste incinerators accounted for 89% of this total. Since emissions from municipal solid waste incinerator have dropped significantly (~ 90%) without corresponding reductions from coal-fired power plants and many other sources, emissions of mercury from outside the region today are responsible for an even greater share of deposition in the northeast.

The NESCAUM report estimates regional emissions at 15,903 kg of mercury (page V-4) and regional deposition from regional sources at 3,787 kg of mercury (page VI-16). This data establishes a rough estimate of 24% of regional emissions being deposited in the region. Again, this figure is almost certainly lower today because of the greater improvements in mercury reduction that have been made in the region than outside the region.

Using this 1995 data that overstates the current contribution of mercury from Maine, and based on Maine's percent of the regional population (3%), all Maine emissions would have resulted in a rough estimate of 1.4% (47% * 3%) of total state deposition.

A study from the New York State Energy Research and Development Authority, "Contributions of Global and Regional Sources To Mercury Deposition in New York State," published in June 2002, concludes that New York State Emissions accounts for 11-21% of total mercury deposited in state. Other sources are 25-29% from contiguous US, 13-19% from Asia, 5-7% from Europe, 2-5% from Canada, 2-3% each from Africa and South America and 0-1% from Mexico and Oceania. http://www.nyserda.org/programs/pdfs/NYSERDAreport02-09.pdf.

Maine's population is less than 7% of New York's. Using this population ratio and the report's conclusion suggests that Maine's emissions 1-2% (11%-21% * 7%) of state deposition.

b. **Products are a small source of Maine emissions**

As a result of actions taken by industry and Federal and Maine governments, mercury emissions from all products have dropped significantly. Industrial uses of mercury have declined by 90% from 1980 and 94% from its high point in the 1960s. According to the US EPA this decline and emission controls required by the Clean Air Act Amendments of 1990, have resulted in emissions of mercury from municipal solid waste incinerators nationally dropping from 42 tons in 1990 to 2 tons in 2001.

The Maine DEP's own data confirms this decline. The 1997 Land and Water Resources Council Annual Report: Appendix A, "Mercury in Maine," estimates that municipal solid waste incinerators emitted 510 pounds of mercury in 1992. The February 2002 Maine DEP report, "Mercury in Maine – Status Report" shows these same emissions have fallen in 2000 by over 90% to 43.5 pounds or roughly 3% of emissions in the state. The only other source of emissions from a button cell in Maine would be landfills. According to the Maine DEP report landfills in the state emitted 6 pounds of mercury or 0.4 % of the state's emissions. All products containing mercury now represent a very small source of emissions. There are no mercury emissions from breakage because mercury in a battery is amalgamated into the zinc electrode and is not freely available even if the integrity of the battery container was compromised.

So button cells would be in the category of products making up 3% of Maine's mercury emissions.

c. **Button cells make up a small portion of mercury in the solid waste stream.**

While batteries historically have been a large source of mercury in the waste stream, button batteries represent a small source of use of mercury in products. Since incinerators generally achieve 95% mercury control, we can use Maine's current emissions to estimate mercury in the incinerator waste stream prior to incineration in 2000 at roughly 870 pounds. With a portion of Maine municipal solid waste going to landfills (>25%) rather than incinerators, we can reasonably estimate that the total solid waste stream (both from incinerators and landfills) contained well over 1,000 pounds of mercury in 2000.

To further illustrate the insignificance of button cell batteries as a source of mercury we offer the following data. NEMA battery manufacturers used 5,283.5 pounds of mercury in button cells sold in the US in 2002. The US Bureau of the Census estimates that as of July 1, 2003 the US had a population of 290 million while Maine's population was 1.3 million. http://eire.census.gov/popest/data/states/tables/NST-EST2003-01.php. Using a relative Maine to total US population of 0.44%, button batteries sold by NEMA manufacturers in Maine contained 23 pounds of mercury in total. This would be around 2% of all mercury entering the municipal waste stream in Maine. While we agree that there are other button cells, primarily found in products, not included in these figures, the number of these other button cells is likely to be proportionately low since the overwhelming use of button cells is in hearing aids where users have to regularly change batteries. Data in the Lowell Center report from Europe confirms that button batteries sold for original equipment makes up only 10% of total button cell sales.

d. **The elimination of button cells containing small amounts of mercury from the Maine waste stream will result in no measurable reduction of mercury in Maine.**

This data shows that a reasonable estimate of mercury deposition in Maine from button cells is:

1%-2% of Maine deposition comes from Maine emissions x 3% of Maine emissions comes from products x 3% of mercury in products comes from button cells = 0.000009 – 0.000018% of Maine mercury deposition comes from button cells.

e. **The statement in the Lowell Center report that "mercury from miniature batteries can be released to the environment during...manufacturing, use and disposal" is partially wrong and totally misleading.**

As we have shown above, emissions of mercury from disposal of button cells are trivial. The Lowell Center report provides no perspective on such emissions. The report is wrong, however, in its statement that mercury is released during use of button cells and we wonder how the Lowell Center could have even come to such a conclusion. Mercury is added to the zinc electrode. It is not in a form that it could be released even in the extremely remote change that the integrity of a button cell was affected during use. Finally, publicly available TRI data shows that releases of mercury to the air during manufacturing are nonexistent.

2. The data presented in the Lowell Center report regarding mercury-free alternatives does not support the conclusion in the report on in the cover letter that there are available commercially available mercury-free button cells. The report also ignores information NEMA provided to the Maine DEP on October 13 showing that such a statement is not defensible.

The Lowell Center conclusion that mercury-free alternatives are commercially available is simply wrong and does not follow from the reports own findings.

a. **There is no mercury-free zinc air cell being sold in the US.**

Energizer is the only company marketing a "zero mercury" zinc air battery and it is only doing this in Europe. According to Energizer, "zero mercury" zinc air hearing batteries remain very challenging to produce. The product design and manufacturing process are not yet robust enough to produce large quantities of batteries on a "day in and day out" basis. Energizer introduced this product in the European market because it represented, for Energizer, a small, manageable volume that would allow complete conversion to the zero mercury construction in that market. As an unlikely contingency for quality or performance issues, this approach allowed for easier product containment.

It is unclear at this time if or when the design and manufacturing issues will be resolved to allow for significantly greater product volumes by Energizer. In addition, Energizer only produces a portion of the zinc air button cells in the US.

The technology Energizer is using is not completely and directly applicable to silver oxide and alkaline manganese button cells. Every chemistry presents a different challenge to eliminating mercury and any success for one chemistry does not guarantee there will be similar success with other chemistries.

b. There still is no mercury-free silver oxide button cell available in the US.

While the Lowell Center report says mercury-free silver oxide button cells are available in the US, the evidence in the report does not support this conclusion. The Lowell Center cites two sources for its conclusion. First, it refers to a press release from Sony indicating it will have a

mercury-free silver oxide button cell for a few product lines. Sony is not a NEMA member and we have no information about the battery other than what is in the press release. While the press release indicated that Sony would make mercury-free cells available for ten out of forty three battery models and only for Original Equipment Manufacturer (OEM) and not consumer use, one of our members has heard that Sony has now scaled that back to five models We also note that no such batteries are currently available so no one can evaluate the battery for reliability and performance. We do not support legislation based on press releases.

The only other source for the Lowell Center conclusion is an assertion that a small Chinese battery company, New Leader, claims to have a mercury-free silver oxide button cell. The report acknowledges, however, that the battery is only available to original equipment manufacturers and is not commercially available for purchase by consumers. The report says that there is no information on how New Leader avoids the use of mercury in these cells.

The Lowell Center report does say that there is no performance testing showing that these batteries avoid leakage, bulging and rupture problems.

So by the Lowell Centers own words, there are no "mercury free" silver oxide button cells available for sale to consumers in the US and there are no publicly available testing supporting "mercury-free" alternatives as a safe and comparable product to existing silver oxide button cells. This information simply does not support the Lowell Center finding.

As indicated above, since each chemistry has different characteristics and presents different challenges for eliminating mercury, it is inappropriate to conclude that successful elimination of mercury in one chemistry means that mercury can be eliminated in all chemistries. In addition, silver oxides batteries cost more than alkaline manganese batteries because of the cost of silver and silver oxides batteries present other environmental challenges because of the use of silver.

Finally, two other factors mean there is likely to be very little environmental benefit to moving to a "no mercury" formula for silver oxide button cells. First, the average amount of mercury in silver oxide button cells is much less than the other two chemistries. As a result, silver oxide batteries use only a small portion of mercury in button cells. Second, because of the value of silver, jewelers already collect silver oxide watch batteries (by far the largest use of silver oxide batteries) meaning that a much smaller percentage of such batteries go into the solid waste stream than the other two chemistries. You can find information about this program at http://www.watchbatteryrecycle.org/.

c. **There is no commercially available "mercury-free" alkaline manganese button cell sold to consumers in the US.**

Despite the Lowell Center's conclusion, the report clearly states that the only company claiming to manufacture a "mercury free" alkaline button cell has not made the button cell commercially available in the US to consumers. The Lowell Center report does say that there is no performance testing showing that these batteries avoid leakage, bulging and rupture problems.

d. Lithium coin cells are not alternatives and recent regulations will increase the cost of such cells.

The Lowell Center report suggests that lithium coin cells are a potential alternative to button cells with mercury. This is a misleading statement. As the report itself acknowledges, there are numerous considerations in designing a product and the battery it will use. Presumably manufacturers who have designed their product to use a button cell rather than a coin cell have made this evaluation and concluded that a lithium coin cell is not the best alternative. What is clear, however, that a lithium coin cell is not an alternative for an existing product. Lithium coin cells cannot be interchanged with button batteries of different chemistries because of different sizes and different voltages.

It also is clear that lithium coin cells are not suitable for hearing aid applications. Hearing aids are high drain devices requiring that far more energy be readily available that is found in a lithium coin cell. A lithium battery the same size as a zinc-air battery would have a small fraction of the capacity of a zinc-air cell.

The Lowell Center report also ignores concerns from the US Department of Transportation's Research and Special Programs Office (RSPA) regarding shipment of lithium batteries including lithium coin cells. This issue is discussed in greater detail below but such regulations may have an adverse effect on the use of lithium coin cells, a fact not acknowledged in the report.

e. Manufacturers will not adopt "mercury-free formulas without a demonstrated record of reliability and performance.

US battery manufacturers generally label their battery packaging to say that they will pay for repair or replacement of products damaged by one of their batteries. No US battery manufacturer is going to market a battery without thorough testing to assure that the battery will meet the company's requirements including that it will not cause damage to products for which they might be responsible. This damage could result from leaking electrolyte affecting the products electronics or having the battery deform and become stuck in the battery cavity. These products include hearing aids and watches that can cost in the hundreds or even thousands of dollars.

In addition, batteries that leak can cause skin burns The CPSC estimates that there are 3,700 emergency room visits because of chemical burns from batteries. .
http://www.cpsc.gov/CPSCPUB/PUBS/5088.pdf This report shows the potential adverse affect for public safety if batteries do not meet exceptional levels of performance.

Without information about the so called "mercury-free" button cell alternatives and the lack of any such testing by US manufacturers, it is highly premature for Maine to even consider mandating use of a product.

f. The battery industry has a long record of environmental accomplishment without needing government regulation and such regulation is not necessary to spur development of mercury-free button cells.

Historically the US battery industry was by far the largest user of mercury in the manufacture of alkaline batteries in the US. In the 1980s, the battery industry used over 1,000 tons of mercury per year, over half of the mercury used by all US industry. Mercury is used to control gassing that leads to leakage, possible rupture and shortened battery life. When concern about mercury in the environment began to grow in the late 1980s, the battery industry developed and implemented alternative technologies to eliminate the use of mercury in all but button cells by 1993. The first phase of this program, reducing mercury levels from 10,000 PPM to 250 PPM was undertaken between 1989 and 1991, before any state legislative effort. In addition, the battery industry phased out the use of mercuric oxide button cells used for hearing aids and replaced them with zinc air batteries reducing mercury use in these batteries by approximately 99%. As a result, use of mercury in batteries declined by well over 99% A further description of this decline can be found in the NEMA brochure, "Household Batteries and the Environment" on the NEMA battery section website, www.nema.org/batteriesehs.

The battery industry tracks the decline of mercury from battery in the waste stream by conducting surveys of batteries collected in recycling programs in Lee County, Florida, Camden County, New Jersey and Hennepin County, Minnesota. In the last complete set of surveys conducted in the fall of 2001 and spring of 2002, average mercury levels in alkaline batteries in the waste stream were in the 158-336 PPM range. That compares to a historical average of roughly 10,000 PPM. It is clear that the vast bulk of mercury from old batteries already has been flushed through the solid waste system.

The battery industry also started the Rechargeable Battery Recycling Corporation (RBRC) to collect rechargeable batteries. Maine is a participant of this program.

NEMA also has a program to provide medical assistance through the National Capital Poison Control Center when someone ingests a battery, usually a button battery. The Center is concerned that button cell collection programs will lead to increasing incidences of battery ingestion.

The battery industry is proud of its record of eliminating mercury in batteries by 1,000 tons a year, to collect rechargeable batteries and to address the problem of battery ingestion. Our record demonstrates that the industry will proactively address mercury reduction without legislative mandates. Our companies are among the world's technological leaders and companies continue to explore "no mercury" formulas. That there are any proposals to manufacturer "no mercury" batteries without any legislative mandate is further proof that the battery industry does not need arbitrary legislative restrictions. We strongly oppose, however, any effort at this time to eliminate use of mercury in button cells.

3. The data presented in the Lowell Center report not only fails to support its conclusion that "miniature battery recycling systems are well-established and readily available in the United States," but also actually shows the opposite that there are virtually no such programs.

a. The evidence in the Lowell Center report fails to show that miniature battery recycling programs are well established. The Lowell Center report concludes, based on an

analysis of four programs, that "battery recycling systems are well-established and readily available in the United States." The programs cited, however, are virtually the only such programs in existence and are not readily available in the United States. They all occur in relatively high population density areas. These few programs are community-funded programs and all address many products of which batteries are only one component making an assessment of even their success difficult. The existence of these few community-based programs does not show that miniature battery recycling programs are well established.

b. The Lowell Center report fails to address the constraints on button cell collection discussed in the NEMA report to Connecticut. The NEMA paper prepared for Connecticut goes into great detail regarding all of the constraints in trying to start a battery collection program. The Lowell Center report addresses none of these constraints, simply relying on the existing of a few community collection programs that accept batteries. Below we discuss the problems of fire, hazardous material transportation regulations and ingestion. Other constrains including contamination of collection with inappropriate products, the large number of button cell distribution points both within and outside of Maine, program costs including the need for and cost of education and insurance, increased liability and environmental costs of collection. The NEMA report estimated battery industry profits from sales of button cells in Connecticut. Profits would be proportionately lower in Maine further limiting the economic feasibility of collection.

c. Existing European battery collection programs demonstrate that collection costs are high and recovery rates low and that the costs of a button cell collection program in Maine would be economically infeasible.

Twelve countries that comprise 67% of the European market currently require the collection of all batteries sold within their borders. In the chronological order in which their requirements were imposed, they are: Austria, Belgium, Netherlands, Switzerland, Sweden, Germany, France, Czech Republic, Hungary, Poland, Portugal, and Spain. In each country, the retailer takes back batteries, including button cells, at the point of sale.

Collection and recycling is funded by levies based on the sales of battery manufacturers that are then passed on through the distribution channel. Retailers are required to participate. Each country's program operates independently. Collection and recycling organization (CRO) cost structures vary widely. Since button cells are not collected separately, many costs are bundled together with the costs of collecting other batteries and cannot be identified separately.

In 2002, the average cost in Europe was 773 euros per ton of batteries collected; however, the costs and the cost structures of the various country collection and recycling organizations vary widely. Costs per button cell collected have been estimated to range from 0.4 cents U.S. in Germany to 13 cents U.S. in Belgium.

The Belgian program is the most successful, yielding a collection rate of about 50% of new battery shipments. To achieve this success, the Belgian CRO paid about 4.6 million euros for promotion and advertising in 2002 (about 2,087 euros per ton of batteries collected), far more than the cost of collection, 0.8 million euros (about 363 euros per ton) or the cost of sorting and

recycling, 1.8 million euros (about 817 euros per ton). Total costs of 11.1 million euros are 6.16 times the cost of sorting and recycling.

The total cost of this program clearly includes costs associated with collecting and recycling other types of batteries. Therefore, the *total cost* cited above is not representative of the total costs of collecting and recycling button cells alone.

NEMA estimated the cost of a program in Connecticut based on the Belgium program. As of July 2000, the population of Belgium was estimated to be 10,241,506 (www.yahooligans.com/reference/factbook/be/popula.html). In December 2003, $1 equaled about 0.85 euros (www.exchangerate.com). (It is worth less today making comparable costs in the US higher) NEMA found that a comparable program in Connecticut would need to spend $1,809,820.60 for promotion and advertising. This figure is more than 6.75 times the industry's profit from selling button cells that reach Connecticut consumers. No business is going to operate where costs are guaranteed to exceed profits.

Thus the European experience shows that button cell collection in Maine is not economically feasible.

4. The report fails to properly evaluate the safety and regulatory issues involved with collection.

a. **The report incorrectly dismisses ingestion concerns ignoring CPSC warnings and the statements of the leading expert in the field of button cell ingestion.**

In five paragraphs the Lowell Center report gives short shrift to concerns about button cell ingestion. In reaching this conclusion the Lowell Center appears to have failed to talk to the leading expert in the field and ignores warnings by the CPSC.

The CPSC first issued a public warning about button cell ingestion in 1983. http://www.cpsc.gov/CPSCPUB/PREREL/prhtml83/83017.html. In this release the CPSC warns consumers to "Keep button batteries out of your child's reach. Discard them carefully." The CPSC reissued a warning just last year http://www.cpsc.gov/CPSCPUB/PUBS/386.html (see question 17) during Poison Control Week. The Lowell Center report fails to mention these CPSC actions.

The Lowell Center also failed to talk about this issue with the leading expert in the US if not the world, Dr. Toby Litovitz, Executive and Medical Director of the National Capital Poison Control Center, which operates the battery ingestion hotline. In comments submitted to the Connecticut Department of Environmental Protection, Dr. Litovitz said the following:

> "More than 1,800 button battery exposure cases are reported to US poison centers each year. Most of these cases are ingestions; some involve batteries placed in the ear or nose. In most cases the batteries pass entirely through the digestive system without causing problems for the patients, but a few ingestions lead to serious medical complications. The complications can be esophageal burns, perforation, stricture, or infrequently death.

Batteries in the ear and nose can cause serious problems such as nasal septal perforation or destruction of parts of the inner ear.

In my opinion, the potential for harm caused by ingestion of a battery, or its placement in the ear or nose, overrides any need to recycle this extremely small amount of material. A safe recycling program would incorporate a mechanism to prevent unintentional ingestion of batteries . . . both at the site of the final repository as well as in the home. In reality, assuring safe collection in the home is problematic. It would require significant investment in designing and providing secure collection devices as well as a fundamental change in the behavior of the user. Neither is a practical concept. We have spoken out repeatedly against battery recycling programs because they fail to address these practical considerations that impact individual consumers collecting these miniature batteries at home, ultimately leaving the batteries accessible to small children and other susceptible individuals. We have not envisioned, nor have we seen a recycling program proposed that would prevent retrieval of the battery from the recycling container AND address the issues of battery accessibility prior to the battery being deposited in the recycling container. For example, recycling containers placed in stores merely encourage consumers to collect batteries at home, ultimately resulting in inadequate storage protection.

We have worked with the toy and hearing aid industries for years to promote secure closures on products using button batteries. In addition, most manufacturer's battery packages are relatively child resistant. We urge you not to undermine these safety gains and to exercise caution before instituting a recycling program that leaves batteries loose and exposed in the home."

Dr. Litovitz will be providing comments directly to you.

For more than twenty years, the battery industry has provided funding to the National Capital Poison Control Center to provide medical response for these situations. Battery packaging warns consumers not to swallow batteries and to call the National Capital Poison Control Center hotline in the event that someone does ingest a battery.

The Lowell Center reports ignores Dr. Litovitz's concerns, ignores the CPSC warnings and ignores the efforts of the battery industry to address this issue.

b. The report incorrectly dismisses concerns about fire hazards, just as the Research and Special Programs Administration of the US Department of Transportation has issued an emergency rule banning passenger shipment of lithium batteries because of their fire hazard.

The Lowell Center report dismisses concerns about the fire hazards from shipping used button cells. In reaching this conclusion the Center spoke to one recycler. It ignored all of the information provided in the NEMA report to the Connecticut Department of Environmental Protection. In that report, NEMA described why there are concerns of fire, examples of fires from collected batteries and a warning letter from Onyx Environmental Services, headquartered

in Stoughton Massachusetts, to its customers regarding shipping used lithium batteries. The relevant section of that reports follows:

> Used batteries may contain small amounts of energy when disposed. Even if consumers only disposed of batteries that they believed to be dead, they may dispose of a battery with remaining energy because consumers cannot readily determine whether a battery is dead. For example, a piece of equipment may stop working because the battery does not have adequate power for the equipment but may still have some remaining power. Consumers also may simply dispose of batteries with remaining power by mistaking them for a dead battery. If terminals of batteries with remaining energy are in contact, that energy will short-circuit creating heat, potential leakage, and possibly a fire.
>
> This is a relatively small problem if there is a 100% pure collection of only spent button cells containing mercury and the container is made of non-conductive and non-combustible material so that there is no fuel for any heat generated by short circuiting batteries. This problem becomes much more serious with lithium coin cells because of the larger surface area of the lithium battery terminals than button cells and their ability to rapidly discharge leading to higher energy output and greater chances of heat generation. It also becomes a problem if other types of batteries are placed in a collection container because button cells can serve as a bridge between terminals of larger batteries to create a short circuit with batteries having greater energy than the button cell itself.
>
> Lithium electrolyte is flammable. These batteries also contain metallic lithium, a highly reactive metal, that, when exposed to water, liberates hydrogen, a very flammable gas. At a mercury recycling facility, batteries will be shredded or hammered. If the recycler shreds or hammers lithium batteries, they will ignite as they are opened. Ultimately the lithium metal may ignite.
>
> It is hardly unreasonable to expect that there will be some level of contamination from any collection program. We see contamination in both the RBRC and TRC collection efforts despite education of stores with collection containers. The RBRC containers explicitly say that consumers should not place alkaline batteries in the containers.
>
> Yet the RBRC, now in its tenth year of operation, still collects 25,000 pounds of nonconforming (non rechargeable) batteries a year. Some communities that collect rechargeable batteries also collect non-rechargeable batteries because they believe consumers do not distinguish one battery type from another. The TRC makes clear that it accepts only whole containers but it still receives cans that contain clipped mercury ampoules. Based on this experience we would expect a similar level of contamination any button cell collection effort despite education efforts.
>
> The DEP appears to agree with these concerns. Its publication, "Managing Household Batteries: A DEP Recycling Program Fact Sheet," states (in relation to collecting silver oxide batteries) that "Sorting batteries is labor intensive, potentially dangerous, and requires familiarity with the various types of batteries." Regarding lithium batteries, the DEP Fact Sheet says "Lithium is a highly reactive metal and, when collected with other

button cells, may present a hazard if not fully discharged."
www.dep.state.ct.us/wst/recycle/batthaz.htm.

Lithium batteries flat-line discharge; that is, they produce current at full voltage until the energy in the electrolyte is completely exhausted, at which point they produce no current. Other types do not flat-line discharge. There is no way to insure that batteries will be fully discharged when collected.

Currently, the vast majority of used button cells are individually disposed of as they are replaced, with minimal risk of short-circuiting and fire.

An industry sponsored collection program will inevitably lead to the accumulation of inventories of used button cells in the hands of both consumers and collectors, increasing that risk and leading to increased insurance costs for the operators of the program.

On August 21, 2003, Onyx Electronics Recycling, a firm that reprocesses lithium batteries has warned its clients by letter that

"If lithium batteries are improperly packaged they can pose a serious fire hazard. Batteries that are loosely packed can short circuit and release a significant amount of heat. The heat can cause more batteries to burst, releasing the lithium, and when the lithium is exposed to a sufficient amount of heat or moisture it will begin to burn. The fire will burst more batteries and the reaction will quickly get out-of-control . . .

Over the past two years, three significant fires have occurred due to improperly packaged lithium batteries, Fortunately, none of these incidents have occurred at Onyx facilities."

In an incident of this type during the night of August 14-15, 2002, an 85-gallon drum of lithium batteries sent for recycling burst into flames at a Safety Kleen facility in Clarence, New York. The fire engulfed the facility, caused $2 million in damages, forced safety officials to consider evacuating the community, and took two hundred town firefighters and a "jet-fuel-fire-fighting apparatus" from the Buffalo-Niagara International Airport seven hours to control.

According to U.S. Chemical Safety and Hazard Investigation Board Incident report number 2002-5199,

"Van Domelen (the facility's manager) said the likely cause was either an internal or external short circuit inside one of the lithium battery casings being stored in a treatment room at the facility. The short sparked a fire, which led to a series of explosions at the plant, where spent lithium and alkaline batteries are stored, treated and shipped for disposal."

This report can be found at www.chemsafety.gov/circ/post.cfm?type=basic&b01=10&rf=full&incident_id=5899#disclaimer.

The event was covered by WIVB, the CBS television affiliate in Buffalo, NY, which subsequently honored the Clarence Fire Company as being the Bravest of Western New York for their efforts at the scene.

In another incident of this type, a fire that evidently started in a battery collection container burned a Radio Shack store in Pennsylvania to the ground.

The Lowell Center statement about the lack of energy left in lithium batteries in inaccurate. As stated above a consumer cannot tell when a battery has no energy left (is dead). In addition, this conclusion does not reflect all commercial practices. Where a product becomes unusable but the battery retains power or where a retailer sells a product and places a new battery in the product replacing a partially used battery there will be energy left in the battery.

The lack of concern about the hazards of fires from batteries does not appear to be shared by the Research and Special Programs Administration (RSPA) of the US Department of Transportation. RSPA first issued a public advisory in July 1999 to remind persons that batteries "...are forbidden from transport unless properly packaged to prevent the likelihood of creating sparks or generating dangerous heat. (64 FR 36743) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=1999_register&docid=99-17123-filed. As a result about the concerns of fire from shipping lithium batteries, as well as concerns regarding fires in passenger aircraft, on December 15 RSPA issued an emergency rule banning the shipment of lithium batteries on passenger aircraft except for personal use. 69 FR 75208.

In view of the incidents of fires and the position of RSPA the Lowell Center's conclusion that there is no evidence that these batteries pose a significant fire hazard is nothing short of remarkable. That the Lowell Center failed to mention RSPA statements on shipping lithium batteries or past incidents is inexcusable.

c. The Lowell Center report completely ignores RSPA Regulations that require special handling to ship batteries.

US Department of Transportation Research and Special Programs Administration (RSPA) regulations require that batteries be shipped only when they are protected from short-circuiting. Special Provision 130 exempts dry batteries (other than lithium batteries) from the RSPA Hazardous Material Rule provided that dry batteries "are securely packed and protected against short circuits." (49 CFR 172.102 (c) found in 68 FR 44991 (July 31, 2003). 49 CFR 173.185 (e)(4) contains a requirement that shippers must prevent short circuiting of lithium batteries and that batteries be packed in strong packaging for conditions normally encountered in transportation. RSPA regulations (49 CFR 173.21) prohibit the shipping of any product unless the product is protected from short-circuiting. That would mean that extra care would have to be taken for batteries by taping the terminals or placing individual batteries in plastic bags as is

done with rechargeable batteries (See RBRC Safety Guidelines http://www.rbrc.org/community/disposal.html#storage).

Taping or repackaging button cells at the collection point will add significantly to the cost and complexity of any industry sponsored collection program, and may dissuade some parties (particularly retailers) of their willingness to implement the program.
To comply with existing transportation requirements and to minimize the danger of shipping used button cells, there would need to be an extensive education program for every employee at a collection outlet and every consumer. This would require both consumers and collection points to distinguish lithium coin cells and other batteries from other button batteries and for consumers or collectors to place each battery in a plastic bag or tape its terminals. Given the number of users of button cells, the greater degree of infirmity of the largest users of button cells, older people with hearing aides, and the number of distribution channels, this task would present a very significant challenge.

The Lowell Center report neither describes the RSPA requirements or the effect of those requirements on any recycling efforts.

5. Labeling packaging would provide no benefit, is inconsistent with other state labeling requirements and would impose an unreasonable burden on interstate commerce.

The suggestion in the cover letter that button battery packages should contain a label would have no benefit because button cells contain so little mercury that collection makes no environmental and economic sense.. It also would be inconsistent with other state labeling requirements. Labeling laws in Rhode Island, Vermont, New York and Connecticut explicitly exempt button cells from state labeling requirements and other states with more limited laws such as Washington, Oregon, Maryland and Minnesota. Such a provision as suggested in your cover letter would be extremely burdensome to industry since manufacturers make products for national and some cases international markers not for state or regional markets.

There are misleading statements in the Maine DEP cover letter

The cover letter says that US battery manufacturers used about 1,000 more pounds in 2002 than 2001. While it is understandable why the report makes this statement, it is not factually correct. First, the 2001 data submission stated that it was based on 2000 data for which there was not a significant difference. So there really is a two-year gap in data. Second, the button cell market is mature and growing slowly. The reported increase is much too large for the growth of the market suggesting that there is a flaw in one of the data points.

There are other errors in the Lowell Center Report.

Page 6 – The report misstates state legislative efforts and European directives with regard to button cells.

With regard to state efforts, these efforts clearly show a lack of focus on addressing button cells, exactly the opposite statement found in the Lowell Center report. In the early 1990s, seventeen

states passed battery laws prohibiting use of mercury in alkaline manganese cells but specifically exempted alkaline manganese button cells. Minnesota's law contained the same provisions but also limited amounts of mercury in zinc air and silver oxide button cells.

Since then states that have acted to address mercury in products have very clearly demonstrated their lack of concern with mercury in button cells. Twelve states (California. Connecticut, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Rhode Island, and Washington) ban the use of mercury in thermometers but directly or indirectly exempt button cells in digital thermometers. Eight states (California, Connecticut – removable button cells, Illinois, Indiana, New York – removable button cells, Oregon, Rhode Island, and Washington) ban the use of mercury in novelties but specifically exempt button cells in novelties. No state requires labeling and a number of states (Vermont, Rhode Island, New York and Connecticut have specific exemptions for button cells). No state requires collection of button cells, no state has established a button cell disposal and no state bans the sale of button cells with mercury. This consistent action shows a lack of concern about button cells, not the "focus" on button cells states in the report.

The Lowell Center report also misstates the draft European battery directive, which is still being debated. As of this point there are no additional restrictions on mercury levels other than the existing restriction on limiting mercury levels to 2% in button cells. There are no "strong incentives" to eliminate mercury from button cells in the existing or draft directive.

Page 9 – The report lists manufacturers of miniature batteries and whether those companies have provided a notification to IMERC. The majority of companies have not provided a notification leaving the impression that these companies are out of compliance and that sale of such batteries is higher than the IMERC data would suggest. The report fails to make clear, however, that some manufacturers, such as NEMA member Wilson Greatbatch, only make lithium coin cells that do not contain mercury and therefore, have no reason to report to IMERC.

Page 17 – The typical useful life of a zinc air miniature battery is not two to three months but is measured in days. That is why there are so many zinc air button cells used in hearing aids.

Page 18 – The chart of zinc air manufacturers does not include Rayovac, the largest US manufacturer of zinc air button cells. Rayovac is clearly listed on the NEMA notification form submitted to IMERC. In addition, Panasonic does not sell zinc air button cells as the report claims.

Page 20 – The chart of silver oxide manufacturers does not include either Rayovac or Panasonic, both of which are clearly listed on the NEMA notification form submitted to IMERC.

Page 22 – The chart of alkaline manganese manufacturers does not include either Duracell or Panasonic, both of which are clearly listed on the NEMA notification form submitted to IMERC.

Pages 28 & 29 – The chart of lithium coin cell manufacturers fails to include Renata and Sony. The VL battery listed for Panasonic is a rechargeable lithium ion coin cell, not a lithium coin primary battery.

Page 35 – The report incorrectly states that button batteries are hazardous wastes and fall under the universal waste rule. Only silver oxide button cells are likely to test positive as a hazardous waste and that is because of the silver not mercury. Of much greater importance to collection are the Research and Special Programs Administration's regulations requiring the shipping of batteries in a manner that prevents batteries from short-circuiting. The report does not even mention these requirements.

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

JOHN ELIAS BALDACCI
GOVERNOR

DAWN R. GALLAGHER
COMMISSIONER

Memorandum

To: Audiologists and Hearing Aid Dealers

From: John James

Date: November 29, 2004

Re: Hearing aid batteries

I write to alert you that hearing aid batteries likely will be a topic of discussion in the upcoming session of the Maine Legislature.

Manufacturers have eliminated the use of mercury in most household batteries but mercury still is used in button cell batteries. U.S. battery manufacturers report they used over 5000 pounds of mercury in button cells sold in the U.S. in 2002. About 85% of this mercury was in the zinc-air batteries used in hearing aids.

Mercury use in batteries is a concern because mercury is a potent neurotoxin. The mercury can be released to the environment during battery manufacture, use and disposal. When released, the mercury tends to accumulate in aquatic ecosystems where it builds up in fish. The levels have become so high that the Bureau of Health has advised people to limit their consumption of fish caught in Maine waters. Pregnant women and infants are at particular risk. Exposure to mercury even at low levels can impair fetal development.

Over the last several years, the State of Maine has taken aggressive action to address this health threat by reducing the use of mercury in products. The Legislature already has enacted bans on the sale of many mercury-added products, including thermometers, thermostats and most switches.

Attention now has shifted to mercury in button batteries, especially in light of recent publicity about the presence of mercury-added batteries in toys distributed with breakfast cereal and fast food meals. Earlier this year, the Maine Legislature passed a law that requires this department to review the use of mercury in button batteries and report back by January 14, 2005.

To assist in preparation of the report, we hired the Lowell Center for Sustainable Production (LCSP) at the University of Massachusetts to:

AUGUSTA
17 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0017
(207) 287-7688
RAY BLDG., HOSPITAL ST.

BANGOR
106 HOGAN ROAD
BANGOR, MAINE 04401
(207) 941-4570 FAX: (207) 941-4584

PORTLAND
312 CANCO ROAD
PORTLAND, MAINE 04103
(207) 822-6300 FAX: (207) 822-6303

PRESQUE ISLE
1235 CENTRAL DRIVE, SKYWAY PARK
PRESQUE ISLE, MAINE 04769-2094
(207) 764-0477 FAX: 764-1507

web site: www.maine.gov/dep

- Estimate the amount of mercury used annually in the manufacture of button batteries;
- Identify and evaluate nonmercury alternatives; and
- Investigate button battery recycling programs.

LCSP has completed its draft report "An Investigation of Alternatives to Miniature Batteries Containing Mercury." If you would like to review this report, please contact me for a copy.

Among other things, LCSP found that manufacturers are beginning to introduce mercury-free versions of the three button battery types in which mercury currently is used, including the zinc air type used in hearing aid batteries. The LCSP findings also suggest that collection of button batteries for recycling is feasible and affordable, and will become more efficient and cost effective if recycling becomes more widespread.

Based on the LCSP findings, our report to the Maine Legislature likely will recommend one of two strategies to reduce mercury emissions from batteries: 1) a ban on the sale of mercury-added batteries; or 2) a ban on their disposal.

- A ban on the sale of mercury-added batteries. The most effective strategy for eliminating mercury emissions from batteries is to use mercury-free batteries. The LCSP reports that mercury-free versions of all three battery formulations that currently use mercury--zinc air, silver oxide and alkaline manganese--have been introduced to the marketplace. Because these mercury-free models are new, data on their long-term performance is lacking. Manufacturers are confident, however, that the performance characteristics of the mercury free batteries will prove to be comparable to mercury-added models.

  While production currently is limited, the mercury-free technology can be expected to quickly become the worldwide standard. Maine and other states could hasten the transition by banning the sale of mercury-added batteries as has been done previously with mercury switches, relays, thermostats, thermometers and other mercury-added measuring devices. The effective date of the ban should be set to give the industry time to develop sufficient production capacity and to ensure that hearing aid users in particular will have access to mercury free replacement batteries. An effective date of January 1, 2008 would provide almost three years for battery manufacturers to make production adjustments.

- A ban on the disposal of mercury-added batteries. As an alternative to an outright ban on the sale of mercury-added batteries, the Maine Legislature could add batteries to the definition of mercury-added product under 38 MRSA §1661. This would have the effect of making batteries subject to the law banning disposal of mercury-added products in the trash [38 MRSA §1663] and the law requiring that mercury products be labeled prior to sale [38 MRSA §1662]. While labeling of the button cell itself may not be practical because of its small size, labeling of the battery packaging will help consumers identify which batteries contain mercury so they can be kept out of the trash and recycled.

A disposal ban will require that provision be made to collect the batteries for recycling, raising the issue of how this should be done and who should be responsible. Municipalities traditionally have provided most waste disposal and recycling services, but policy makers increasingly are turning to manufacturers to share the cost of handling wastes that have toxic constituents like mercury. This approach is attractive because it shifts costs from municipal solid waste budgets to the marketplace. If manufacturers must pay the costs of safely managing any mercury in the product, they have a powerful incentive to redesign the product to eliminate the use of this toxic substance.

We likely will recommend that manufacturers share responsibility for putting an effective collection system in place if the Maine Legislature decides to ban the disposal of mercury-added batteries. Maine law at 38 MRSA §2166(3) provides one possible approach. That law requires manufacturers of mercuric oxide or rechargeable batteries to do the following:

- Establish and maintain a system for the proper collection, transportation and processing of the batteries for purchasers in this State;
- Clearly inform purchasers of the batteries of the prohibition on disposal and the available systems for proper collection, transportation and processing; and
- Include the cost of collection, transportation and processing of the waste batteries in the battery sales price.

The department invites your input regarding the two mercury reduction strategies outlined above, including your views on whether either strategy would result in hardships for you or your customers. We also welcome your suggestions and ideas about the best way to collect spent hearing aid batteries if the Legislature decides to ban their disposal and require that they be recycled. Would you be willing to educate your patients and customers about the need for recycling? Would you be willing to provide collection services for hearing aid users?

To ensure we have time to fully consider your comments in preparing our final report to the Legislature, we must receive them by December 21, 2004. Our final report is due by January 14, 2005.

I look forward to hearing from you on this important matter. Please feel free to call me at 207 287-7866 or email me at john.james@maine.gov.

Gil Poliquin
hearing aid & optical center, inc.
50 Lisbon Street, Lewiston, ME 04240
(207) 784-0333 800-649-0334 Fax (207) 784-9346

12-15-04

Mr. John James
17 State House Station
Augusta, ME 04333

Dear Mr. James:

"Mercury is becoming a huge issue" states Bill Hanson, a senior Biologist with FPL Hydro Energy of Lewiston. And he sites the bad air from coal burners down wind of us appear to be the major contributors. Is the environmental impact of the mount of mercury found in hearing aid battery button cells comparable?

My concern is for the hearing impaired utilizing amplification every day, all day. The amount of mercury used in button cells for hearing aid use in the US appears to be significant. It is important to consider what percentage of Maine hearing aid users consume in that total. I can only assume that number is quite small and the consequential environmental impact may not outweigh the hardships that a ban or required disposal policy may pose.

The majority of hearing aid users are elderly. They are complaining about the high cost of medication and some are not taking drugs because of financial constraints. I encounter hearing aid users who turn their hearing aids off during the day just to conserve the battery life. Adding cost to this part of their hearing health needs should be avoided.

I am not aware of any practical replacement of Zinc Air batteries at this time. I have heard of attempts but these has been either unsuccessful of very expensive. The battery manufacturers need to be pressured to develop alternatives, not the consumers or caregivers. Please keep in mind that this is not a luxury item. We're not talking about toys in cereal boxes or kid's sneakers that light up. Hearing aid batteries are a necessity for a number of disabled, most often living on a fixed income.

Establishing a collection system, using labeling and encouraging voluntary compliance would probably be the best way to reduce the mercury contamination stemming from hearing aid battery disposal. Requiring it would definitely increase the cost and it is naïve to think the manufacturers will absorb this expense. And then there's the cost in creating an agency to establish and maintain a system.

Thank you for hearing me,

Gil Poliquin, BC-HIS

James, John

From: Jean Toth [toth@ainop.com]

Sent: Tuesday, December 21, 2004 4:37 PM

To: john.james@maine.gov

Subject: hearing aid batteries

Mr. James, In reponse to your memorandum regarding hearing aid batteries, I wanted to take a moment to share my thoughts. I am interested in taking the steps necessary to protect the environment.

It is my understanding that the amount of mercury in hearing aid batteries has been reduced substantially, and is now minute. Before I start advising my clients to collect dead batteries at home, and deliver them to a collection site periodically, serious consideration needs to be given to the hazard that will be created. I talk to every client about the dangers of swallowing a hearing aid battery, and safe handling of batteries. In the past twenty years, I have had one client actually swallow a battery. That person was a ten year old child. If each person now collects the old batteries in a can or box at home, how many children will suffer the consequences of ingesting a battery? I can't help but think that the incidence of such occurrences will increase markedly.

Another concern of mine is that we will be taking the minute quantities of mercury found in an individual's trash when they dispose of a couple batteries per months, and gathering them into one large hazard area. What assurance do we have that a new system will be better for people and better for the environment? I am not ready to ask my clients to collect dead batteries in their homes.

I look forwar to the next update on this matter.

Jean L. Toth, M.A., CCC-A
Audiologist
Aural Rehabilitation Services
Presque Isle, Maine

APPENDIX D

National Electrical Manufactures Association

- *Button Cell Battery Collection: Why It Does Not Make Sense*
- *Analysis of Battery Industry Sponsored Button Cell Collection Programs*

Setting Standards for Excellence

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209
703-841-3200
Fax: 703-841-3300

BUTTON CELL BATTERY COLLECTION: WHY IT DOES NOT MAKE SENSE

JANUARY 2003

BUTTON CELL BATTERY COLLECTION: WHY IT DOES NOT MAKE SENSE

Some states and local communities have proposed collecting button cell batteries because the batteries contain mercury. This paper will discuss why such collection does not make sense.

USE OF MERCURY IN BATTERIES

At one time, battery manufacturers used small amounts of mercury to suppress the formation of internal gasses that affect all batteries containing zinc electrodes. Gassing can lead to leakage, possible rupture and/or short shelf life of batteries. The battery industry developed alternative product designs that eliminated added mercury in all batteries except button cells. In addition, the industry offered the zinc-air button cell to replace mercuric oxide button cells used primarily in hearing aids. These alternatives resulted in a decrease in mercury use of over 1,000 tons per year. The US Department of the Interior has published a chart showing this decline in the following document, http://minerals.er.usgs.gov/minerals/pubs/commodity/mercury/.

TYPES OF BUTTON BATTERIES

Button batteries are used in hearing aids, digital thermometers, insulin pumps, portable medical monitors, hospital pagers, watches, toys and calculators.

Silver oxide and alkaline manganese button cells provide a nominal 1.5 volts per cell -- zinc air button cells provide a nominal 1.4 volts per cell.

Zinc air button cells are used primarily in hearings aids. Oxygen, which reacts with the zinc electrode, is obtained from air that enters the cell from one or more holes. Because of need for continuous supply of air, zinc air batteries cannot be used in tightly sealed products. Because zinc air cells are used in hearing aids, this chemistry is the most prevalent type of button cell. Because of the number of zinc air batteries sold and the level of mercury in these cells, zinc air button cells contain over 70% of the mercury used in button cells.

Alkaline manganese and **silver oxide** button cells may be used in tightly sealed products. Common applications include watches, toys and calculators.

Lithium coin cells are similar in appearance to coins and provide a nominal 3 volts per cell. Lithium coin cells cannot be interchanged with other button cells because of their different size and different voltage. Lithium coin cells contain no mercury.

Mercuric oxide button cells use mercuric oxide as an electrode. This results in these cells containing 30-40% mercury by weight. These cells were used primarily in hearing aids. The battery industry phased out these cells between 1991-1995. Federal law enacted in 1996 bans the sale of these cells.

WHY THE BATTERY INDUSTRY USES MERCURY IN BUTTON CELLS

Beginning in the 1980s, the battery industry increased the refining of zinc to reduce impurities that lead to gassing. The large size of cylindrical and rectangular alkaline manganese batteries allows these batteries to be packed less fully and allow for some internal expansion. These and other factors prevent the buildup of internal gas pressures that cause leaking or cell rupture.

Button cells present unique problems. They are relatively small. In addition, manufacturers need to provide maximum energy in their small interiors to provide acceptable battery power and reliable performance. This results in little or no room for any internal gas buildup before it affects the button cell. Gas buildup can cause bulging that can lead to leakage and/or rupture. US federal law and the laws in many states reflect this need for mercury by allowing levels of up to 25 mg in alkaline button cells. The industry did offer the zinc-air button cell to replace the mercuric oxide button cell in hearing aides resulting in a greater than 98% reduction in mercury use per button cell.

Cumulatively, all button cells sold in the US on an annual basis contain less than 2 tons of mercury. That means the battery industry has reduced its use of mercury from over 1,000 tons per year to less than 2 tons per year. Two-thirds of the mercury in button cells is in zinc air batteries because of the large number of batteries used in hearing aids. The average mercury levels are 3 mg in silver oxide cells, 8 mg in zinc air cells and 11 mg in alkaline manganese cells. This means that only one pound of mercury is used to manufacturer 57,000 zinc air batteries.

COLLECTION OF BUTTON CELLS PRESENTS UNIQUE COST, SAFETY AND ENVIRONMENTAL PROBLEMS

A. **Collection of button cells is not cost-efficient** – Collection of button cells is not cost-efficient because there is little mercury in each cell. This results in the need to collect very large numbers of button cells to collect very little mercury. There are a wide range of distribution sources for button cells, but no established collection infrastructure. A new program would be required to collect button cells. This effort would need to be independent of established program such as the Rechargeable Battery Recycling Corporation (RBRC). Button cell collection is incompatible with the RBRC program due to concerns with contaminating the RBRC collection effort with mercury. Furthermore, there is little economic sense to collect button cells for the small amount of mercury they contain because there is no value in recovered mercury and collection costs are significant.

B. **Collection and storage can create a safety hazard** – Storing large quantities of loose, unpackaged button cells can create a safety hazard. Used button cells may still contain small amounts of energy and there is the possibility that collected batteries may be short-circuited, creating heat and in unusual cases even fires if the battery terminals remain in contact and the batteries have been mixed with flammable materials. To avoid this problem button cells would have to be stored to ensure that their terminals are not in contact increasing processing of button cells and collection costs.

In addition, storing batteries is likely to lead to an increase in battery ingestion by young and old as people retain button cells for collection. Such ingestions can, in a few situations, lead to serious injury. The Director of the National Capital Poison Control Center opposes button cell collection because of the likely increase in ingestions.

C. **Environmental costs of collection and transportation are likely to exceed the small environmental benefits** – A life cycle analysis of various collection systems conducted for the British Government shows that collecting and transporting primary batteries may have greater detrimental environmental impact than any benefits gained from recycling batteries. Available data shows that emissions of mercury from landfills are small. The EPA Mercury Report to Congress estimates that landfill emissions of mercury from all sources are less than 0.1 tons nationwide. An estimate of mercury emissions from Florida landfills conducted with the Florida DEP concluded that landfills contribute less than 1% of manmade sources of mercury emissions. Finally, the 2002 New Jersey Mercury Report came to the following conclusion: "Low concentration of mercury in landfill gas...argues that no efforts to control this source are necessary at this time." Data also shows that incinerators are no longer a major source of emissions. A 2002 EPA memo shows mercury emissions from incinerators declined in the US from 42 tons in 1990 to 2 tons in 2000. This would be less than 2% of all manmade sources of mercury emissions in the US.

SUMMARY

- The battery industry has virtually eliminated the use of added mercury.
- For performance and safety reasons, button cells require very small amounts of added mercury.
- Collection is not cost-efficient.
- Collection can cause safety hazards.
- Collection can cause more environmental harm than any benefit that might result.
- No country or US state requires only button cell collection.

NEMA

The Dry Battery Section of the National Electrical Manufacturers Association (NEMA) is the trade association of United States manufacturers of dry cell batteries. Members of the NEMA Dry Battery Section (http://www.nema.org/drybattery/) include:

Duracell, Inc.
Eastman Kodak Company
Eveready Battery Company, Inc.
Panasonic Industrial Company
Polaroid Corporation
Rayovac Corporation
Renata SA
Saft, Inc.
Wilson Greatbatch, Ltd.

For additional information, contact:

NEMA
1300 North 17th Avenue, Suite 1847
Rosslyn, Virginia 22209
Telephone: (703) 841-3200
Fax: (703) 841-3300
Website: www.nema.org

Analysis of Battery Industry Sponsored

Button Cell Collection Programs

Presented to the

Dry Battery Section
National Electrical Manufacturers Association

December 19, 2003

Prepared by

Richard F. Tozer
Consultant to Management
2911 Turtle Creek Blvd., Suite 300
Dallas, Texas 75219

Phone 214-521-3440
rftozer@hotmail.com

Member, The Institute of Management Consultants

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The General Assembly of the State of Connecticut has determined that

> "mercury is a persistent and toxic pollutant . . .[and] . . . the virtual elimination of the discharge of anthropogenic mercury should be pursued."

Public Act 02-90 effective July 1, 2002 requires that battery manufacturers create a program to collect used button cell batteries containing mercury. The Department of Environmental Protection is enforcing this legislation, which also permits the Commissioner to grant exemptions for products for which collection is deemed not feasible.

The Dry Battery Section of the National Electrical Manufacturers Association (NEMA) has asked me to assemble and analyze available information regarding the feasibility of collection programs for button cell batteries. This document is my report.

Button cells are tiny electrical batteries packaged in tiny metal containers approximately the size and shape of shirt buttons. They are used to power an almost endless array of electronic devices: watches, cameras, calculators, hearing aids, toys, games, medical devices, small flashlights, etc. Button cells that use silver oxide, manganese alkaline, and zinc-air electro-chemical systems contain trace amounts of mercury.

Button cell batteries have no value independent of the devices in which they are used. Most of the value realized by consumers is in the cost of the devices; most of the remaining value is in the retail distribution of the button cells, not in their manufacture. Button cells that sell at retail for a few dollars are advertised at the manufacturer's level for about thirty cents. Devices such as watches and hearing aids may cost as much as hundreds or thousands of dollars.

Total button cell battery manufacturers' profits on the sale of batteries purchased by Connecticut consumers are estimated to be about a quarter of a million dollars per year. This figure is something of an upper bound on the cost of a manufacturer-financed collection program, since manufacturers are free to stop selling batteries in Connecticut if the costs of the program exceed their profits in the state.

Seventeen other states and the Federal government have passed some type of battery law and none of these requires collection of button cells by anyone. Without a legislative mandate on retailers or device manufacturers there is no way battery manufacturers can recover the costs of a collection program from consumers.

Virtually every consumer in Connecticut uses one or more devices powered by one or more button cells. No one knows how many such devices are sold to consumers in Connecticut each year, but manufacturers estimate that each year several million button cells are sold in the replacement market in the state.

Programs already exist to collect silver oxide button cells. These programs are driven by the financial value of the silver that can be recovered from these cells. Unfortunately, the materials that can be recovered from manganese alkaline or zinc-air button cells are worth less than the cost of recovery.

No one knows exactly how button cells are distributed. Button cell manufacturers do not sell directly to consumers in Connecticut, but through a maze of intermediate distribution channels to several thousand retail points in Connecticut: mass-market retailers, specialty stores, jewelers, watchmakers, audiologists, hearing aid specialists, internet vendors, and by mail order from vendors inside and outside the state. Each of these retailers is an independently owned business.

There do not appear to be any obvious high volume retail outlets at which manufacturers could collect a significant portion of used button cells or capture a significant amount of mercury. Since retailers in Connecticut are not required by law to participate, they have minimal incentive to cooperate.

We have identified seven related battery collection programs: the silver oxide button cell collection programs organized by the American Watchmakers Association and the silver recovery industry, various battery collection programs operating in Europe, two community-based battery collection programs and one mercury collection program operating in the United States, the Rechargeable Battery Recycling Corporation program for rechargeable batteries, and the Thermostat Recycling Corporation program for recovery of mercury in thermostats.

The silver oxide collection programs (which currently operate in Connecticut) are the only battery collection programs we can identify that have been financed without financial assistance from another party. Financing by state and local governments, or by retailers and device manufacturers operating under a legislative mandate has been required for every other program. These financial sources are not available to support the collection of other button cells in Connecticut.

All button cell collection programs in Connecticut (or elsewhere) are limited by nine significant constraints: the risk of fire safety, U.S. Department of Transportation regulations regarding shipping, the risk of ingestion by consumers, contamination of the waste stream by lithium batteries and other contaminants, the need and cost of educating consumers, the cost and limited availability of insurance, uncertain access to recycling, contingent Superfund liability, and environmental costs.

Used button cells may contain small amounts of energy when disposed of. If multiple batteries are placed in contact, there is a risk of sparking, short circuits, high temperatures, leakage, and fire. Consequently, U.S. Department of Transportation regulations require that battery terminals be separated during shipment. This regulation implies that used button cells would have to be taped or placed in individual plastic bags for shipment, a time consuming and expensive process.

More than eighteen hundred button battery exposure cases are reported to U.S. poison control centers each year. Most of these are ingestions by young children or the elderly. The effects can be serious. Button cell collection programs will encourage consumers to stockpile used batteries for collection and recycling and thus exacerbate this problem.

Lithium cells or other contaminants may contaminate the waste stream of used button cells when collected. Lithium cells are similar in appearance but larger than button cells; they do not contain mercury, but the lithium electrolyte is flammable. These batteries also contain metallic lithium, a highly reactive metal, that when exposed to water liberates hydrogen, a very flammable gas. If these batteries are opened at a mercury recycling facility they will ignite. Lithium battery contamination of the waste stream would result in a recycling facility receiving material it is not permitted to handle, placing its permits in jeopardy and exposing it to potential fines.

Individual consumers and retail employees throughout Connecticut have assumed, learned or been taught that it is legal and appropriate to dispose of used button cells one by one in the household waste stream. The success of any additional button cell collection program depends on the industry's ability to change this attitude. It is unlikely that consumer or employee attitudes can be changed with a budget of less than the button cell manufacturers' annual profits in Connecticut.

Any new button cell collection program can be expected to be held liable for damages that may be caused by the collection, sorting, packing, transportation, and recycling of the used button cells. Insurance will be required. Whether such insurance is available, and if so, at what cost, is unknown. Such insurance costs tend to be fixed, rather than dependent on the volume of material collected.

NEMA has identified only one company capable and interested in recovering mercury from mixed used button cells. Should this company be unable to perform, and if NEMA cannot identify an alternative company interested in taking mixed used button cells, then any new button cell collection program would be unable to recover mercury and collected batteries would be disposed of in landfills, essentially returning them to the waste stream from which they had been collected at great effort and expense.

This one company is a Superfund site. Persons that dispose of waste material at Superfund sites become jointly and severally liable for all past and future costs of cleanup. It seems doubtful that the continued profits on the sale of button cells in Connecticut alone are sufficient to justify a manufacturer taking on this contingent liability.

Collection, sorting, packing, transportation, and recycling of used button cells in a newly developed collection program will create additional environmental impacts. The nature and magnitude of these impacts is difficult to calculate and will depend on the design of the program and its relative success.

An additional button cell collection program in Connecticut may require significant startup costs plus annual expenditures for education, marketing, and promotion of the program; for containers, shipping, and processing of the button cells; and for management, general, and administrative expense, including insurance, and the cost of a web site and 1-800 phone system if needed. These costs are largely fixed, rather than dependent on the volume of material collected.

The vast majority of mercury being deposited in Connecticut is coming from outside the region. Even within the region, Connecticut emissions would make up a small portion of emissions in the region. Button cells make up a tiny portion of mercury entering the state's municipal solid waste incinerators. Any effort to collect button cells in Connecticut will result in virtually no change in mercury deposition in Connecticut.

No state requires the labeling of button cells. No other state requires manufacturers to collect button cells. No state bans the disposal of button cells.

NEMA members would operate any new button cell collection program in Connecticut by setting up a new corporation to collect and recycle used button cells. The owners of the new corporation would then contract with NEMA or another entity to manage it. Legal fees, insurance, and other setup costs for the new corporation alone could easily exceed the industry's annual profits on batteries sold to consumers in Connecticut.

Once established, the new corporation would select one or more of five collection programs: retail take back, partnership with audiologists/hearing instrument specialists, mail back, partnership with household hazardous waste collection, or partnership with municipal transfer stations.

Each of these alternatives has a different set of appropriate partners who would operate the points at which citizens would offer used button cells for collection. Each potential program is either cost prohibitive, or would require partners with little or no incentive (and no legal mandate) to participate, or would require complex arrangements which appear to be inefficient and/or cost prohibitive. Each alternative would increase the risk of fire and ingestion.

The House sponsor of Public Act 02-90 assumed that the Department would decide that it was unfeasible to establish a program to collect button cell batteries.

2. LEGISLATIVE HISTORY

In Section 1 of Public Act 02-90 effective July 1, 2002, the General Assembly of the State of Connecticut determined that . . .

> "mercury is a persistent and toxic pollutant that bioaccumulates in the environment, and that in order to create and maintain a healthful environment and protect public health, the virtual elimination of the discharge of anthropogenic mercury should be pursued."

When originally introduced in the legislature, the bill creating this act banned the disposal of all mercury containing products, including button cells, or products containing button cells in Connecticut. When the Act was passed, this ban had been deleted, and replaced by provisions calling for the creation of collection programs for mercury containing products.

Specifically, among other provisions, Section 9 of the Act specified that . . .

> (a) On and after July 1, 2003, no person shall offer any mercury-added product for sale or distribute any such product for promotional purposes unless the manufacturer either on its own or in concert with other persons has submitted a plan to the commissioner [of the Department of Environmental Protection] for a system that reasonably enables the collection of such products. If a mercury-added product is a component of another product, the collection system shall provide for removal and collection of the mercury-added component or collection of both the mercury-added component and the product containing it.
>
> (b) The collection system shall include (1) a public education program to inform the public about the purpose of the collection program and how to participate in it; (2) a targeted capture rate for the mercury-added product or component; (3) a plan for implementing and financing the collection system; (4) documentation of the willingness of all parties to the system to implement the proposed collection system; (5) a description of the performance measures to be utilized and reported by the manufacturer to demonstrate that the collection system is meeting capture rate targets; (6) a description of additional or alternative actions that will be implemented to improve the collection system and its operations in the event that the program targets are not met; and (7) a recycling or disposal plan.
>
> And . . .
>
> (d) The cost for the collection system shall not be borne by state or local government.

It further specified that . . .

> (f) The following are exempt from the provisions of this section . . . (5) any other product for which the commissioner determines a collection plan is not feasible.

Thus it remains legal for anyone to dispose of virtually all button cells or products containing button cells in the state.

The House sponsor of the bill creating this Act was Representative Jessie Stratton, House Chair of the Joint Environment Committee. During floor debate, she engaged in the following interchange with Representative Lou Wallace:

Representative Wallace:

> "Section 9 allows the Commissioner to waive certain items from a collection plan due to its small size and traced amounts of mercury. Would button cell batteries likely be exempt from collection?"

Representative Stratton:

> "Yes, it would be my assumption that the Department would decide that it was unfeasible to particularly establish a specified collection program for button cell batteries."

You have asked me to assemble and analyze available information regarding the feasibility of various industry sponsored button cell collection programs that could be implemented in response to the Act. This document is my report.

3. BACKGROUND

a. The Product

"Button cells" are miniature electric batteries packaged in tiny cylindrical metal containers approximately the size and shape of commonly used buttons. Some are smaller than the tiny buttons used on dress shirt collars.

Each button cell is constructed from six major components: an anode (zinc), a cathode (silver oxide, manganese dioxide, oxygen), a tiny cylindrical metal can, a potassium hydroxide electrolyte, a round metal plate forming the top of the can, and a rubberized or plastic insulating seal that bonds the top to the can, preventing leakage. The can and the flat plate top are the electrical terminals of the battery.

Button cells that contain added mercury commonly fall into three electro-chemical systems: manganese-alkaline, silver oxide, and zinc-air. Each of these electro-chemical systems delivers a trickle of direct current at approximately one and one half volts. Each has a unique energy density, useful life, and capacity for delivering power over time. Each system is manufactured in various sizes.

Button cell manufacturers also produce a few models in which button cells are stacked to create a six-volt or twelve-volt unit. These models may be confused in appearance with round cells used in flashlights.

b. Applications

Button cells are used to power an almost endless array of electronic devices: watches, cameras, calculators, hearing aids, toys, games, medical devices, small flashlights, etc.

Each chemical system is associated with specific product applications, is used in a specific manner, and is packaged, distributed, and sold somewhat differently.
In a recent survey, NEMA member button cell manufacturers reported that approximately three quarters of all silver oxide batteries are used in watches. Most of the remaining silver oxide batteries are used in cameras. Only a very small percentage of the silver oxide batteries manufactured are used in toys, games, medical devices, etc.

About ninety percent of manganese alkaline button cells are used in cameras. Less than one percent each are used in toys, games, and watches; the balance are used in a wide variety of other devices.

Silver oxide and manganese alkaline button cells used in watches, cameras, calculators, toys, games, and medical devices come in more than forty-five sizes and shapes and have a useful life measured in years. Consumers buying replacements typically buy one unit at a time, infrequently, to replace a battery that has been depleted in service. Replacement silver oxide button cells are typically packaged in individual packages. Consumers usually buy them only as needed and almost never maintain an inventory of fresh silver oxide or alkaline button cells.

One hundred percent of zinc air button cells are used in hearing aids. These devices have a much higher power drain than watches, etc. As a result, zinc-air button cells have a useful life measured in days; they are produced in just five sizes. Replacement zinc-air button cells are typically packaged in multiples: six packs, eight packs, and twelve packs. Hearing aid users typically buy multiple units at a time, frequently, in anticipation of need, and often maintain an inventory of fresh zinc-air button cells.

c. Attributes of The Button Cell Value Chain

A button cell battery has no intrinsic value in and of itself until it goes into some other device and retailers sell that other device. The cost of button cells to consumers is tiny compared to the value of the devices in which they are used. Button cells costing no more than one to three dollars at retail are commonly used to power hearing aids costing more than a thousand dollars, watches costing more than a hundred dollars, andcostly cameras and medical devices. Most of the value realized by consumers is in the costof the device; most of the value that remains is in the retail distribution of the button cell, not in its manufacture. Button cells that sell in retail stores for a few dollars are advertised at the manufacturer or master distributor level for sale at about $0.30.

The market for button cells is mature and growing slowly. Although manufacturers work diligently to differentiate their brand names and their products, button cells are often regarded by consumers as commodities and are often sold and promoted on price. Price competition is fierce.

In a survey completed in September 2003, NEMA member button cell manufacturers estimated that their estimated profits from the sale of button cells in Connecticut in 2002 were $267,848, of which $37,671 was from the sale of manganese alkaline cells, $102,024 was from the sale of silver oxide cells, and $128,153 was from the sale of zinc-air cells.

The manufacturer's profit represents something of an upper bound on the costs of any reasonable collection program in Connecticut. Button cell manufacturers will have no way of imposing the costs of such a program on to consumers in Connecticut so the costs of the collection program will have to be paid by consumers throughout the country. It makes little sense for the button cell manufacturers to pay more for a program in Connecticut than their profits in Connecticut, since they have the option of labeling their battery packaging "Illegal for sale in Connecticut" and essentially leaving the state.

d. Mercury Content

The battery industry has taken the initiative in reducing the mercury content of its products. All mercury has been eliminated from round cells. In button cells, manufacturers significantly reduced the mercury content of hearing aid batteries by replacing the mercuric oxide electro-chemical system with the zinc-air system. This change reduced the amount of mercury per cell by 98%. Battery manufacturers continue to research alternatives to the use of mercury in button cells.

Each of the current button cell electro-chemical systems uses very small amounts of mercury as an amalgamated component on the anode to prevent internal discharge and gassing, both of which present serious leakage issues. Use of mercury also allows a high rate of discharge, necessary in some small applications. Leakage would shorten battery life and cause damage to the device in which the battery was installed, and in certain hearing aids, wristwatches, and medical devices, could potentially expose the user to serious, immediate and acute adverse health effects.

The amount of mercury in each button cell varies by electro-chemical system, cell size, and manufacturer but each cell contains less than 25 mg of mercury. During the past decade, battery manufacturers have consistently reduced the average amount of mercury per cell.

In its September 2002 submission to the Interstate Mercury Education and Reduction Clearinghouse of the Northeast Waste Management Officials' Association, NEMA reported that in 2000 the amount of mercury in each silver oxide button cell ranged from a low of 0.74 milligrams (mg) to a high of 16.27 mg, with an average of 3.1 mg. The amount of mercury in each zinc-air button cell was reported to range from a low of 1.3 mg to a high of 24.8 mg, with an average of 7.9 mg. The amount of mercury in each manganese alkaline button cell was reported to range from a low of 0.006 mg to a high of 17 mg, with an average of 11.4 mg. There were no significant changes in 2001.

A new survey of NEMA members was completed in September 2003. Based on the weighted average of the sizes of cells actually sold by each manufacturer, this survey determined that the average silver oxide button cell currently contains 2.5 mg. of mercury, the average zinc-air button cell currently contains 8.5 mg. of mercury, and the average manganese alkaline button cell contains 10.8 mg. of mercury. The more recent survey included data from one additional NEMA member who had joined since the 2000 survey was completed.

A fourth electro-chemical system, based on the element lithium, is also used, primarily in somewhat larger batteries, called "coin cells" because many of them are approximately the size and shape of common coins. Lithium cells come in a variety of sizes and shapes and deliver electrical direct current at approximately three volts. Lithium cells do not contain mercury. A complicating factor is that lithium cells are used in watches, cameras, and many of the other applications that use button cells.

Lithium cells are a concern for any button cell collection program because they are often confused with button cells and can be expected to contaminate the button cell waste stream. Unlike the other systems, lithium battery electrolyte is flammable.

In the September 2003 survey, NEMA members estimated that the button cells they shipped in the United States in 2002 contained 5,283.5 pounds of mercury, of which 269.6 pounds were in manganese alkaline cells, 473.6 pounds were in silver oxide cells, and 4,540.3 pounds were in zinc-air cells. NEMA members believe they supply the overwhelming majority of button cells sold in the United States.

No comparable data is available for the state of Connecticut. However, according to the Statistical Abstract of the United States, the 1997 Census of Retailers, and Hearing Journal magazine respectively, Connecticut has about 1.2% of the population of the United States, about 1.4% of the retail sales, and about 1.0% of hearing aid sales.

These factors indicate that in 2002 Connecticut consumers purchased about 3,785,000 button cells manufactured by NEMA members. These cells contained about 55.8 pounds of mercury. Of these totals, about 160,000 (containing about 3.8 pounds of mercury) were manganese alkaline cells, about 1,200,000 (containing about 6.6 pounds of mercury) were silver oxide cells, and about 2,425,000 (containing 45.4 pounds of mercury) were zinc-air cells.

Collection programs already in place for silver oxide cells have been reported to achieve a 95% collection rate. (See below).

e. Distribution Channels

Button cells are ubiquitous. Virtually every consumer in Connecticut uses one or more devices powered by a button cell.

Button cells reach consumers through a maze of diverse, complex distribution channels which are somewhat different for each application and therefore, for each chemical system. Manufacturers do not sell button cells directly to consumers. Few button cell manufacturers have a physical presence in Connecticut; some foreign manufacturers have no physical presence in the United States.

Button cells are not taxed separately from other products. No statistical reporting of button cell shipments is required by any government agency. Valid, universally recognized, published market research data regarding the sale of button cells is not available.

Button cells are sold through the original equipment market and the replacement market.

In the original equipment market, button cell manufacturers sell directly and indirectly through distributors to manufacturers, wholesalers, and retailers of electronic devices (watches, cameras, calculators, hearing aids, toys, games, etc.) who provide button cells as original equipment when the devices are sold to consumers. Some of these device manufacturers, wholesalers, and retailers also use their channels of distribution to offer button cells to consumers for replacement purposes.

In the replacement market, button cell manufacturers sell directly to some retail accounts, and indirectly through distributors to a large number of other retailers, traditional mail-order houses, and internet based vendors.

An individual button cell may pass through multiple levels of distribution between the manufacturer and the consumer. Each participant in these replacement market distribution channels is an independent business that fiercely guards its customer list. The button cell manufacturer has no control and little influence over its customers. Because of the complexity of the distribution channels, manufacturers generally do not know the identity of the retail outlets that sell their button cell batteries directly to consumers, and do not know the ultimate destination of the button cells they ship.

Button cells shipped into Connecticut may be re-exported to other states; conversely, button cells shipped into other states may be reshipped to retailers and mail order houses that sell to consumers in Connecticut. Also, Connecticut residents may buy button cells out of state personally, by mail order, or on the internet.

A manufacturer may sell button cells to a distributor in Connecticut who resells those batteries to a distributor or retailer in another state; or, the manufacturer may sell button cells to a distributor in another state who resells those batteries into the state of Connecticut.

Connecticut consumers acquire replacement button cells from mass-market retailers, specialized retailers, and mail order and internet vendors, both in-state and out-of state.

f. Mass-Market Retail Channels

NEMA member button cell manufacturers believe that the majority of button cells of all three chemistries reach consumers through mass market retail channels: food and drug stores, department stores, warehouse clubs, hardware stores, office supply stores, and electronics stores.

According to the 1997 Census of Retailers (the latest available) Connecticut was home to 783 supermarkets, 549 pharmacy and drug stores, 130 department stores, 14 warehouse clubs and superstores, 109 variety stores, 199 hardware stores, 586 electronics and appliance stores, 101 office supply stores, and 350 convenience stores, a total of 2,821 mass-market retail outlets, each of which was a potential (and likely) retail outlet for button cells. These numbers have probably not changed appreciably, and are consistent with current data on the number of retail taxpayers supplied by the Department of Revenue Services.

Mass-market retailers typically display button cells in more than one location in each store. There are multiple points of contact in each store at which each button cell purchase transactions may occur. Many of these points of contact are self-serve, and are not staffed.

Button cells that are regarded as impulse purchases are displayed at checkout counters; hearing aid (zinc-air) batteries are displayed at the pharmacy window; a wide selection of button cells is displayed along with all other batteries, flashlights, etc.; and a few button cells may be displayed along with the devices they power (watches, cameras, etc.). Mass-market retailers of size have multiple checkout counters.

If mass-market retailers handled 60% of the button cells sold in Connecticut in 2002, and if the calculations made above are correct, then in 2002 mass-market retailers in Connecticut sold about 2,271,000 button cells containing a total of about 33.5 pounds of mercury. Of these totals, about 96,000 (containing about 2.3 pounds of mercury) were in manganese alkaline cells, about 720,000 (containing about 4.0 pounds of mercury) were in silver oxide cells, and about 1,455,000 (containing about 27.2 pounds of mercury) were in zinc-air cells.

If each of the 2,821 potential retail outlets in Connecticut did in fact carry button cells, and if the above calculations are correct, then on the average each retail outlet in Connecticut sold 805 button cells containing a total of 0.0119 pounds (about 0.19 ounce) of mercury in 2002.

It would be more conservative to assume that all of the 783 supermarkets and 549 pharmacy and drug stores did sell button cells in 2002, but that none of the department stores, warehouse clubs, superstores, variety stores, hardware stores, electronics and appliance stores, office supply stores, or convenience stores did. Under this conservative assumption, the average mass-market retail outlet in Connecticut sold about 2042 button cells containing 0.0252 pounds (about 0.40 ounces) of mercury in 2002.

If we assume the average mass-market retailer has three points of contact with button cell consumers, and if the calculations above are correct, then the average mass-market retail point of contact with button cell consumers in Connecticut delivered from 268 to 681 button cells containing from 0.0040 to 0.0084 pounds of mercury (0.063 to 0.133 ounces) of mercury in 2002.

There is no apparent concentration among mass-market retailers, and thus there are no logical mass-market retail partners with whom to form a collection program. The largest supermarket operator in New England (Stop & Shop, Inc.) has just 78 stores in Connecticut. A major pharmacy chain (Rite-Aid) has just 26 stores. The likely largest chain of electronics stores, Radio Shack appears (from the map on their website) to have just 67.

Mass-market retailers choose to carry button cells primarily as a convenience to their customers, because the gross profit margin on button cells is higher than on other products, and because they occupy very little space. It is very difficult to construct any reasonable scenario in which button cells represent more than one to two tenths of one percent of sales for any mass-market retailer. For example, in a supermarket, button cells may account for no more than twenty-five out of twenty five thousand stock keeping units.

Since mass-market retailers have no motivation to devote management time to button cells, button cell manufacturers have limited influence on how mass-market retailers merchandise the product. Individual manufacturers complain they are unable to convince even the most professionally run mass-market retailers to properly display and promote button cells, even when they can demonstrate that proper merchandising will have a significant positive impact on the retailer's total profit.

Under these conditions, it seems unlikely that any significant number of mass-market retailers would be willing to implement a button cell collection program, even if paid a nominal fee per battery collected.

g. Specialized Retail Channels

Button cells also reach consumers through specialized channels of distribution:

- For silver oxide cells: jewelers, watch-makers and watch repair facilities, and camera and photo stores
- For zinc-air cells: audiologists, hearing instrument specialists, hearing instrument manufacturers and service centers, and mail order/internet vendors.
- For manganese alkaline cells: camera and photo stores, toy and game stores, device manufacturers, etc.

According to the 1997 Census of Retailers, Connecticut was home to 350 jewelry stores, 175 hobby and game stores, and 60 camera and photography supply stores.

These numbers have probably not changed appreciably. Each of these was a potential (and likely) retail outlet for button cells.

The American Watch Association estimates that 95% of silver oxide button cells are captured in existing collection programs that focus on, but are not limited to jewelers and watchmakers. (See below).

If the remaining 40% of manganese alkaline button cells are distributed by hobby, game, camera, and photography stores, and if our previous calculations are correct, then in 2002 these outlets delivered button cells containing 1.52 pounds of mercury. If each of these specialty stores carried manganese alkaline button cells, then in 2002 the average specialty store delivered manganese alkaline button cells containing 0.00647 pounds, or 0.10 ounces of mercury.

According to the Connecticut Department of Public Health, as of October 16, 2003, there were 231 licensed audiologists and 127 licensed hearing instrument specialists in the state, a total of 358 licensed professionals. While it is true that some of these licensed professionals are inactive, and others practice in small groups, each is in some sense a separate retailer, and a potential (and likely) retail outlet for button cells. It is impossible to identify the number of retail outlets that distribute hearing aids that do not require the services of a licensed professional for fitting.

If licensed audiologists and hearing instrument specialists account for 30% of zinc-air hearing aid battery sales in Connecticut, and if our previous calculations are correct, then in 2002, these professionals delivered about 808,000 button cells containing 13.62 pounds of mercury, an average of about 2258 button cells containing about 0.038 pounds (0.61 ounces) of mercury per professional.

According to the 1997 Census of Business, Connecticut was also home to 188 electronic shopping and mail order houses. Presumably this number has increased as a result of the increased popularity of the Internet. It is impossible to determine how many of these sell button cells to consumers, how many customers they have in Connecticut, nor how many such establishments located outside Connecticut sell button cells to Connecticut residents.

A Google search of the Internet for Hearing Aid Batteries produced approximately 125,000 hits. I checked the first 19 pages (181 entries) and found each advertising zinc-air button cells for sale to individuals. A Google search of the Internet for Watch Batteries produced approximately 770,000 hits. Most of these appeared to offer button cells in association with other products.

It is difficult to make a clear distinction between mail order distribution of zinc-air hearing aid batteries and professional distribution through audiologists and hearing instrument specialists, because many licensed professionals offer batteries to their patients both on a walk-in basis and by mail as a convenience, as a means of building a lasting relationship with their patients, and as a source of additional income.

Mail order (and Internet) vending of button cells is a business with low barriers to entry and low barriers to exit. Mail order vendors compete on price and maintain tiny profit margins. Suppliers come and go, and are impossible to identify geographically. Increasingly, they represent Chinese and other foreign button cell manufacturers who maintain no physical presence in the United States

Some mail order vendors, like the audiologists and hearing instrument specialists, provide button cells by mail as an add-on to their primary business in a related product line; others are highly specialized and offer no other products and services. Mail order vendor advertising for button cells is everywhere button cell users congregate on the Internet and in print. Magazines like the American Association of Retired Persons (AARP) Modern Maturity that cater to older people more likely to use hearing aids are full of tiny ads from mail order vendors, some of whom are very sophisticated, significant businesses.

There is no apparent concentration among mail order vendors. AARP itself does not sell button cells; it does contract with a Minneapolis mail order house, United Health, as its official vendor. United Health has much less than 5% of the market.

Because of the cost and administrative burden it is unlikely that mail order vendors would be willing to volunteer to implement a button cell collection program for a single state.

If mail order vendors account for the remaining 10% of zinc-air hearing aid battery sales in Connecticut, and if our previous calculations are correct, then, in 2002, these vendors delivered button cells containing 4.54 pounds of mercury. The amount delivered per mail order vendor is much smaller, and cannot be calculated.

4. RELATED BATTERY COLLECTION EXPERIENCE

We have identified seven related battery collection programs: the silver oxide button cell collection programs organized by the AWA and the silver recovery industry, various battery collection programs operating in Europe, two community-based battery collection programs and one mercury collection program operating in the United States, the Rechargeable Battery Recycling Corporation program for rechargeable batteries, and the Thermostat Recycling Corporation program for recovery of mercury in thermostats.

The silver oxide collection programs (which currently operate in Connecticut) are the only battery collection programs we can identify that have been financed without financial assistance from another party. Financing by state and local governments, or by retailers and device manufacturers operating under a legislative mandate has been required for every other program. These financial sources are not available to support the collection of manganese alkaline or zinc-air button cells in Connecticut.

a. Silver Oxide Button Cell Collection Program

According to the AWA, 95% of watch batteries are currently recycled.

The collection of silver oxide button cells is driven by the monetary value of the silver that can be recovered from used silver-oxide cells. At early December 2003 prices, silver is being sold at $87 per pound. Zinc sells at $0.45 per pound or roughly 1/200th the price of silver.

The American Watchmakers and Clockmakers Institute Education Trust ("AWI") accepts donations of used batteries nationwide and enables retailers and watch manufacturers to write off the value of the silver content for tax purposes. AWI promotes the program through its state chapters and conducts an annual competition rewarding the chapter whose members accept the most. There is also a robust silver recovery industry: waste management companies routinely approach all industrial sources of used silver, including retailers, and purchase silver-oxide batteries directly.

b. European Collection Programs

Twelve countries that comprise 67% of the European market currently require the collection of all batteries sold within their borders. In the chronological order in which their requirements were imposed, they are: Austria, Belgium, Netherlands, Switzerland, Sweden, Germany, France, Czech Republic, Hungary, Poland, Portugal, and Spain. In each country, the retailer takes back batteries, including button cells, at the point of sale.

Collection and recycling is funded by levies based on the sales of battery manufacturers that are then passed on through the distribution channel. Retailers are required to participate. Each country's program operates independently. Collection and recycling organization (CRO) cost structures vary widely. Since button cells are not collected separately, many costs are bundled together with the costs of collecting other batteries and cannot be identified separately.

In 2002, the average cost in Europe was 773 euros per ton of batteries collected; however, the costs and the cost structures of the various country collection and recycling organizations vary widely. Costs per button cell collected have been estimated to range from 0.4 cents U.S. in Germany to 13 cents U.S. in Belgium.

The Belgian program is the most successful, yielding a collection rate of about 50% of new battery shipments. To achieve this success, the Belgian CRO paid about 4.6 million euros for promotion and advertising in 2002 (about 2,087 euros per ton of batteries collected), far more than the cost of collection, 0.8 million euros (about 363 euros per ton) or the cost of sorting and recycling, 1.8 million euros (about 817 euros per ton). Total costs of 11.1 million euros are 6.16 times the cost of sorting and recycling.

The total cost of this program clearly includes costs associated with collecting and recycling other types of batteries. Therefore, the *total cost* cited above is not representative of the total costs of collecting and recycling button cells alone.

But Connecticut does not require collection of other types of batteries. Therefore, in Connecticut, all the cost of education (promotion and advertising) reported in Belgium would likely be required to support a button cell collection program.

As of July 2000, the population of Belgium was estimated to be 10,241,506 (www.yahooligans.com/reference/factbook/be/popula.html). Currently, $1 equals about 0.85 euros (www.exchangerate.com). Thus, a comparable program in Connecticut would need to spend $1,809,820.60 for promotion and advertising. This figure is more than 6.75 times the industry's profit from selling button cells that reach Connecticut consumers.

c. Community Based Programs

Hennepin County, Minnesota

Hennepin County, Minnesota has a land area of 611 square miles and a population of about 1.1 million people living in and around the city of Minneapolis. According to Amy Roering of the Hennepin County Environmental Services Department, the county collects button cells as part of a comprehensive system, which currently collects all types of batteries, fluorescent lamps, mercury-containing items, consumer electronics and household hazardous waste.

Mixed button cells are collected in small cardboard boxes provided by the county at 176 locations throughout the county. When the box becomes full, the location calls the county for a pickup and a replacement box.

The county also collects button cells along with other types of dry cell batteries in larger, 30-gallon containers at an additional 71 locations (no duplicates with the button boxes). The City of Minneapolis also provides curbside pickup of all types of batteries (button and dry cell).

Battery boxes and containers are located in certain city halls, county buildings, drug stores, health care facilities, hardware stores, jewelers, libraries, photo stores, retail stores, senior apartment complexes, and senior citizens' organizations. The county contracts with PPL Industries to service the 30 gallon containers; the City of Minneapolis sorts and consolidates the batteries by type, and stores them in drums until a shipment is warranted. Button cells are consolidated at PPL, but they are not sorted by type. The county's hazardous waste vendor sorts the button cells and recycles/disposes of them.

Hennepin County has followed the practice of accumulating used button cells over time and shipping them to reclamation/recycling facilities at irregular intervals. One drum, containing 803 pounds of button cells was shipped in 1991, eleven drums containing 7,676 pounds of button cells were shipped in 1998, two drums containing 1,822 pounds of button cells were shipped in 2001, and one drum containing 798 pounds of button cells was shipped in 2002. Assuming that all the cells shipped in 1991 were accumulated in 1991, the county shipped a total of 15 drums containing 11,099 pounds of button cells in twelve years, an average of about 925 pounds per year.

This program presents certain safety risks (as discussed below); it does not appear to comply with U.S. Department of Transportation regulations regarding the shipment of batteries in separated compartments or containers.

In this program, button cells are collected and processed as part of larger waste stream; therefore no cost breakout is available. An unknown percentage of the button cells collected are lithium cells.

Local governments finance this program, a practice prohibited in Connecticut.

Burlington, Vermont

Chittenden County, Vermont has a population of about 150,000 people living in and around the city of Burlington. According to Jen Holliday of the Chittenden County Solid Waste District, the county receives button cells at seven recycling centers. Over a three year period, from fiscal year 2001 to fiscal year 2004, the District has received 174 pounds of mixed button cells and 9 pounds of lithium coin cells (about 5% of the total), an average of 58 pounds of mixed button cells per year.

Operational details are unknown. A local government finances this program, a practice prohibited in Connecticut.

Miscellaneous Community Programs

Wheelabrator Technologies Inc., of Hampton, New Hampshire has mercury collection programs in sixty-nine communities, and has offered to collect button cells in each one. Only six communities with a total population of 183,000 have agreed to participate. Each has a collection box in the town hall. In 2002, these programs collected 53,120 button cells. An unknown number were lithium cells. Without further knowledge of the sixty-three communities that have chosen not to participate it is not possible to use this information to predict the success of a community collection program in Connecticut.

d. Rechargeable Battery Recycling Corporation (RBRC)

The Rechargeable Battery Recycling Corporation (RBRC) is a 501(c)(4) not-for-profit corporation engaged in the business of collecting and recycling nickel-cadmium, nickel-metal hydride, lithium-ion and valve regulated lead acid (small sealed lead acid)

rechargeable batteries (< 2.0 lbs) in the United States and Canada. The company is operated by a board of directors represented by battery manufacturers and outside directors, but is financed by the manufacturers and marketers of the devices in which those batteries are used.

This program began as a response by the Portable Rechargeable Battery Association (PRBA) (a trade association of manufacturers of batteries and battery-operated products) to a series of laws in seven states mandating the collection of nickel cadmium batteries. Product manufacturers have been required by law to participate.

The RBRC supplies participating retailers and community collection sites with collection boxes and pre-paid shipping materials. When a retailer sells a rechargeable battery, they take back the spent battery, put it in a plastic bag supplied by RBRC, and drop it in a pre-addressed, pre-paid shipping box supplied by RBRC. When the shipping box is full, the retailer ships it postage-paid to RBRC via United Parcel Service. Communities are similarly supplied collection boxes and incur no cost in shipping batteries to recycling facilities. Business collection sites follow a similar procedure, however, they must pay their own freight costs. RBRC pays actual the cost to recycle batteries from all sources. The RBRC program sends all batteries to INMETCO, an EPA certified recycler in Ellwood City, PA where they are sorted by chemistry and any contamination is removed and the batteries are recycled. Recovered materials, including cadmium and nickel are recovered, and can be used to make new products, including batteries and stainless steel.

RBRC believes that retailers are willing to participate because they make money on the sale of the devices powered by the batteries. Rechargeable batteries are typically much more expensive than button cells; it is not unusual for a laptop computer or cell phone battery to retail for more than $100. Only laws in Iowa, Maryland, and New Jersey require retailer participation.

RBRC currently serves about 35,000 large and small participating retailers nationwide, but none are supermarkets or drugstores who normally don't sell a lot of rechargeable products. The focus is changing away from smaller, single unit retailers toward large chain stores and service and repair centers, where volumes are higher.

RBRC drives participation in the program with an extensive public service media and advertising campaign, a website, and a toll free consumer help line (1-800-8BATTERY). The website gets about 31,000 hits per month, and the phone system over 12,000 calls per month.

License fees paid by product manufacturers finance the RBRC program. In return for the fees, product manufacturers receive the right to display the RBRC battery recycling seal, label their battery packs, and inform consumers and state and federal officials that the RBRC program covers their batteries. In 2002, RBRC revenue was $9.63 million. Total program and management expenses were $7.74 million. The balance of funds is held in reserve to cover future collection costs.

In 2002, RBRC collected 3.7 million pounds of nickel cadmium batteries, 250 thousand pounds of nickel metal hydride batteries, and 150 thousand pounds of lithium ion batteries. RBRC also collected 25 thousand pounds of non-rechargeable batteries. At the end of the year, additional spent batteries were in the system, at the collection sites or in transit. Because these batteries last several years in service, and are often retained or hoarded after end of life, it is impossible to determine what percentage of the annual sales of these batteries were collected.

RBRC believes that the process has to be totally cost free and convenient for the retailer, must be designed to minimize contamination, and works because it is focused on large volume collection sites. Unfortunately, there do not appear to be any obvious high volume collection sites for button cells in Connecticut.

RBRC automatically replenishes stores with collection containers and bags and encourages the stores to locate the collection box behind the counter so the batteries can be packed properly. The clerk serves as a last line of defense against contamination.

Of the $7.74 million spent in 2002, recycling expenses were $3.59 million, marketing expenses were $3.35 million, and management, general, and administrative expenses were $0.8 million.

Major items included in marketing expenses were: paid TV, radio and print advertising, $2.1 million, public relations, $0.3 million, a professional spokesperson, $0.25 million, trade shows, $0.15 million, and maintaining the web site and 1-800 phone system, $0.1 million. In addition to the paid advertising, RBRC benefits from numerous public service announcements due to its not-for-profit status. More than 366 million media impressions were generated by RBRC's media education campaign in 2002 RBRC qualifies for not-for-profit status because of its largely educational purpose. RBRC expects to increase marketing expenses in 2004.

Recycling expenses were about equally split, about $1.2 million each for purchasing and distribution of the collection boxes, freight to collect the batteries, and actual processing at the INMETCO facility.

Total RBRC expenses of $7.74 million were 6.45 times the actual processing cost at the INMETCO facility.

Management, general, and administrative expenses included approximately $100,000 for liability insurance.

Significant costs were required to setup RBRC and significant assets have been required to maintain its program. Since its founding in 1994, RBRC has invested more than $1 million in software development alone. At the end of 2002, RBRC had total assets of almost $20 million, and net assets of $12.6 million. The RBRC has set aside the bulk of these net assets for the future collection of unfunded batteries.

RBRC experience cannot be used to predict results for a button cell collection program in Connecticut because the industry has no means to compel device manufacturers (or retailers) to participate.

e. Thermostat Recycling Corporation (TRC)

The Thermostat Recycling Corporation (TRC) is a not-for-profit corporation owned by three NEMA member companies. It facilitates collection of all brands of used, wall-mounted mercury-switch thermostats by heating, ventilation, and air-conditioning (HVAC) wholesalers from HVAC contractors so the mercury can be purified for reuse.

The TRC began operation in eight Midwest states and Florida in early 1998, expanded the program to include fourteen eastern jurisdictions in 2000, and to remaining lower 48 states in 2001.

In a process similar to that of the RBRC, TRC places shipping containers in HVAC stores nationwide; store personnel encourage contractors to leave used thermostats in the containers when they purchase new ones. When the container is full, it is shipped to TRC, where the contents are accumulated in larger batches and shipped to a recycling facility. TRC also processes thermostats returned to the three manufacturers.

As of August 20, 2003, there were 1,676 TRC containers in nearly 1,000 HVAC wholesale stores in the lower 48 states; 21 containers were in 12 stores in Connecticut. In 1997, according to the Census of Wholesalers, there were 5,524 HVAC wholesalers in the United States, 58 in Connecticut. TRC's voluntary approach has achieved participation by about 18% of the eligible locations.

TRC believes that participation is stimulated because HVAC wholesalers who participate have a competitive advantage—they can advertise that they offer collection to HVAC contractors who may have no other legal means of disposing of used thermostats containing mercury. HVAC contractors who come in to a store to dispose of used thermostats presumably are more likely to buy larger, more expensive HVAC systems at the same store.

These incentives to participate do not apply to retailers who might be involved in the collection of button cells in Connecticut.

During the first half of 2003, the TRC collected 37,014 thermostats and processed 358.04 pounds of mercury in the United States; 512 thermostats and 3.72 pounds of mercury in Connecticut. Additional thermostats were collected but remained in participating wholesalers inventory pending shipment. Because thermostats are typically in service for many years, it is impossible to calculate a meaningful capture rate.

Each thermostat evidently contains about 500 times the amount of mercury as a typical button cell.

Data on start-up expenses and costs of operation are not available.

Thermostat manufacturers finance the TRC program.

TRC experience is not directly applicable to a button cell collection program in Connecticut because the industry has no means to compel device manufacturers (or retailers) to participate and button cell retailers would not have the benefit of participation that would accrue to an HVAC wholesaler.

5. BUTTON CELL COLLECTION CONSTRAINTS

The design of any button cell collection program in Connecticut is constrained by nine significant constraints: the risk of fire safety, U.S. Department of Transportation regulations regarding shipping, the risk of ingestion by consumers, contamination of the waste stream by lithium batteries and other contaminants, the need and cost of educating consumers, the cost and limited availability of insurance, uncertain access to recycling, contingent Superfund liability, and environmental costs.

a. Fire Safety

Used batteries may contain small amounts of energy when disposed. Even if consumers only disposed of batteries that they believed to be dead, they may dispose of a battery with remaining energy because consumers cannot readily determine whether a battery is dead. For example, a piece of equipment may stop working because the battery does not have adequate power for the equipment but may still have some remaining power. Consumers also may simply dispose of batteries with remaining power by mistaking them for a dead battery. If terminals of batteries with remaining energy are in contact, that energy will short-circuit creating heat, potential leakage, and possibly a fire.

This is a relatively small problem if there is a 100% pure collection of only spent button cells containing mercury and the container is made of non-conductive and non-combustible material so that there is no fuel for any heat generated by short circuiting batteries. This problem becomes much more serious with lithium coin cells because of the larger surface area of the lithium battery terminals than button cells and their ability to rapidly discharge leading to higher energy output and greater chances of heat generation. It also becomes a problem if other types of batteries are placed in a collection container because button cells can serve as a bridge between terminals of larger batteries to create a short circuit with batteries having greater energy than the button cell itself.

Lithium electrolyte is flammable. These batteries also contain metallic lithium, a highly reactive metal, that, when exposed to water, liberates hydrogen, a very flammable gas. At a mercury recycling facility, batteries will be shredded or hammered. If the recycler shreds or hammers lithium batteries, they will ignite as they are opened. Ultimately the lithium metal may ignite.

It is hardly unreasonable to expect that there will be some level of contamination from any collection program. We see contamination in both the RBRC and TRC collection efforts despite education of stores with collection containers. The RBRC containers explicitly say that consumers should not place alkaline batteries in the containers. Yet the RBRC, now in its tenth year of operation, still collects 25,000 pounds of nonconforming (non rechargeable) batteries a year. Some communities that collect rechargeable batteries also collect non-rechargeable batteries because they believe consumers do not distinguish one battery type from another. The TRC makes clear that it accepts only whole containers but it still receives cans that contain clipped mercury ampoules. Based on this experience we would expect a similar level of contamination any button cell collection effort despite education efforts.

The DEP appears to agree with these concerns. Its publication, "Managing Household Batteries: A DEP Recycling Program Fact Sheet," states (in relation to collecting silver oxide batteries) that "Sorting batteries is labor intensive, potentially dangerous, and requires familiarity with the various types of batteries." Regarding lithium batteries, the DEP Fact Sheet says "Lithium is a highly reactive metal and, when collected with other button cells, may present a hazard if not fully discharged." www.dep.state.ct.us/wst/recycle/batthaz.htm.

Lithium batteries flat-line discharge; that is, they produce current at full voltage until the energy in the electrolyte is completely exhausted, at which point they produce no current. Other types do not flat-line discharge. There is no way to insure that batteries will be fully discharged when collected.

Currently, the vast majority of used button cells are individually disposed of as they are replaced, with minimal risk of short-circuiting and fire.

An industry sponsored collection program will inevitably lead to the accumulation of inventories of used button cells in the hands of both consumers and collectors, increasing that risk and leading to increased insurance costs for the operators of the program.

On August 21, 2003, Onyx Electronics Recycling, a firm that reprocesses lithium batteries has warned its clients by letter that

> "If lithium batteries are improperly packaged they can pose a serious fire hazard. Batteries that are loosely packed can short circuit and release a significant amount of heat. The heat can cause more batteries to burst, releasing the lithium, and when the lithium is exposed to a sufficient amount of heat or moisture it will begin to burn. The fire will burst more batteries and the reaction will quickly get out-of-control . . .
>
> Over the past two years, three significant fires have occurred due to improperly packaged lithium batteries, Fortunately, none of these incidents have occurred at Onyx facilities."

In an incident of this type during the night of August 14-15, 2002, an 85-gallon drum of lithium batteries sent for recycling burst into flames at a Safety Kleen facility in Clarence, New York. The fire engulfed the facility, caused $2 million in damages, forced safety officials to consider evacuating the community, and took two hundred town firefighters and a "jet-fuel-fire-fighting apparatus" from the Buffalo-Niagara International Airport seven hours to control.

According to U.S. Chemical Safety and Hazard Investigation Board Incident report number 2002-5199,

> "Van Domelen (the facility's manager) said the likely cause was either an internal or external short circuit inside one of the lithium battery casings being stored in a treatment room at the facility. The short sparked a fire, which led to a series of explosions at the plant, where spent lithium and alkaline batteries are stored, treated and shipped for disposal."

This report can be found at www.chemsafety.gov/circ/post.cfm?type=basic&b01=10&rf=full&incident_id=5899#disclaimer.

The event was covered by WIVB, the CBS television affiliate in Buffalo, NY, which subsequently honored the Clarence Fire Company as being the Bravest of Western New York for their efforts at the scene.

In another incident of this type, a fire that evidently started in a battery collection container burned a Radio Shack store in Pennsylvania to the ground.

b. USDOT Regulations

US Department of Transportation Research and Special Programs Administration (RSPA) regulations require that batteries be shipped only when they are protected from short-circuiting. Special Provision 130 exempts dry batteries (other than lithium batteries) from the RSPA Hazardous Material Rule provided that dry batteries "are securely packed and protected against short circuits." (49 CFR 172.102 (c) found in 68 FR 44991 (July 31, 2003). 49 CFR 173.185 (e)(4) contains a requirement that shippers must prevent short circuiting of lithium batteries and that batteries be packed in strong packaging for conditions normally encountered in transportation. RSPA regulations (49 CFR 173.21) prohibit the shipping of any product unless the product is protected from short-circuiting. That would mean that extra care would have to be taken for batteries by taping the terminals or placing individual batteries in plastic bags as is done with rechargeable batteries (See RBRC Safety Guidelines http://www.rbrc.org/community/disposal.html#storage).

Taping or repackaging button cells at the collection point will add significantly to the cost and complexity of any industry sponsored collection program, and may dissuade some parties (particularly retailers) of their willingness to implement the program.

To comply with existing transportation requirements and to minimize the danger of shipping used button cells, there would need to be an extensive education program for every employee at a collection outlet and every consumer. This would require both consumers and collection points to distinguish lithium coin cells and other batteries from other button batteries and for consumers or collectors to place each battery in a plastic bag or tape its terminals. Given the number of users of button cells, the greater degree of infirmity of the largest users of button cells, older people with hearing aides, and the number of distribution channels, this task would present a very significant challenge.

c. Ingestion Risk

According to the National Capital Poison Center (NCPC), there are thousands of incidents each year in which people swallow button cell batteries. Most of these people are young children or elderly. Hearing aids and games and toys are the most common intended use of the batteries involved.

In most cases, ingested batteries will travel through the body without a problem. In some cases, however, batteries can become lodged in the esophagus, the ear, or the nose canal, which can result in tissue damage. Damage can result either from leaking alkaline electrolyte or generation of an external current.

Esophageal burns can lead to a number of adverse effects. Lodging of button batteries in ear and nose canals can result in tissue damage, hearing impairment, and facial paralysis. Lithium coin cells present a greater ingestion risk because of their larger voltage. Their larger size leads to a greater chance of lodging.

A collection program would encourage people to retain inventories of spent batteries rather than disposing of them promptly. This added retention time would increase the time available for battery ingestion. People currently dispose of most button batteries individually, so there is less opportunity for mischief with the batteries.

Individuals most at risk would be hearing aid users, who tend to be older and more infirm than the general population, take more medicines orally, have poorer eyesight, and are more forgetful.

In response to a written request from the Connecticut Department of Environmental Protection, Dr. Toby Litovitz, Executive and Medical Director of the National Capital Poison Control Center said the following:

> "More than 1,800 button battery exposure cases are reported to US poison centers each year. Most of these cases are ingestions; some involve batteries placed in the ear or nose. In most cases the batteries pass entirely through the digestive system without causing problems for the patients, but a few ingestions lead to serious medical complications. The complications can be esophageal burns, perforation, stricture, or infrequently death. Batteries in the ear and nose can cause serious problems such as nasal septal perforation or destruction of parts of the inner ear.

> In my opinion, the potential for harm caused by ingestion of a battery, or its placement in the ear or nose, overrides any need to recycle this extremely small amount of material. A safe recycling program would incorporate a mechanism to prevent unintentional ingestion of batteries . . . both at the site of the final repository as well as in the home. In reality, assuring safe collection in the home is problematic. It would require significant investment in designing and providing secure collection devices as well as a fundamental change in the behavior of the user. Neither is a practical concept. We have spoken out repeatedly against battery recycling programs because they fail to address these practical considerations that impact individual consumers collecting these miniature batteries at home, ultimately leaving the batteries accessible to small children and other susceptible individuals. We have not envisioned, nor have we seen a recycling program proposed that would prevent retrieval of the battery from the recycling container AND address the issues of battery accessibility prior to the battery being deposited in the recycling container. For example, recycling containers placed in stores merely encourage consumers to collect batteries at home, ultimately resulting in inadequate storage protection.
>
> We have worked with the toy and hearing aid industries for years to promote secure closures on products using button batteries. In addition, most manufacturer's battery packages are relatively child resistant. We urge you not to undermine these safety gains and to exercise caution before instituting a recycling program that leaves batteries loose and exposed in the home."

The Connecticut DEP made no reference to Dr. Litovitz's comments in its letter to NEMA of July 10, 2003. Ingestion is a concern even without a collection system in place, but the DEP has ignored Dr. Litovitz's observation that requiring collection will increase ingestion risk because it will motivate people to maintain larger inventories of batteries for much longer periods of time.

NEMA agrees that the problem requires attention. For more than twenty years, the battery industry has provided funding to the National Capital Poison Control Center to provide medical response for these situations. Battery packaging warns consumers not to swallow batteries and to call the National Capital Poison Control Center hotline in the event that someone does ingest a battery. The DEP suggestion that ingestion may be more effectively addressed through a collection plan ignores the comments that the DEP solicited from Dr. Litovitz, who believes that collection will result in a greater frequency of ingestion.

d. Contamination

Any collection program for used button cells will attract contaminants: lithium cells, coins, and other items that do not contain mercury and cannot be recycled. Some may be dangerous (the European programs report having received munitions in unsupervised curbside collection boxes). The safety hazards and the costs of removing and

transporting these contaminants place significant constraints on the design and operation of a button cell collection program.

Contamination is a concern both in collection and at recycling facility. Contamination may result in a recycling facility receiving materials and products the facility is not permitted to handle, placing their permits in jeopardy. Recycling permits and technology are material specific.

As the RBRC has observed, involving trained personnel at the point of collection can reduce contamination. Collection boxes should be supervised wherever possible; the program should require citizens to interact with a trained person at the point of collection.

e. Education

Individual consumers throughout Connecticut have assumed, learned or been taught that it is legal and appropriate to dispose of used button cells one by one in the household waste stream and that collection and recycling is *optional*. Absent some reason to collect and recycle, the typical consumer will not be a willing participant.

The success of any additional button cell collection program depends on the industry's ability to change this attitude. That will require a significant educational campaign of public relations and advertising that may be cost prohibitive. It is unlikely that the attitude of every consumer (or any significant percentage of consumers) can be changed with an industry budget of less than $300,000 per year.

Success with a button cell collection program also requires that we educate and train the individual employees in the distribution channels who contact consumers who use (and might return) button cells. We would also have to train individuals to properly sort, pack, and ship collected cells. Since retail service personnel have high turnover rates, the employee education program will need to be repeated frequently.

f. Insurance

Any new button cell collection program can be expected to be held liable for damages that may be caused by the collection, sorting, packing, transportation, and recycling of the used button cells. Insurance will be required. Whether such insurance is available, and if so, at what cost, is unknown.

Insurance costs for such a collection program are specific to the material, collection methods, and recycling facilities employed. Such policies are unique. There is a very limited market. Both RBRC and TRC report that their insurance is essentially a fixed cost determined by what they do, *not* a variable cost based on the volume of material they collect.

g. Uncertain Access to Recycling

NEMA has identified only one company capable and interested in recovering mercury from mixed used button cells: Mercury Refining Company, Inc., (MERECO) in Albany, New York. INMETCO, used by RBRC, does not accept button cells.

Should MERECO be unable to perform, and if NEMA cannot identify an alternative company interested in taking mixed used button cells, then any new button cell collection program would be unable to recover mercury and collected batteries would be disposed in landfills, essentially returning them to the waste stream from which they had been collected at great effort and expense.

Presumably, sorting out the contaminants would be required to make a mixed used button cell waste stream acceptable to additional recovery companies. As the DEP publication cited above "Managing Household Batteries: A DEP Recycling Program Fact Sheet," states (in relation to collecting silver oxide batteries) "Sorting batteries is labor intensive, potentially dangerous, and requires familiarity with the various types of batteries."

h. Contingent Superfund Liability

MERECO Is a Superfund site.

In the Federal Register, October 2, 2003, pages 56835-56836, the U.S. Environmental Protection Agency gave notice of an administrative settlement agreement with Mercury Refining Company, Inc. and Leo Cohen, its founder, sole shareholder, and former president, for the payment of past and future response costs for this site. The settlement requires that the EPA be paid a total of approximately $524,000.

Persons that dispose of waste material at Superfund sites become jointly and severally liable for all past and future costs of cleanup if the facility is unable to meet its obligations, or if new obligations are discovered. Thus, any single manufacturer who chooses to participate in a new button cell collection program in Connecticut could become exposed to liability for the entire cleanup cost of the MERECO site. It seems doubtful that the continued profits on the sale of button cells in Connecticut alone are sufficient to justify a manufacturer taking on this contingent liability.

i. Environmental Costs

Collection, sorting, packing, transportation, and recycling of used button cells in a newly developed collection program will create additional environmental impacts. The nature and magnitude of these impacts is difficult to calculate and will depend on the design of the program and its relative success.

Collection of button cells will involve transportation from the consumer's home to a collection point, from the collection point to a central aggregation facility, and from that facility to a recycling facility. This transportation will impact the environment.

Sorting and packaging cells at the initial collection point will require collection boxes and packaging materials (probably plastic bags) to keep the cells separated. The manufacture and distribution of these supplies would impact the environment as would commuting trips to and from home to the collection points for the people sorting and packing the batteries.

Additional materials, supplies, and labor would be required at the aggregation point, and additional transportation would be required from the aggregation point to the recycling (or resource recovery) facility. Each of these would also impact the environment.

The magnitude of the environmental impact will depend on how the program operates, on the number of batteries collected, and on the extent of contamination.

In an August 2001 study entitled "Assessment of the Environmental Impacts Associated with the Transport of Waste Batteries in Europe," the European Portable Battery Association determined that significant environmental impacts were associated with the transportation of used batteries in each of three scenarios: curbside collection, collection at civic amenity sites, and retail take-back collection. Button cells were considered as part of the total waste battery stream. The authors assumed that 75% of batteries sold would be collected. An analysis was made for the UK and extrapolated to Europe for each of two transportation plans of 200 km and 500 km.

For each scenario, for each measure of pollution, using the most comparable (200 km) transportation plan, the annual environmental impact of transporting collected button cells in the UK was determined to be equivalent to that of the environmental pollution of one to four typical passenger cars. This analysis probably understated the environmental cost of a button cell specific collection program because the fixed environmental costs of the infrastructure were shared with the other battery types.

It is tempting to say that the environmental impact of an additional button cell collection plan in Connecticut would be very small. After all, if 300 to 400 million button cells are sold in the replacement market in the U.S. each year, if 1.2% of them are sold in Connecticut, and if there are, on the average, 600 cells per pound, then all the button cells sold in Connecticut in a year weigh just 7000 pounds, and the environmental impact of the program would appear to be equivalent to shipping one truck load with 7000 pounds of button cells and 4.2 million small plastic bags (a few pounds) from Connecticut to the recycling facility.

But in reality, any new program will not collect 100% of the button cells sold, they will be collected in small quantities from numerous locations, extra supplies will be necessary, many vehicles will travel with light loads, and depending on the specific plan adopted, many people may have to commute to sort and pack batteries at scattered collection points.

6. BUTTON CELL COLLECTION COSTS

An additional button cell collection program in Connecticut may require significant startup costs plus annual expenditures for education, marketing, and promotion of the program; for containers, shipping, and processing of the button cells; and for management, general, and administrative expense, including insurance, and the cost of a web site and 1-800 phone system if needed.

Annual education, marketing, and promotion expenses will include costs of public relations, advertising, and trade shows designed to reach the general public and any partnering organizations.

Costs of shipping and recovery of the mercury should be directly proportional to the number of batteries collected. MERECO has quoted a price of $4.25 per pound for recovering the mercury from zinc-air button cells.

Other costs are not predictable. Containers and processing costs will depend on the program design, especially on how the batteries will be separated and packed in individual plastic bags for shipment. Costs of marketing, education, and promotion will be arbitrary and will depend on the type of program. It seems almost impossible to predict the relationship between marketing, promotion, and education costs and the number of batteries collected.

A button cell battery collection program implemented in a single state would have many fixed costs comparable to those in a national program.

7. ENVIRONMENTAL BENEFITS OF BUTTON BATTERY COLLECTION

Sources of Mercury in Connecticut – We are aware of no comprehensive data on sources of mercury in Connecticut. There are data available, however, from federal, regional, state and industry sources.

i. **Out of State Sources** – The NESCAUM 1998 report, "Mercury Study, A Framework for Action," using 1995 data, estimated that 53% of mercury emissions in the northeast (New York, New Jersey and the six New England states), came from outside the region (Page VI-16). In 1995 the largest source of mercury emissions in the region came from municipal solid waste incinerators. The report estimates that 42% of all mercury deposition in the Northeast came from municipal solid waste and sewage sludge incinerators in the northeast (Page VI-24). Sewage sludge incinerators emitted 1/8 the mercury of municipal solid waste incinerators so the overwhelming amount of mercury in this category comes from municipal solid waste incinerators.

Since then municipal solid waste incinerator emissions have dropped sharply (see below) without declines in other larger sources such as power plant emissions and fuel oil burning. An EPA Region V estimate of mercury emissions in the US shows that US emissions have declined from 149 to 115 tons of mercury. This decline came from emission reductions from municipal solid waste and medical waste incinerators. In addition, newer information has shown that a greater percentage of mercury deposition in the US is coming from outside the US. (See for example the 2003 UNEP Global Mercury Assessment citing modeling studies showing up to 50% of anthropogenic mercury deposition in the US comes from outside the US.)

We understand that NESCAUM currently is updating its estimate of sources of mercury. This update will undoubtedly show that a far greater percentage of mercury is coming from outside the region than shown in the earlier report because of the very large reduction of emissions from municipal solid waste incinerators and the large historic contribution of mercury in the northeast from this source.

ii. **Incinerators** – The Connecticut draft solid waste plan says that 82% of the state's solid waste is disposed in municipal solid waste incinerators. www.dep.state.ct.us/wst/solidw/swplan.htm. According to EPA Region V data and newer information from a survey conducted by EPA, municipal solid waste incinerator emissions have declined from 42 tons in 1990 to 24 tons in 1995 to 2 tons in 2001 (See http://www.epa.gov/region5/air/mercury/progress.html and June 20, 2002 memo from Walt Stevenson of EPA showing actual national mercury emissions from Municipal solid waste incinerators at 2 tons in 2001.

The 1998 NESCAUM report estimated that the region's municipal solid waste incinerators emitted 15,874 pounds of mercury in 1995. According to the EPA Status of State Plans for Large Municipal Solid Waste Incinerators, Connecticut has 17.7% of the region's incinerator capacity. That suggests 1995 mercury emissions from Connecticut MSW facilities were 1,276 pounds.

A survey conducted by the Integrated Waste Services Association (IWSA), which represents the municipal solid waste incinerator industry, shows that emissions from five of six Connecticut incinerators (only the smallest incinerator not surveyed) emitted 288 pounds of mercury in 2001.

According to IWSA, municipal solid waste incinerators currently remove 95% of mercury emissions. With a current emission level of 288 pounds of mercury, the amount of mercury entering Connecticut's municipal solid waste incinerators would equal 5,760 pounds of mercury.

iii. **Landfills** – The EPA Mercury Report to Congress concluded that total mercury emissions from municipal solid waste landfills was only .05 percent of total manmade sources of mercury emissions or 162 pounds out

of 154 tons. In making this estimate, EPA used a range of 5.8ng/m^3 to 20.8ug/m^3 of mercury emissions from landfills. A more recent study funded in part by the Florida DEP found that the mean concentration of total gaseous mercury emissions measured at the Brevard County landfill was 7.2 ug/m^3, well within the range that EPA used in its report. A recent analysis of mercury emissions for the New York – New Jersey Harbor prepared for the New York Academy of Sciences, after reviewing the Florida data and applying it to the Fresh Kills landfill in Staten Island, concluded, "...landfills are not a major source of gaseous emissions of mercury." "Sources and Material Balance of Mercury in the New York – New Jersey Harbor, by Nickolas J. Themelis and Alexander F. Gregory, Report to the New York Academy of Sciences, November 31, 2001, P. 23. And the 2002 New Jersey Mercury Report (p. 157) concludes, "Low concentration of mercury in landfill gas...argues that no efforts to control this source are necessary at this time." The Vermont Agency of Natural Resources estimated that in 2000, 0.1 % of mercury emissions in the state came from landfills even though the vast majority of garbage in Vermont is disposed in landfills.

iv. **Other New England State Data** – Other recent New England state data shows that mercury emissions from products are small sources of instate emissions. Button cells would be a very small source of the emissions from products.

a. Vermont – According to the Vermont Air Pollution Control Division, the 2000 Source Contribution of Mercury Emissions in the state were as follows:

Residential Fuel Combustion	- 36.4%
Automobile Switches	- 22.2%
Mobile Sources	- 15.3%
Industrial Fuel Combustion	- 11.7%
Residential Open Burning	- 4.1%
Lamp Breakage	- 3.9%
Crematoria	- 3.8%
Dental Applications	- 1.5%
Lab Use	- 1.0%
Landfills`	- 0.1%

Vermont has no in state municipal solid waste incinerators.

b. New Hampshire – The New Hampshire Department of Environmental Services released state emissions data from 2000. Of the 1,000 pounds of emissions, 37.6% came from burning fuel oil and 28.6% came from coal combustion. Large municipal solid waste incinerators were responsible for 16.6 %. The emissions from this source, however, exclusively came

from one incinerator that has installed emission controls since the DES released the study. As a result, municipal solid waste incineration now accounts for less than 2% of emissions in the state.

c. Maine – The Maine Department of Environmental Protection has published a report, "Mercury in Maine: A Status Report" in February 2002. The report estimates that of the 1,467.21 pounds of mercury emitted in 2001 in Maine, 845 came from commercial and industrial boilers. Municipal solid waste incinerators emitted 43.6 pounds or less than 3% of mercury emissions. Landfills emitted 6 pounds or 0.41% of emissions. Volatilization of mercury from breakage of all products emitted 93 pounds or 6.34% of emissions.

v. **Contribution of Button Cells** – Based on existing information, button cells disposed in landfills would not result in emissions of mercury. While Hennepin County encourages its citizens to take button cells to collection sites, the County website says that it is "OK to place in trash." www.co.hennepin.mn.us/environmental/learning/HHW.html.

According to the NEMA survey data, button cells sold by NEMA members in Connecticut in 2002 contained roughly 56 pounds of mercury. Silver oxide batteries, 95% recovered by existing collection programs, contained about 7 pounds. This means that button cells containing approximately 50 pounds are going into the solid waste stream. That is roughly one percent of the mercury currently entering municipal solid waste incinerators in the state.

With municipal solid waste incinerators having a 95% control rate, even assuming that all disposed cells are going into MSW incinerators except for collected silver oxide cells, button cells disposed in the MSW stream result in about than 2.5 pounds of emissions in the state.

vi. Summary

The vast majority of mercury being deposited in Connecticut is coming from outside the region. Even within the region, Connecticut emissions would make up a small portion of emissions in the region. Button cells make up a tiny portion of mercury entering the state's municipal solid waste incinerators. Any effort to collect button cells in Connecticut will result in virtually no change in mercury deposition in Connecticut.

8. EXISTING REGULATIONS

i. Federal – Almost all button cells are non-hazardous waste under the Resource Conservation and Recovery Act (RCRA). Button cells are not ignitable, corrosive, or reactive. Only the largest size button cells may fail the Toxicity Characteristic Leaching Procedure (TCLP). Under RCRA, even for the few

button cells that might fail the TCLP test, homeowners, who use the overwhelming percentage of button cells, can dispose of their button cells in the trash. Button cells are not regulated as hazardous materials under the US Department of Transportation hazardous materials requirements as long as they are packed to avoid short-circuiting.

Commingled batteries managed outside of the household and municipal collection schemes should be managed as "universal waste." EPA's Universal Waste Rule provides regulatory flexibility for generators and handlers of the commingled batteries, provided the materials are destined for viable treatment and/or recycling. Destination facilities that store the commingled batteries prior to recycling, however, invoke full RCRA Subtitle C jurisdiction, which includes satisfying all applicable BDATs (Best Demonstrated Available Technologies) under the LDR (Land Disposal Restriction) program as well as mercury NESHAP provisions of the Clean Air Act. Such regulatory burdens will result in higher costs to employ expensive thermal recovery techniques, or unnecessary sorting by handlers or destination facilities prior to recycling.

ii. Connecticut – Connecticut follows the RCRA hazardous waste rules. Public Law 02-90 does not ban the disposal of button cells in the trash.

iii. Collection/Labeling/Disposal/Use Requirements in Other States

Maine – Maine's mercury products labeling and disposal ban law does not apply to button cells. Maine bans the use of mercury in thermometers except for button cells.
New Hampshire – New Hampshire bans the use of mercury in thermometers and novelties.
Vermont – Vermont's labeling law specifically excludes button cells from the labeling requirement. The disposal ban only applies to labeled products.
Massachusetts – Massachusetts bans the sale of thermometers with mercury except for thermometers with button cells.
Rhode Island – Rhode Island's mercury law, which is not yet effective, exempts button cells from labeling, collection and the disposal ban. The bill bans the sale of thermometers and novelties with mercury except for those products with button cells.
Maryland – Maryland's law bans the use of mercury in thermometers except if they contain a button cell.
Florida – Florida's disposal ban does not apply to button cells.
Illinois – Illinois's law bans the sale of thermometers and novelties with mercury but exempts products with button batteries.
Indiana – Indiana law bans the sale of thermometers and novelties with mercury but exempts products with button batteries.
Minnesota – Minnesota's law bans the disposal and requires the labeling of many products containing mercury except button cells.

California – California law bans the sale of thermometers and novelties with mercury but exempts those products containing button batteries.
Oregon – Bans the sale of fever thermometers and novelties with encapsulated mercury.
Washington – Washington's law bans the sale of thermometers and novelties with mercury except those containing a button cell.

Summary – No state requires the labeling of button cells. No state requires manufacturers to collect button cells. No state bans the disposal of button cells.

9. ALTERNATIVE BATTERY INDUSTRY SPONSORED BUTTON CELL COLLECTION PROGRAMS

NEMA members would operate any new button cell collection program in Connecticut by setting up a new corporation to collect and recycle used button cells. The owners of the new corporation would then contract with NEMA or some other entity to manage it. NEMA would require the manufacturers (owners of the new corporation) to indemnify NEMA from all liabilities that might be associated with its operation.

Legal fees, insurance, and other setup costs for the new corporation alone could easily exceed the industry's annual profits on batteries sold to consumers in Connecticut; NEMA's current rates for management services are $135 per hour.

Once established, the new corporation would select one or more of the five collection programs described below. Each has a different set of appropriate partners who would operate the points at which citizens would offer used button cells for collection.

Each of these programs would require the new corporation to pay the setup costs of recruiting appropriate partners, arranging for insurance, writing software, buying initial supplies, and establishing systems to collect and sort the batteries at the partners' collection points, transport them to a central facility, sort them again to eliminate contamination, and ship them to MERECO. The new corporation would also have to pay the cost of marketing, promotion, and education of consumers, and the annual operating costs of the systems described above. Most of these costs would be fixed, and not dependent on the volume of button cells collected.

Based on the limited data on comparable programs we have cited above, both the setup and the annual operating costs for such a new program would far exceed the button cell manufacturers' annual profits on batteries sold to Connecticut consumers.

The five collection programs are: retail take back, partnership with audiologists/hearing instrument specialists, mail back, partnership with household hazardous waste collection, and partnership with municipal transfer stations,

a. Retail Take Back

NEMA members could attempt to form a partnership with one or more mass-market retailers similar to the RBRC partnership. Button cell collection is incompatible with the RBRC program because it would contaminate the RBRC waste stream with mercury. NEMA members could supply button cell collection packaging, retail personnel could be trained to ask to take back a battery for each battery sold, the batteries could be collected in the store, packed in individual plastic bags, and shipped UPS collect to a central facility where they could be consolidated into larger shipments to MERECO. The retailer and NEMA members could undertake an educational and advertising campaign to encourage public participation.

It is unlikely that a mass-market retailer would willingly participate, even if compensated by NEMA members. Unlike the bottle bill, which requires retail participation by law, there are no incentives to the retailer to participate in this plan other than a general civic duty to protect the environment. In my opinion, most mass-market retailers would opt out.

Even a successful retail take back program focused on mass-market retailers would yield very small amounts of mercury per store. Partnership with just one chain might be possible, but yield small returns. The Federal Robinson-Patman Act prohibits discrimination by manufacturers in providing advertising or other services to retailers; what was offered to one would have to be offered to all others.

Set up costs for a program that reached all mass-market retailers in Connecticut would be prohibitive. RBRC's program reaches the entire country for its products through 35,000 stores; A Connecticut button cell program would reach about 1.2% of the country's population through about 2,800 stores, about 8% of the RBRC total.

It is not feasible for NEMA members to change the consumer attitudes and behavior of the entire population of Connecticut with an annual promotional budget equal to total profits earned on button cells sold in the state.

Adequate employee education for this approach is equally infeasible. The 2,821 mass-market retailers identified above reported to the 1997 Census of Business that they employed more than 80,345 employees in Connecticut; at least half must be customer contact personnel who would require training. The stores represented in the more conservative estimate of 1,332 mass-market outlets reported they employed 48,953 people. According to the National Retail Foundation, average turnover in retail employment is 64% per year, so the training would have to be repeated frequently.

Since the mass-market retailers have more employees per store than the more focused retailers favored by RBRC, employee education costs per store for this approach would be much higher than RBRC's costs. Per store yield in pounds of mercury per year would be much less.

This approach would encourage mass-market retailers to accumulate used button cells until they had enough to send back, which invites all kinds of mischief.

Any successful effort to change the consumer attitudes and behavior towards collection of button cells will encourage consumers to collect inventories of spent batteries, which may present fire hazards in the home and will increase the number of reported ingestions. This applies to all possible collection programs.

b. Partnership with Audiologists/Hearing Instrument Specialists

NEMA members might seek a partnership with audiologists and hearing instrument specialists, who might them educate them and their patients about the need for recycling zinc-air batteries. NEMA members could supply educational materials, attend and make speeches to hearing industry conventions and trade shows, offer prizes for participation, and distribute mail back packaging and instructions so that patients could inventory their spent batteries and return them either to NEMA members or to the audiologists and hearing instrument specialists. NEMA members could then aggregate the batteries and ship them to MERECO for recycling.

Audiologists and hearing instrument specialists would have no incentive to participate other than a general feeling of responsibility toward the environment. There might be a limited positive benefit for a few who deal with environmentally conscious consumers. The time and trouble of participation would put them at a competitive disadvantage against mass-market retailers, mail-order vendors, and audiologists and hearing instrument specialists who were not willing to participate. It is impossible to identify the capture rate or the number of audiologists and hearing instrument specialists who would be willing to participate.

This approach would encourage consumers to collect inventories of spent batteries, which would present fire hazards in the home and would increase the number of reported ingestions.

c. Mail Back

Mail order vendors could be approached and asked to include mail back packaging and instructions with shipments of new batteries to consumers in Connecticut. Under this program, consumers would be encouraged to inventory spent batteries and mail them to NEMA members, who would aggregate them and ship them to MERECO for recovery of the mercury. Unfortunately, there is little concentration among mail order vendors serving Connecticut; in many cases, battery manufacturers do not know who the mail order vendors are.

Mail order vendors, if they could be located, would have no incentive to segregate their Connecticut business from their other business. Consumers would have little incentive to comply. Capture rate cannot be predicted. Ingestion and fire safety risks would exist.

d. Household Hazardous Waste Collection

Residents might be educated to bring spent button cells to a household hazardous waste collection program. There is a fairly well established household hazardous waste program in Connecticut. Residents participate routinely and some button cells are undoubtedly collected in this fashion already.

However, spent button cells would have to be separated from the hazardous waste stream, bagged or taped, accumulated for transportation, and transported to a central site for shipment to a recovery site, at some expense. Section 9(d) of the Act states "The cost of collection shall not be borne by state or local government."Local government currently pays for household hazardous waste collections. Therefore under this approach, the battery manufacturers would have to reimburse local governments for these costs. It is not clear that it is either possible or efficient for local governments to keep track of the volume of cells that would come in or the separable costs of processing those cells at the hazardous waste collection points,

There are currently only three permanent household hazardous waste collection facilities in Connecticut with one more planned. There are only eight Regional Shared One Day Collection programs, which typically collect in the spring or fall. (See www.dep.state.ct.us/wst/recycle/househaz.htm.) Because there are so few sites, and because of the Regional One Day Collection programs, this approach would encourage consumers to build inventories of spent button cells, increasing the risks of fire and ingestion.

Based on the capture rates of other community collection programs, this number of hazardous waste collection facilities is not adequate to capture a meaningful quantity of button cells. If a system of cost calculation and reimbursement could be set up, the cost would be prohibitive.

e. Municipal Transfer Stations

Residents might drop off spent button cells at a municipal transfer station. As mentioned, the cost cannot be borne by state or local government; a system would need to be established to either pack them and mail them to a recycling or aggregation facility through a prepaid mailer or by reimbursing the municipality. Any cost reimbursement system would face the same challenges as noted under Household Hazardous Waste Collection above. If the consumer picked up packing and mailing supplies at the Household Hazardous Waste Collection facility, packed them with spent cells, and either mailed them or returned the packages to the facility for mailing, there would be the added safety risks of improper packaging.

On the surface, it appears that a system like the one in Hennepin County installed in Connecticut, could be expected to collect about three drums (2400 pounds) of batteries per year. Assuming 582 batteries per pound and that each cell contains 8.5 mg. Of

mercury, a comparable program in Connecticut could be expected to recover about 26.2 pounds of mercury per year.

In practice, however, this number would be reduced, since the Hennepin County collection included an unknown number of lithium cells, and because zinc-air cells gain about 5% in weight as they are discharged.

Furthermore, Hennepin County's results were achieved using 247 collection stations in 611 square miles serving 1.6 million people. To achieve a comparable density in Connecticut would require 529 collection stations for Connecticut's 3.425 million people, or 1953 collection stations for Connecticut's 4,832 square miles.

If a system like the one in Chittenden County were installed in Connecticut, we could expect to collect about 1,324.3 pounds of button cells per year, yielding about 14.4 pounds of mercury, assuming no lithium cells were collected, without correcting for the increase in weight of the zinc-air batteries. To match the density of Chittenden County's collection stations in Connecticut's population would require about 160 collection stations.

There are not enough municipal transfer stations in Connecticut to achieve results comparable to those in Hennepin or Chittenden Counties. The costs of additional facilities would be prohibitive for button cell manufacturers, much larger than industry profits on batteries that are purchased by Connecticut consumers.

10. ABOUT THE AUTHOR

Richard F. Tozer is a consultant in Dallas, Texas, who uses analytical methods to counsel owners of emerging companies; help them make better strategic decisions, and accomplish their objectives. He also helps attorneys as an expert witness in legal cases involving complex business issues, and develops and presents financial and strategic management training programs.

A former member of management in a New York Stock Exchange listed company, Dick has been an adjunct professor in the Cox School of Business at Southern Methodist University, and is a lecturer in the School of Management of the University of Texas at Dallas, where he developed and presents the Entrepreneurial Ventures course in the Executive MBA program.

Mr. Tozer is a graduate of Case Institute of Technology, Cleveland, and of the doctoral program of the Harvard Business School. He is a member of the Institute of Management Consultants (former board member of the Dallas-Fort Worth Chapter), the Dallas Economists Club, and the National Association for Business Economics.

Dick has conducted several hundred financial and management training programs for various corporations and organizations. He has served consulting clients in the banking, information services, industrial distribution, manufacturing, training and professional

engineering industries, and has been conducting market research in the button cell battery industry since the early 1980s.

APPENDIX E

Enacted legislation on button batteries in novelties

APPENDIX E
Enacted legislation on button batteries in novelties

Connecticut

- **Definition**

  "Mercury-added novelty" means a mercury-added product intended mainly for personal or household enjoyment or adornment, including, but not limited to, products intended for use as practical jokes, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, footwear, other items of apparel or similar products. A product is not a "mercury-added novelty" solely on the basis that it includes a removable button cell battery containing mercury. *Connecticut General Statutes, sec. 22a-613(6)*

- **Ban on sale**

  The sale of a mercury-added novelty is prohibited beginning July 1, 2003. *Connecticut General Statutes, sec. 22a-616(a)*

- **Labeling**

  Beginning July 1, 2004, the sale of novelties and other products that contain button cell batteries as the only mercury component is prohibited unless the packaging and any product instructions are labeled. The label must be clearly visible and must be sufficient to inform the purchaser that mercury is present in the product and that the product should be disposed of or recycled in accordance with hazardous waste requirements. Button batteries sold separately (i.e., replacement batteries) are exempt from the labeling requirement. *Connecticut General Statutes, sec. 22a-619(a),(c) and (g).*

- **Collection required**

  Beginning July 1, 2003, the sale of mercury-products (including novelties that contain button cell batteries as the only mercury component) is prohibited unless the manufacturer has submitted a plan for a system that reasonably enables the collection of such products. If the mercury-added product is a component of another product, the collection system must provide for removal and collection of the mercury-added component or collection of both the component and product containing it. This collection system requirement applies to manufacturers who make button batteries. *Connecticut General Statutes, sec. 22a-620(a)*

  The Commissioner of Environmental Protection can grant an exemption if collection is not feasible. The National Electrical Manufacturers Association, the American Watch Association and the Toy Industry Association have filed an exemption request for mercury-added button batteries. A final decision on the request is pending. *Connecticut General Statutes, sec. 22a-620(f)*

Indiana

- **Definition**

"Mercury-added novelty" for purposes of IC 13-20-17.5, means a mercury-added product intended mainly for personal or household enjoyment or adornment, including:

(1) items intended for use as practical jokes;
(2) figurines;
(3) adornments;
(4) toys;
(5) games;
(6) cards;
(7) ornaments;
(8) yard statues and figurines;
(9) candles;
(10) jewelry;
(11) holiday decorations; and
(12) footwear and other items of apparel.

Indiana Code, Title 13, article 11, chapter 2, section 128.3 [IC 13-11-2-128.3]

- **Ban on sale**

Sec. 1. This chapter does not apply to antiques.

Sec. 2. Prohibition of sale or distribution of mercury-added products

(a) This section does not apply to a mercury-added novelty if:
(1) the novelty uses a mercury-added button cell battery to function; and
(2) the only mercury contained in the novelty is found in the mercury-added button cell battery.
(b) After July 1, 2003, a mercury-added novelty may not be:
(1) offered for final sale; or
(2) distributed for promotional purposes;

in Indiana if the offerer or distributor knows or has reason to know that the novelty contains mercury. *IC 13-20-17.5*

Minnesota

- **Definition**

  Minnesota law does not define the term "mercury-added novelty."

- **Ban on sale.**

  A person may not sell a toy or game that contains mercury, or a tax-exempt item of clothing or wearing apparel that contains an electric switch that contains mercury. *Minnesota Statutes, § 116.92, subd. 8*

- **Labeling.**

  The sale of mercury-added products is prohibited unless labeled in a manner to clearly inform the purchaser or consumer that mercury is present and that the item may not be placed in the garbage until the mercury is removed and reused, recycled or otherwise managed to keep it out of solid waste or waste water. This requirement does not apply to a novelty or other product in which a battery is the only component that contains mercury. *Minnesota Statutes, § 116.92, subd. 8*

New Hampshire

- **Definition**

  "Mercury-added novelty" means a mercury-added product intended mainly for personal or household enjoyment or adornment. Mercury-added novelties include, but are not limited to, items intended for use as practical jokes, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, and items of apparel, including footwear. *New Hampshire Revised Statutes, § 149-M:51(II)*

- **Ban on sale**

  Effective January 1, 2001, no toy, game, card, ornament, or mercury-added novelty may be offered for sale if the seller knows or has reason to know that the product contains mercury. Manufacturers that produce and sell mercury-added novelties shall notify retailers about the provisions of this section and how to dispose of the remaining inventory properly. *New Hampshire Revised Statutes, §149-M:53(I)*

  The New Hampshire Department of Environmental Services, by administrative interpretation, does not apply this prohibition to a mercury-added novelty that has a button cell battery as its only mercury-containing component.

New York

- **Definition**

  "Mercury-added novelty product" means a mercury-added product intended mainly for personal or household enjoyment or adornment. Mercury added novelties include, but are not limited to, items intended for use as practical joke3s, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, items of apparel (including footwear, or similar products. A product is not a mercury-added novelty solely on the basis that is a game with a light screen display containing mercury, or includes a removable battery containing mercury. *N.Y. Envtl. Conserv. §27-2101(8)*

  New York, like Maine and Vermont, excludes button batteries from the definition of mercury-added product. *N.Y. Envtl. Conserv. §27-2101(7)*

- **Ban on sale**

  Effective January 1, 2005, no person may sell, offer to sell or distribute a mercury-added novelty product. *N.Y. Envtl. Conserv. §27-2107(1)*

Oregon

Ban on sale. Oregon Laws 2001, Chapter 924, section 5 [eff. January 1, 2002] provides:

"(1) A person may not sell or offer for sale a novelty item that contains encapsulated liquid mercury.

(2) Upon notification to the Department of Environmental Quality by any person that a novelty item for sale in the state contains encapsulated liquid mercury, the department shall notify persons identified as selling the novelty item of the prohibition on the sale of such items.

(3) The department may impose a penalty as provided in ORS 459.995 if a person continues to sell a novelty item that contains encapsulated liquid mercury after notification of the prohibition on the sale of such items."

Rhode Island

- **Definitions.**

  "Mercury-added button cell battery" means a button cell battery to which the manufacturer intentionally introduces mercury for the operation of the battery. *Rhode Island General Laws, 23-24.9-3(8)*

  "Mercury-added novelty" means a mercury-added product intended mainly for personal or household enjoyment or adornment. Mercury-added novelties include, but are not limited to, items intended for use as figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, items of apparel (including footwear), or similar products. *Rhode Island General Laws, 23-24.9-3(9)*

- **Ban on sale**

  The sale of mercury-added novelties is prohibited effective January 1, 2003. Manufacturers of mercury-added novelties must notify retailers about this ban and how to dispose of any remaining inventory. The ban does not apply to a novelty incorporating one or more mercury-added button cell batteries as its only mercury-added component or components. *Rhode Island General Laws, 23-24.9-6(a) and (d)*

- **Labeling.**

  Novelties exempt from the sales ban (i.e., those that have button cell batteries as their only mercury-added component) are also exempt from the labeling requirements of Rhode Island's Mercury Reduction and Education Act. *Rhode Island General Laws, 23-24.9-8(a)*

- **Ban on disposal.**

  Effective July 1, 2005, no person may dispose of mercury-added novelty or other mercury-added product in a manner other than by recycling or disposal as hazardous waste. The ban does not apply to mercury-added button cell batteries. *Rhode Island General Laws, 23-24.9-9(a) and (c)*

- **Collection.**

  Effective July 1, 2005, a mercury added product may not be sold in Rhode Island unless the manufacturer has submitted a plan for collecting the product when the consume is finished with it and the plan has been approved by the Department of Environmental Protection. The collection system requirement does not apply to novelties that are exempt from the sales ban (.i.e. those that have button cell batteries as their only mercury-added component). *Rhode Island General Laws, 23-24.9-10(a)and (b)*

Washington

- **Definition.**

  "Mercury-added novelty" means a mercury-added product intended mainly for personal or household enjoyment or adornment. Mercury-added novelties include, but are not limited to, items intended for use as practical jokes, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations, items of apparel, and other similar products. Mercury-added novelty does not include games, toys, or products that require a button-cell or lithium battery, liquid crystal display screens, or a lamp that contains mercury.

  State of Washington, Laws of 2003, Chapter 260, section 2

- **Ban on sale.**

  "Effective January 1, 2006, no person may sell, offer for sale, or distribute for sale or use in this state a mercury-added novelty. A manufacturer of mercury-added novelties must notify all retailers that sell the product about the provisions of this section and how to properly dispose of any remaining mercury-added novelty inventory.

  State of Washington, Laws of 2003, Chapter 260, section 6

APPENDIX F

Proposed Maine legislation to further regulate the use of mercury in batteries

APPENDIX F

An Act to Regulate the Use of Mercury in Batteries

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA § 1661, sub-§6, is enacted to read:

6. Novelty. "Novelty" means a product intended mainly for personal or household enjoyment or adornment. "Novelty" includes, but is not limited to, items intended for use as practical jokes, figurines, adornments, toys, games, cards, ornaments, yard statues and figures, candles, jewelry, holiday decorations and items of apparel.

Sec. 2. 38 MRSA § 1661-C, sub-§ 9, is enacted to read:

9. Novelties. After January 1, 2007, a person may not sell or offer to sell or distribute a novelty that contains a mercury-added battery.

Sec. 3. 38 MRSA § 1662, sub-§ 1-A, is enacted to read:

1-A. Labeling of mercury-added batteries. After January 1, 2007, the manufacturer of a mercury-added battery that is to be sold in this state shall label the battery packaging to clearly identify that the battery contains mercury. This requirement does not apply to products containing one or more mercury-added batteries.

Sec. 4. 38 MRSA § 2165, sub-§ 6, ¶E, is enacted to read:

E. Effective January 1, 2010, a battery that contains any added mercury or a product containing such a battery except a mercuric oxide battery as provided under subsections 2, 3 and 4.

Sec. 5. By February 1, 2007, the Department of Environmental Protection shall submit a report to the joint standing committee of the Legislature having jurisdiction over natural resources matters on the following:

A. The reliability of mercury-free button batteries, including whether manufacturers have been successful in preventing the formation of gas inside the battery canister; and

B. Whether mercury-free button batteries are being produced or capable of being produced in sufficient numbers to meet the needs of Maine consumers.

SUMMARY

The bill bans the sale of toys and other novelties containing mercury-added batteries beginning January 1, 2007, and bans the sale of all other mercury-added batteries, except certain mercury oxide batteries allowed under 38 MRSA §1665 beginning January 1, 2010.