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Mercury-free button batteries: their reliability and availability

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I. Introduction

This report has been prepared pursuant to the requirements of Public Laws 2005, Chapter 509, a copy of which is attached as Appendix A. Section 2 of the law bans the sale of mercury-added button cell batteries in Maine effective June 30, 2011. Section 3 directs the Department of Environmental Protection (department) to review the state of the technology for mercury-free button cell batteries and their use in products, especially watches, precision instruments, hearing aids and medical devices. Specifically, the law directs the department to review and report on the following matters by January 15, 2009:

- The availability of mercury-free button cell batteries in retail outlets in the State;
- The reliability and safety of mercury-free button cell batteries being sold in the State;
- The existence of reasonable substitutes for mercury-added button cell batteries in all applications;
- The status of any testing and analysis of mercury-free button cell batteries;
- The disparity, if any, between the costs of mercury-free button cell batteries and button cell batteries containing mercury; and
- Whether prohibiting the sale of mercury-added button cell batteries after June 30, 2011 is practical.

This report follows our March 2005 report on mercury use in button cell batteries¹ and a companion report by the Lowell Center for Sustainable Production (LCSP) on its investigation of alternatives to button cell batteries containing mercury.²

In our 2005 report, we detailed the amount of mercury contributed to U.S. commerce from the sale of products containing button cell batteries as well as replacement batteries sold separately. We described the three types of mercury-added button batteries (zinc air, silver oxide and alkaline manganese) sold in Maine.³ And we presented information on the feasibility of eliminating the use of mercury in button batteries.

LCSP's contemporaneous investigation buttressed the department's conclusion that manufacturers were beginning to market mercury-free versions of all three button cell battery types. LCSP further found the performance characteristics of these new batteries as reported by their manufacturers was comparable to the mercury-added versions. It was acknowledged, however, that the long-term reliability of the batteries was unproven. Moreover, there were concerns about whether production levels would prove to be sufficiently robust to support a rapid phase-out of mercury in all button battery applications.

¹ Maine Department of Environmental Protection, *Mercury Use in Button Batteries: a Report to the Joint Standing Committee on Natural Resources*, 122nd Maine Legislature, March 2005.

² Catherine Galligan and Greg Morose, *An Investigation of Alternatives to Miniature Batteries Containing Mercury*, Lowell Center for Sustainable Production, 2004.

³ The sale of a fourth type of mercury-added button battery, called mercuric oxide batteries, is banned in Maine. See 38 MRSA §2165(6)(B).

In light of these concerns, the department recommended a two-part mercury reduction strategy, the main feature of which was a ban on the sale of mercury-added batteries effective January 1, 2010. A prospective ban was recommended to give the industry time to perfect the mercury-free technology and increase production capacity while at the same time hastening the deployment of the new technology by setting a target date for the phase-out of mercury-added batteries. The Legislature ultimately enacted the proposed ban, settling on an effective date of June 30, 2011 in consultation with battery manufacturers.

The second part of the department's strategy, also enacted by the Legislature, called for this interim report as a precautionary step in advance of the ban's effective date. The purpose is to update the Legislature as to whether reliable, mercury-free button batteries are being produced, or are capable of being produced, in sufficient numbers to meet the needs of Maine consumers by that date.

This report proceeds in four sections. Section II provides a brief overview on the use of mercury in button batteries. Section III details the use and availability of four types of mercury-free button batteries. Sections IV and V set forth the department's conclusions and recommendations.

II. Mercury use in button batteries

Button cell batteries are used in hearing aids, watches, calculators, toys and numerous other small, portable devices that require a compact source of electrical power. The four major technologies used in the manufacture of button batteries are: lithium; zinc air; silver oxide; and alkaline manganese. Lithium button batteries contain no intentionally added mercury. Zinc air, silver oxide and alkaline manganese button batteries typically contain 0.1% to 2.0% mercury by weight.

The function of the mercury is to inhibit gas formation inside the battery. Gas buildup can cause the battery casing to bulge and separate, potentially resulting in leakage of the battery materials. This leakage affects the ability of the battery to continue functioning.

Button cell batteries enter commerce in two ways—through the sale of products with the battery embedded and through the sale of replacement batteries. Most U.S. made button cell batteries are sold on the replacement market. Button cells sold in products, on the other hand, almost certainly come from outside the U.S. according to the National Electrical Manufacturers Association (NEMA).⁴ NEMA represents the principal U.S. based manufacturers of button cell batteries, including Duracell, Energizer, Kodak, Panasonic and Rayovac.

Replacement batteries sold in the U.S. by NEMA members accounted for about 4000 pounds of mercury in 2001, about 2,200 pounds in 2004 and about 2,000 pounds in 2007. This downward trend—a decline in mercury usage of 50% in just 6 years—is in keeping with the U.S. battery industry's pledge to eliminate mercury from button cell batteries by June 30, 2011, the effective date of Maine's sales ban.⁵

⁴ Ric Erdheim, National Electrical Manufacturers Association (NEMA), personal communication, July 27, 2004.

⁵ National Electrical Manufacturers Association, *NEMA Announces Battery Industry Commitment to Eliminating Mercury in Button Cells*, March 2, 2006.

The exact amount of mercury introduced into U.S. commerce through the sale of products with embedded button batteries is not known. Data compiled by the Interstate Mercury Education and Reduction Clearinghouse (IMERC)⁶ shows that these sales accounted for at least 1900 pounds of mercury in 2001, at least 2900 pounds in 2004 and at least 2300 pounds in 2007. However, not all manufacturers of toys and other products that contain button batteries have disclosed their U.S. sales to IMERC. A recent investigation by this department, for example, identified 15 models of digital fever thermometers on sale in Augusta Maine stores that contained mercury-added button batteries. The thermometers were distributed by nine different companies, only two of which had reported this mercury usage to IMERC.

We are unable to estimate the extent to which the IMERC data under-represents the total mercury entering U.S through the button battery sales. The data is thought to be lacking mainly with respect to imported products containing foreign-made batteries. A European study estimates that only 10% of button batteries enter commerce through product sales, suggesting that the mercury contribution from this segment of the market may be modest compared to the sale of replacement batteries.⁷

On the other hand, millions of foreign made products, many containing button batteries, are sold in the U.S. each year, suggesting that the IMERC data may reflect only a modest fraction of the market. For example, in 2004, an estimated 17 million Spider Man toys were distributed in Kellogg's breakfast cereals. The toys, which were made in China, each contained two mercury-added alkaline manganese button cells. Assuming each battery contained just a single milligram of mercury, over 70 pounds of mercury were contributed to U.S. commerce through this single promotional campaign.⁸ Most alkaline manganese button cells contain between 5 and 10 milligrams of mercury based on information submitted to IMERC.

In 2004, manufacturers based in China consumed an estimated 109 tons of mercury in the production of alkaline manganese button cell batteries, the battery type most likely to be used in imported toys and novelties.⁹ It is reasonable to assume that significant numbers of these batteries are included in products made in China (and elsewhere in Asia) and ultimately sold in the United States.¹⁰ Americans buy roughly 60% of all toys exported from China.¹¹

Though definitive data on the amount of mercury consumed in U.S. button battery sales are lacking, a September 2008 report by the European Commission (EC) allows us to gauge the possible magnitude of this mercury usage. In the report, the EC's Directorate for the General

⁶ IMERC, a program of the Northeast Waste Management Officials Association (NEWMOA), was formed to coordinate the collection of data pursuant to laws in several states, including Maine, that prohibit the sale of mercury-added products unless the manufacturers has disclosed the amount mercury in their U.S. sales of the product. The Maine law requiring this disclosure is codified at 38 MRSA §1661-A.

⁷ BIO Intelligence Service, *Impact Assessment on Selected Policy Options for Revision of the Battery Directive*, European Commission, July 2003, p. 54.

⁸ Kellogg's subsequently announced it will no longer use mercury-added batteries in connection with any of its U.S. promotions after September 30, 2004. Gary Pilnick, General Counsel, Kellogg Company, in personal communication to Eliot Spitzer, Attorney General, New York, July 14, 2004.

⁹ United Nations Environment Program (UNEP), *Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes*, July 14, 2008, p.39.

¹⁰ Galligan and Morose, *supra* n. 2 at 13.

¹¹ Donovan Hahn, "Through the open door: searching for deadly toys in China's Pearl River Delta", *Harper's Magazine*, September 2008, p.49.

Environment estimates that the mercury in button cells marketed yearly in the 27 member nations of the European Union plus Norway and Switzerland (the “EU27+2”) could total 5.5 to 7.7 tons (5 to 7 metric tons).¹² An extrapolation of this estimate to the U.S. based on population—the U.S. population (305 million) is about 60% of the EU27+2 population (501 million)—yields a range of 3.3 to 4.6 tons of mercury in annual U.S. button battery sales. The corresponding range for button battery sales in Maine is about 30 to 40 pounds of mercury per year. All or most of that mercury presumably will end up in the municipal solid waste stream when the batteries and products containing them are discarded.

III. Use and availability of mercury-free button batteries

A. Zinc-air

Zinc air button batteries currently account for about half of the mercury used by U.S. button battery manufacturers. The vast majority of these batteries are sold for use in hearing aids, a demanding use that requires a high energy battery. To function properly, zinc air batteries require oxygen from the ambient air and therefore are uniquely suited for use in hearing aids, which offer access to ambient air.¹³ Zinc air button cells are produced in just five sizes and have a useful life measured in days.¹⁴ Hearing aid users typically buy multiple replacement batteries at a time.

Reliable, mercury-free zinc air button batteries are beginning to be offered for sale in the U.S., including in Maine. Representatives of the battery industry agree that these mercury-free alternatives will be widely available by the July 2011 target date.¹⁵ We found them on the shelves in two Maine stores in November 2008 at prices equivalent to their mercury-added counterparts.

In October 2008, Energizer battery announced that, after more than a decade of development and extensive testing, the company is introducing zero-mercury hearing aid batteries to the U.S. market.¹⁶ The company has been selling zero-mercury hearing aid batteries in Europe since 2001 but delayed introduction to the U.S. until now due to limited production capacity. According to Energizer, its zero-mercury batteries have been tested against applicable safety, reliability and performance standards and have been found to compare favorably to mercury-added batteries.¹⁷

¹² European Commission, *Options for reducing mercury use in products and applications and the fate of mercury already circulating in society*, September 2008, p. 41.

¹³ Galligan and Morose, *supra* n. 2 at 17.

¹⁴ Richard Tozer, *Analysis of Battery Industry Sponsored Button Cell Collection Programs*, National Electrical Manufacturers Association, December 19, 2003, p.8.

¹⁵ National Electrical Manufacturers Association (NEMA), Dry Battery Section, *Assessment of Mercury-Free Button Battery Technology*, September 2008, p. 1.

¹⁶ Reuters News, “Bennington seniors first in nation to receive new zero mercury hearing aid batteries” (October 6, 2008), www.reuters.com, accessed December 9, 2008.

¹⁷ Mark Kohorst, NEMA, personal communication, November 2008.

In August 2008, U.S. based manufacturer Rayovac introduced its ProLine mercury-free hearing aid battery.¹⁸ Testing is still underway,¹⁹ but the company expects the batteries to be available through hearing aid professionals and retail outlets in the first quarter of 2009.²⁰

B. Silver oxide

Silver oxide button cell batteries are used mainly in watches and cameras, but also may be used in miniature clocks, electronic games, calculators and other products that require a flat discharge profile.²¹ NEMA reports that about three quarters of all silver oxide batteries made by its member manufacturers are used in watches with cameras accounting for most of the rest.²²

Although no U.S. battery manufacturer currently offers mercury-free silver oxide button cells, an assessment of the technology by NEMA indicates that mercury-free alternatives are likely to be widely available to U.S. consumers by July 2011.²³ A number of foreign manufacturers, including the Japan-based companies Sony, Seiko and Hitachi, have offered mercury-free silver oxide batteries in a variety of sizes for several years. In 2008, Germany-based VARTA Microbattery also started producing an assortment of mercury-free silver oxide button cells.²⁴ These batteries are available to original equipment manufacturers for use in their end products and are beginning to become available in the U.S. for purchase by end-consumers as replacement batteries.

The Sony Corporation introduced its line of mercury-free silver oxide button cells in September 2004 and currently lists 25 mercury-free models on its website.²⁵ Hitachi Maxell introduced mercury-free silver oxide button cells six months later in April 2005. The company's website claims that the reliability of the batteries has been verified by more than ten years of testing.²⁶

Seiko Instruments, through its subsidiary SII Micro Parts Ltd., announced in August 2005 that it also had developed a mercury-free silver oxide battery.²⁷ Seiko has constructed a plant with capacity to manufacture 30 million of the batteries annually. Seiko's mercury-free

¹⁸ Rayovac Introduces Mercury-Free Hearing Aid Battery, www.healthyhearing.com, accessed December 9, 2008.

¹⁹ Kohorst *supra* n. 17.

²⁰ Will Campbell, "Mercury falling: the race to deliver mercury-free hearing batteries doesn't end until 2011, but Energizer and Rayovac already across the finish line", *The Hearing Review*, Nov/Dec 2008.

²¹ The discharge profile of button batteries is either flat or sloping. A flat discharge profile indicates that the battery delivers a constant voltage during use; a sloping discharge profile indicates that the voltage delivered by the battery decreases during the battery life. Galligan and Morose *supra* n.2 at 14.

²² Tozer *supra* n. 14 at 8.

²³ NEMA *supra* n 15 at 1.

²⁴ VARTA Microbattery GmbH, www.varta-microbattery.com.

²⁵ Sony Corporation, "Sony silver oxide batteries: line up" www.sony.net, accessed November 6, 2008.

²⁶ Hitachi Maxell, Ltd., "Maxell introduces a zero-mercury, zero-lead added silver-oxide cell, reducing environmental impact while maintaining current product-life levels", www.maxell.co.jp, accessed December 10, 2008.

²⁷ Seiko Instruments, Inc., "Mercury/lead-free silver oxide battery", <http://speed.sii.co.jp>, accessed December 10, 2008.

batteries are marketed worldwide and can be purchased online.²⁸ As of June 2008, every Seiko watch is offered exclusively with batteries that contain no mercury.²⁹

The E. Gluck Corporation reports that 98% of their watches contain mercury-free button cell batteries from Sony, Maxell and Seiko.³⁰ Some American Watch Association members (AWA) also have begun to use mercury-free batteries made by Japanese companies.³¹ A number of models of mercury-free silver oxide button batteries also were found on the shelves of one Maine retail outlet in November 2008 at prices equivalent to those for the mercury-added versions, although the manufacturer of the cells could not be identified.

Several companies based in China make mercury-free silver oxide batteries but the extent of their availability and use in the U.S. is unknown. These companies include Chung Pak,³² Pak Ko³³ and New Leader, each of whom also manufactures mercury-free alkaline manganese button batteries. The U.S. distributor for Chung Pak reports that it sells mercury-free batteries to Radio Shack and Rayovac among others at a bulk rate price that is about 25¢ to 50¢ per cell more than mercury-added batteries.³⁴ Several multinational corporations, including McDonald's, Coca Cola and PepsiCo, are reported to have ordered souvenirs powered by Pak Ko mercury-free button batteries³⁵ but these likely were alkaline manganese cells. A very small percentage of silver oxide button cells are used in toys and novelties.³⁶

The watchmaker E. Gluck Corporation noted that both battery manufacturers and movement manufacturers have conducted tests of the mercury-free silver oxide button cells, but not enough time has passed to support a conclusion as to the long-term reliability of the batteries.³⁷ The AWA says its members will need at least two years of rigorous experience with mercury-free batteries to test the reliability of the new batteries, their rate of leakage, their longevity, their ability to deliver a constant 1.55 voltage and their ability to operate without corrosive harm to precision watch movements.³⁸ At least one AWA member, however, is monitoring mercury-free cells through its service department and has not noticed any problems so far.³⁹

Some product manufacturers, watchmakers in particular, have noted that mercury-free, silver oxide button cells are not available for all their product models. Representatives of U.S. battery manufacturers, in a meeting with the authors of this report, suggested this may reflect economies of scale. Silver oxide button cells are made in numerous sizes, many of which are

²⁸ Microbattery.com, <http://shopping.microbattery.com/s.nl/sc.2/category.14212/.f>, accessed December 11, 2008.

²⁹ Seiko Watch Company, "Seiko to lead the watch industry by switching to mercury-free batteries", www.seikowatches.com, accessed December 10, 2008.

³⁰ Marjorie Brown, E. Gluck Corporation, personal communication, November 6, 2008.

³¹ Emilio Collado, American Watch Association, personal communication, November 3, 2008.

³² Chung Pak Battery Works Ltd., Hong Kong China, www.chungpak.com. Chung Pak markets its batteries under the brand name Vinnic.

³³ Pak Ko Batteries Factory Ltd., Hong Kong, China "Green cell series", www.pakkobatteries.com.

³⁴ Martin Kuchinski, Evergreen (C.P) USA, Inc., personal communication, December 30, 2008.

³⁵ "Foreign firms get products advice", *China Daily*, April 5, 2007.

³⁶ Tozer *supra* n. 14 at 8.

³⁷ M. Brown, personal communication, *supra* n. 30.

³⁸ E. Collado, personal communication, *supra* n. 31.

³⁹ *Id.*

not in large enough demand to make it economically worthwhile for manufacturers to re-engineer them to eliminate the use of mercury.

According to NEMA, five specific silver oxide battery types—those designated SR357, SR364, SR371, SR377 and SR395 under the battery nomenclature published by the International Electrotechnical Commission (IEC)⁴⁰—account for more than 90% of all silver oxide button battery sold in the U.S. in 2007.⁴¹ Most other silver oxide button cells are produced in low volume for specialized applications that do not justify the investment required to transition to mercury-free technology.

NEMA strongly recommends that Maine delay the applicability of its sales ban to these so-called “low-runners” in the silver oxide button battery market so that devices using them are not rendered obsolete prematurely.⁴² For example, although Olympus Corporation has converted to mercury-free batteries for most of its products, the company still uses mercury-added silver oxide button cells in its capsule endoscopy system because the available mercury-free button cell batteries do not have the required electrical capacity.⁴³

C. Alkaline manganese

Alkaline manganese button cell batteries are used in many products including cameras, calculators, digital thermometers, remote controls, souvenirs and other novelties, toys and games. NEMA reports that 90% of the alkaline manganese button batteries made by its members are used in cameras; less than one percent is used in toys and games.⁴⁴ Less is known about the use of alkaline manganese button batteries made by foreign manufacturers although they appear to be the battery type of choice in imported toys and novelties that contain button cells. As previously noted, manufacturers in China are estimated to have used over 100 tons of mercury in the manufacture of alkaline manganese button cells in 2004⁴⁵ compared to 661 pounds for NEMA members.⁴⁶

The transformation of alkaline manganese chemistry presents a formidable technical challenge according to NEMA, and the association therefore is not optimistic about the ability of the industry to produce reliable, mercury-free alkaline manganese button cells by the July 30, 2011 target date.⁴⁷ NEMA observes that silver oxide button cells could provide suitable alternative in the meantime. They will fit and work but may not always achieve the same performance or battery life, and they cost more.⁴⁸ A price comparison of popular button cell battery sizes suggests that alkaline manganese button cells are available in bulk

⁴⁰ Under the IEC nomenclature, ‘S’ signifies a silver oxide battery, ‘R’ signifies that the battery is round. The numerals signify the battery dimensions.

⁴¹ M. Kohorst, NEMA, personal communication, January 5, 2009.

⁴² *Id.*

⁴³ Robert Morse, Olympus Corporation, personal communication, November 3, 2008.

⁴⁴ Tozer *supra* n. 14 at 8.

⁴⁵ UNEP *supra* n. 9 at 39.

⁴⁶ IMERC *supra* n. 6.

⁴⁷ NEMA *supra* n. 15 at 2.

⁴⁸ Kohorst *supra* n. 17.

quantities at prices of 10¢ or less compared to a range of 30¢ to 50¢ for comparable sized silver oxide cells.⁴⁹

A more optimistic view is offered by a faculty member at the University of Massachusetts who is conducting research on green battery chemistry. He suggests that bismuth, indium and organic surfactants can suppress gas generation as effectively as mercury, and that there are no technical difficulties in eliminating mercury from alkaline manganese batteries by 2011.⁵⁰ In fact, at least five foreign manufacturers, all based in China, already offer mercury-free alkaline manganese button cell batteries in a variety of sizes.

Mercury-free alkaline manganese button cells made in China are beginning to appear in products sold in the U.S. and have been in use here for a number of years. In 2003, toymakers Mary Meyers and Radica China notified IMERC that they had begun using mercury-free alkaline manganese button cells made by New Leader.⁵¹ The Little Tikes Company reported that it also was considering a switch to New Leader mercury-free batteries and presumably has done so as the company did not file mercury usage information with IMERC for the 2004 and 2007 reporting years. Additionally, our investigation of digital fever thermometers (see appendix B) found that six out of twenty-five thermometers contained New Leader mercury-free alkaline manganese button cells; three others contained Super Energy⁵² mercury-free alkaline manganese button cells and one contained a lithium coin cell battery.

Other companies known or reported to sell products containing New Leader mercury-free alkaline manganese buttons batteries include Wal-Mart, K-Mart, Hallmark Cards, MacDonald's, Burger King, Kellogg's and the Gap. Other companies known to make this type of mercury-free battery include Chung Pak⁵³ and Pak Ko⁵⁴ (both of whom also make mercury-free silver oxide button cells), and Shenzhen Thumbcells.⁵⁵

Mercury-free alkaline manganese button cells are sold mainly to original equipment manufacturers for use in end products. However, one model was found on the shelves of an Augusta Maine store in November 2008 at prices equivalent to those for the mercury-added version, although the manufacturer could not be identified.

In March 2005, during legislative deliberations on the bill that ultimately established Maine's ban on the sale of mercury-added button batteries, representatives of the U.S. battery industry testified to the poor performance of New Leader mercury-free button cell batteries. A NEMA representative reported that an anonymous company experienced a high rate of failure and an Energizer representative presented a chart showing that 63 of 75 New Leader

⁴⁹ www.BFMBatterySales.com, accessed January 12, 2009.

⁵⁰ Deyang Qu, Assistant Professor, University of Massachusetts Boston, personal communication, January 10, 2006.

⁵¹ New Leader Battery Industry, Ltd., Hong King, China, "Mercury free 0% Hg LR button battery", <http://newleader.semitrade.com>.

⁵² Super Energy Battery Industries, Ltd., Hong Kong, China, wee.superenergy.com.hk.

⁵³ Chung Pak *supra* n. 32.

⁵⁴ Pak Ko, "Green cell mercury free alkaline manganese dioxide button cell", *supra* n. 33.

⁵⁵ Shenzhen Thumbcells Company, Ltd, Shenzhen City, China, "0% Hg alkaline manganese dioxide button cell", www.thumbcells.cn.

batteries tested leaked within one year, compared to Energizer and other brands of mercury-added batteries that show little, if any, leakage at 3 to 5 years.⁵⁶

In November 2005, Gap Inc reported that it found New Leader's non-mercury button batteries to be a good alternative and asked its suppliers to start using them in lieu of mercury-added alkaline manganese button cells.⁵⁷ Before taking this step, Gap conducted long-duration testing of the New Leader batteries through two independent labs to determine if the batteries were comparable in performance and safety to mercury-added cells.⁵⁸ A Gap colleague also visited the New Leader factory in China to assess the production process.

No other information on the performance of New Leader batteries has been brought to our attention since we last reported to you on this subject. However, NEMA recently has reiterated its concerns about the performance of mercury-free button alkaline manganese button cells, citing past assessments of New Leader batteries as evidence that they do not perform to NEMA battery section standards.⁵⁹ A NEMA member company currently is conducting a new regimen of tests on more recent New Leader batteries, but results are not yet available.⁶⁰

D. Lithium

Lithium miniature batteries, which are shaped more like a coin than a button, have no added mercury and are a possible alternative to mercury-added button cells. Existing products would have to be redesigned, however, to accommodate the different physical shape (typically flatter and wider) of lithium batteries. Lithium batteries also have a much higher operating voltage than the three button cell battery types and therefore may not be suitable for some applications.⁶¹

Lithium batteries are available in a wide range of capacities⁶² and offer the second highest energy density, after zinc air, of the four miniature battery technologies.⁶³ They also have the lowest self-discharge rate and provide excellent leakage resistance.⁶⁴ Lithium batteries are ideal for applications requiring low current drain and offer the greatest range of operating temperatures compared to the other three miniature battery technologies.⁶⁵ According to NEMA, "much of the gadgetry that traditionally relied on silver oxide technology has progressed to higher energy density batteries such as lithium, which are preferable in some applications due to the increased complexity of modern electronic devices."⁶⁶

⁵⁶ Ric Erdheim, NEMA, and Mark Boolish, Energizer, in testimony on LD 1058, 122nd Maine Legislature, Joint Standing Committee on Natural Resources, March 25, 2005.

⁵⁷ Pam Utz, Gap Inc., in personal communication with Terri Goldberg, IMERC, November 3, 2005.

⁵⁸ *Id.*

⁵⁹ M. Kohorst *supra* n. 17.

⁶⁰ *Id.*

⁶¹ Galligan and Morose *supra* n. 2 at 27.

⁶² Capacity is the quantity of electricity that may be draw from a fully charged battery.

⁶³ Galligan and Morose *supra* n. 2 at 28.

⁶⁴ *Id.*

⁶⁵ *Id.*

⁶⁶ M. Kohorst *supra* n. 17.

Timex reported that 95% of its watches use lithium batteries.⁶⁷ Lithium batteries also are common in electronic games, calculators, car lock systems, garage door openers and greeting cards. The presence of three lithium (CR2032) batteries in packaging for Flex-a-min, an over-the-counter dietary supplement for treatment of arthritis, suggests that these batteries are available to product manufacturers at a bulk rate price that is not cost prohibitive. The October 2008 edition of Esquire magazine, published by Hearst Communications, Inc., contained 6 lithium (CR2016) batteries to power “the world’s first E-ink cover.”

IV. Conclusions

The marketplace appears to be moving steadily toward the environmental protection goal set in 2005 when the Legislature established June 30, 2011 as the target for elimination of mercury from button cell batteries sold in Maine. Mercury-free versions of all three button battery chemistries that traditionally have used mercury are now available in Maine stores. There is no evidence to suggest that adherence to the 2011 ban date will adversely affect Maine consumers, either by making essential products unavailable or by rendering products purchased before that date obsolete due to the lack of mercury free replacement batteries. To minimize the latter possibility, the Legislature could extend the effective date of the ban as applied to those sizes of silver oxide batteries that, due to low demand, are less likely to be made available in mercury-free versions. Silver oxide button batteries are commonly used in watches and in cameras, products that can have a relatively long useful life.

- Mercury-free zinc air batteries for hearing aids are likely to be widely available by July 30, 2011, the effective date of Maine’s ban on the sale of mercury-added button cell batteries. Mercury-free zinc air-cells made by Energizer already are beginning to appear on store shelves in Maine. Hearing aid batteries currently account for about 50% of the mercury used in the manufacture of U.S. made button batteries.
- Mercury-free alternatives for commonly used sizes of silver oxide button batteries also are likely to be widely available by July 30, 2011 as well. Sony, Seiko, Hitachi and Varta are among the companies that already make and sell mercury-free silver oxide button batteries.

Mercury-free versions of less commonly used sizes of silver oxide button batteries are unlikely to be produced by U.S. manufacturers because low sales volumes do not warrant the investment. Mercury-free versions of these so-called “low runners” may or may not be available from foreign battery manufacturers. If not, users of products that require those battery sizes will not be able to legally purchase a replacement battery after June 30, 2011.

- At least five companies, all based in China, are known to make mercury-free versions of alkaline manganese button batteries. These mercury-free batteries have been found in some products sold in Maine (e.g., digital thermometers, sound books). Testing by U.S. manufacturers suggests that many of these batteries do not perform to industry standards. U.S. manufacturers say that the elimination of mercury from alkaline manganese button batteries presents a more formidable technical challenge than is the case with silver oxide

⁶⁷ Freddy Gochuico, TMX Philippines Inc., personal communication, October 28, 2008.

and zinc air batteries. Accordingly, they are less optimistic than in the case of zinc air and silver oxide batteries about the industry's ability to perfect mercury-free production techniques for alkaline manganese button batteries by June 30, 2011.

Mercury-free silver oxide or lithium batteries could be substituted in most or all products that currently use mercury-added alkaline manganese button battery, albeit at greater cost. Mercury-free silver oxide button batteries can be used as a drop-in replacement, while the use of lithium coin batteries would require the product to be redesigned because of the different battery configuration. No application was identified in which alkaline manganese is the most effective or only battery type that could be used.

V. Recommendations

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

- Amend 38 MRS §1661-C, sub-§9, banning the sale of button cell batteries to extend the effective date of the ban as applied to silver oxide batteries from June 30, 2011 to January 1, 2015 for all but the following standard size designations: 357; 364, 371, 377 and 395;
- Reaffirm the June 30, 2011 effective date of the ban as applied to all other mercury-added button cell batteries; and
- Amend 38 MRS §2165, sub-§6,⁶⁸ as enacted in 1992, to reconcile language governing the allowable mercury content of alkaline manganese button batteries with the ban on sale of mercury-added button batteries under §1661-C, sub-§9.

See Appendix C for proposed legislation to implement these recommendations.

NOTE: In April 2006, shortly after the bill requiring this report was enacted,⁶⁹ the chairs of the Legislature's Committee on Natural Resources Committee wrote the Commissioner of Environmental Protection requesting the department to include in its report recommendations on how to manage the inventory of button batteries and products containing button batteries that were manufactured prior to the 2011. We have considered this potential problem and do not think legislative action is needed. The prospective phase out date gives battery manufacturers, product manufacturers and retailers ample time to fairly resolve the matter.

⁶⁸38 MRS §2165(6) prohibits the sale of zinc carbon and alkaline manganese batteries containing added mercury. At the time this provision was enacted in 1992, the battery industry had not been able to eliminate the need for mercury in most miniature batteries. In recognition of this unsolved technological challenge, the Maine Legislature exempted button cells from the sales ban if they contain no more than 25 milligrams of mercury. The exemption by its terms applies only to alkaline manganese button cells but has been interpreted to apply to zinc air and silver oxide batteries as well.

⁶⁹ See *An Act to Regulate the Use of Batteries Containing Mercury*, LD 1058, 122nd Maine Legislature.

APPENDICES

APPENDIX A

*An Act To Regulate the Use of Batteries Containing Mercury, Public Laws
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APPENDIX A
PUBLIC LAWS
Second Regular Session of the 122nd Maine Legislature

CHAPTER 509
S.P. 375 - L.D. 1058

An Act To Regulate the Use of Batteries Containing Mercury

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA §1661, sub-§2-A is enacted to read:

2-A. Mercury-added button cell battery. "Mercury-added button cell battery" means a button cell battery to which the manufacturer intentionally introduces mercury.

Sec. 2. 38 MRSA §1661-C, sub-§9 is enacted to read:

9. Button cell batteries. After June 30, 2011, a person may not sell or offer to sell or distribute for promotional purposes a mercury-added button cell battery for consumer use or a product for consumer use that contains a mercury-added button cell battery.

Sec. 3. Report. By January 15, 2009, the Department of Environmental Protection shall submit a report, including recommendations, on the state of the technology of mercury-free button cell batteries to the joint standing committee of the Legislature having jurisdiction over natural resources matters. As part of its study, the department shall review and report on the following matters concerning all uses of button cell batteries and specifically their use in watches, precision instruments, hearing aids and medical devices:

1. The availability of mercury-free button cell batteries in retail outlets in the State;
2. The reliability and safety of mercury-free button cell batteries being sold in the State;
3. Whether reasonable substitutes exist for mercury-added button cell batteries in all applications;
4. The status of any testing and analysis of mercury-free button cell batteries;
5. The disparity, if any, between the cost of mercury-free button cell batteries and button cell batteries containing mercury; and
6. Whether prohibiting the sale of mercury-added button cell batteries after June 30, 2011 is practical.

The department shall confer with and solicit information from representatives of the battery, watch, precision instrument, hearing aid and medical device industries regarding the industries' experience with testing, reliability of use, cost and availability of mercury-free button cell batteries.

The joint standing committee of the Legislature having jurisdiction over natural resources matters may report out legislation relating to the department's report to the First Regular Session of the 124th Legislature.

Effective August 23, 2006.

APPENDIX B

Research Methods

In preparing this report, the authors reviewed relevant information in the public domain and solicited information from interested parties. We also visited several stores in Augusta Maine to determine the availability of mercury-free button batteries.

Information from interested parties

In October 2008, the department wrote to button battery manufacturers, manufacturers of products that contain button batteries, audiologists and hearing aid dealers. The letter reminded them of Maine's upcoming ban on the sale of mercury-added button cell batteries and invited their input on the availability, use and performance of mercury-free button cell batteries.

Battery manufacturers

The information request was mailed to 12 battery manufacturers and two manufacturer associations. The only response came from the National Electrical Manufacturers Association (NEMA), which represents most U.S. based manufacturers of button cell batteries. We also met with representatives of NEMA and two of its member manufacturers—Energizer and Renata—on November 12, 2008. As stated in the body of this report, NEMA's assessment of the marketplace indicates that, for two of the three mercury-added button cell battery chemistries—zinc air and silver oxide—mercury-free alternatives are likely to be available for widespread use by Maine's July 2011 target date. NEMA is "less optimistic" about the transformation of alkaline manganese chemistry. Mercury-free alkaline manganese button cell batteries are available in the market but testing by NEMA indicates they do not perform up to industry standards.

Manufacturers of products that contain button batteries

The information request was mailed to 29 product manufacturers and two retailers. The recipients were identified from the database of the Interstate Mercury Education and Reduction Clearinghouse (IMERC) as companies that make or sell products containing button cell batteries. They included 22 watch manufacturers, 5 manufacturers of medical devices, two toy manufacturers and two retailers. We received eight replies, most of which are referenced in the body of this report. Five of the respondents commented on the practicality of July 30, 2011 deadline:

- The American Watch Association (AWA), representing the majority of watch brands sold in the United States, wrote that its members are "very uncomfortable" with the dilemma posed by Maine's July 2011 deadline. They are captives of the technology and production methods of battery manufacturers and fear that new mercury-free batteries may not be available in the exact size needed, may not deliver the exact same performance as the batteries they replace and will not work in existing watch movements. They urge Maine to adopt a flexible deadline for the prohibition of mercury in button cell batteries instead of the rigid July 2011 deadline.
- Timex said that 98% of its watches already are sold with mercury-free button cell batteries. Timex's ability to install a mercury-free battery in the remaining models by the 2011 deadline

depends on whether battery manufacturers completely switch to mercury-free button cell batteries by that time.

- Watchmaker E. Gluck does not believe the 2011 deadline is practical, asserting that “there will always be some products that will have to be made with mercury-added button cell batteries.”
- American Diagnostic Corporation, a manufacturer of digital fever thermometers, stated that it will probably be practical to effect a change in their existing thermometer design by June 30, 2011.
- The Olympus Corporation wrote that it has not yet found a mercury-free replacement for the silver oxide button cell (SR927) it currently uses in its capsule endoscope system
- RadioShack stated that it is not yet practical to prohibit the sale of mercury-added button cell batteries after June 30, 2011. The company said that the impediment to using mercury-free batteries in its products is performance, including shelf life, though the company also said it has not tested mercury-free button cells in its products.

Audiologists and hearing aid dealers

The information request was mailed to 94 Maine audiologists and hearing aid dealers and two hearing industry associations. We received replies from two audiologists. Both said that mercury-free zinc air button cells are not yet available to them, and as such, they have not had any experience with these cells. They both expected mercury-free batteries to be widely available soon. One did not express concerns about the June 30, 2011 deadline on mercury-added button cell batteries, while the other audiologist recommended that the deadline be delayed until better data on the life expectancy and the cost of the batteries becomes available.

Investigation of battery sales at Augusta Maine stores

In November 2008, the department visited stores in Augusta, Maine, including CVS, Hannaford, K-Mart, RadioShack, Rite-Aid, Shaw’s, Target, Walgreens and Wal-Mart, to investigate: (1) whether mercury-free, button cell replacement batteries were available for purchase and (2) whether digital fever thermometers available in Maine used mercury-free button cell batteries to power the devices.

Table 1 presents our findings on the availability of mercury-free replacement batteries. It shows that mercury-free zinc air, silver oxide, and alkaline manganese button cell batteries were available on the shelves of retail outlets in Maine.

Table 2 presents our findings on the types of button cell batteries used in currently available digital fever thermometers. We specifically chose to investigate button batteries in digital fever thermometers because of Maine’s long-standing ban on the sale of liquid-in-glass fever thermometers⁷⁰ and the public health interest in ensuring that digital thermometers remain available as alternative to the liquid-in-glass mercury thermometers.

⁷⁰ See 38 MRSA §1661-C, sub-§1.

A total of 25 digital thermometers were purchased in order to ascertain the chemistry of the button batteries used to power the devices, whether or not the batteries contained mercury, and the identity of the companies that made the batteries. We found that:

- 15 of the 25 thermometers purchased contained mercury-added button cell batteries.
- 10 contained mercury-free button cell batteries. Of these, six contained New Leader mercury-free alkaline manganese button cells, three contained Super Energy mercury-free alkaline manganese button cell, and one contained a lithium coin cell battery.

Table 1. Mercury-free button cell replacement batteries in Augusta, Maine stores, Nov 2008

Retailer	Brand / manufacturer	Chemistry	Models	Pricing
Rite-Aid	Energizer	Zinc air	10, 13, 312	\$11.99 (8 pack)
Walgreens	Energizer	Zinc air	10, 13, 312	\$9.49 (8 pack)
Wal-Mart	Rayovac ⁷¹	Silver oxide	357/303	\$4.87 (3 pack)
Wal-Mart	Rayovac ⁷¹	Silver oxide	364, 377, 392	\$4.87 (2 pack)
Wal-Mart	Rayovac ⁷¹	Alkaline Manganese	A76	\$4.37 (3 pack)

Table 2. Button cell batteries in digital fever thermometers, Nov 2008

Retailer	Brand / Distributor	Location of Manufacturer	Model	Price	Battery
Shaw's	Becton Dickinson	China	Rapid Flex Digital Thermometer (524928)	\$9.99	GP 392 (silver oxide) (Gold Peak International)
Shaw's	Becton Dickinson	China	SpongeBob Squarepants Digital Thermometer (524924)	\$9.99	GP 192 (alkaline manganese) (Gold Peak International)
Shaw's	Kaz, Inc.	China	Vicks ComfortFlex Thermometer (V966)	\$14.99	GP 392 (silver oxide) (Gold Peak International)
Shaw's	Albertsons, Inc.	China	Equaline Digital Thermometer	\$5.39	LR 41 (alkaline manganese) (New Leader 0% Hg)
Shaw's	MEDport, LLC	Taiwan	Timex 5 Second Acrobat Bendable Thermometer	\$9.99	AG 13 (silver oxide)
Shaw's	MEDport, LLC	China	Timex Accu-Curve Oral Digital Thermometer	\$14.99	GP 392 (silver oxide) (Gold Peak International)
CVS Pharmacy	CVS Pharmacy	China	Digital Thermometer (MT19R1)	\$14.99	GP 392 (silver oxide) (Gold Peak International)
CVS Pharmacy	CVS Pharmacy	China	Digital Thermometer Flexible Quick Read	\$9.99	LR 43 (2) (alkaline manganese) (New Leader 0% Hg)
CVS Pharmacy	CVS Pharmacy	China	Digital Thermometer	\$5.99	LR 41 (alkaline manganese) (New Leader 0% Hg)
Walgreens	Dr. Fresh, Inc.	?	Disney Digital Thermometer	\$8.99	LR 41 (alkaline manganese) (Super Energy Hg free)
Walgreens	Walgreen Co.	China	Digital Thermometer	\$4.99	GP 192 (alkaline manganese)(Gold Peak Intl)
Walgreens	Walgreen Co.	China	Ultra Quick Read Digital Thermometer	\$11.99	AG 10 (alkaline manganese) (Super Energy Hg free)

⁷¹ These batteries are sold under Rayovac brand but were not made by Rayovac. The Rayovac name was licensed to another, unidentified manufacturer, a common practice in the industry.

Table 5 (cont). Button cell batteries in digital fever thermometers, Nov 2008

Retailer	Brand / Distributor	Location of Manufacture	Model	Price	Battery
Rite Aid	BD	China	Musical SpongeBob Digital Thermometer	\$11.99	GP 392 (silver oxide) (Gold Peak International)
Rite Aid	Kaz, Inc.	China	Vicks Underarm Thermometer (V932)	\$12.99	Vinnic L736 (alkaline manganese) (Chung Pak)
Rite Aid	Rite Aid	China	Quick Read Digital Thermometer	\$11.99	LR 43 (2) (alkaline manganese) (New Leader 0% Hg)
Rite Aid	Rite Aid	China	Digital Thermometer	\$6.99	LR 41 (alkaline manganese) (New Leader 0% Hg)
Rite Aid	Kaz, Inc.	China	Vicks Digital Thermometer (V900)	\$9.99	LR 41 (alkaline manganese) (New Leader 0% Hg)
Rite Aid	Kaz, Inc.	China	Vicks SpeedRead Thermometer (V911)	\$12.99	CR1225 (lithium)
Wal-Mart	MABIS Healthcare	China	ReliOn Flexible Digital Thermometer	\$8.52	LR41 (alkaline manganese) (SuperEnergy Hg free)
Wal-Mart	MABIS Healthcare	China	ReliOn Rigid Digital Thermometer	\$2.96	LR41 (alkaline manganese)
Hannaford	Hannaford Bros. Co.	China	Digital Thermometer	\$4.99	LR41 (alkaline manganese)
Hannaford	Hannaford Bros. Co.	China	9-Second Flexible Tip Digital Thermometer	\$5.99	LR41 (alkaline manganese)
Target	The First Years by Learning Curve	China	10-Second Thermometer	\$11.99	GP 392 (silver oxide) (Gold Peak International)
Target	Target Corp.	China	Digital Thermometer	\$4.99	GP 192 (alkaline manganese) (Gold Peak International)
Target	Target Corp.	China	Basal Thermometer	\$10.99	GP 192 (alkaline manganese) (Gold Peak International)

APPENDIX C

Proposed Legislation to Implement the Recommendations of this Report

An Act to Affirm and Amend the Ban on the Sale of Mercury-Added Button Cell Batteries

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA §1661-C, sub-§9, as enacted by PL 2005, c. 509, §2, is repealed and the following is enacted in its place:

9. Button cell batteries.

A. After June 30, 2011, a person may not sell or offer to sell or distribute for promotional purposes a button cell battery of the following types or a product that contains a button cell of the following types:

(1) A mercury-added zinc air battery;

(2) A mercury-added alkaline manganese battery; or

(3) A mercury-added silver oxide battery stamped with the designation SR 357, SR 364, SR 371, SR 377 or SR 395.

B. After January 1, 2015, a person may not sell or offer to sell or distribute for promotional purposes any mercury-added silver oxide button cell battery or a product that contains any mercury-added silver button cell battery.

Sec. 2. 38 MRSA §2165, sub-§ 6, as enacted by PL 1991, c. 808, §2, is amended 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, until June 30, 2011, any alkaline manganese battery resembling a button or coin in size and shape, may contain no more than 25 milligrams of mercury.

SUMMARY

The bill reaffirms the ban on the sale of mercury-added button cell batteries and amends the effective date of the ban with respect to certain silver oxide battery sizes.