MERCURY IDENTIFICATION IN WASHINGTON STATE MANUFACTURING:

Final Report on Manufacturers in Washington State That May Use Mercury

And

Potential Non-Mercury Alternatives

Date: December 2002

Submitted to:

Washington Department of Ecology
Contract Number C0300063

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Executive Summary

This project involved a literature and data review, along with interviews, to identify manufacturers in Washington state that intentionally add mercury to a product in a manufacturing process, or produce a product containing mercury that is not intentionally added, and/or use mercury in a production process. The objectives were to:

- assess quality and availability of data on mercury use by Washington manufacturers;
- identify Washington manufacturers that are, or may be using, mercury in products or processes, and if quantifiable, the amount used annually;
- recommend a list of products, manufacturers, and potentially contractors, to target mercury reduction or replacement alternatives in Washington State.

Mercury recovery, retrofit or exchange initiatives were generally excluded, as were facilities or sectors not considered product manufacturers, such as medical, dental, and laboratory facilities, military and federal facilities, recyclers, waste management, repair and maintenance operations, and companies that mine, process or burn excavated materials or fossil fuels that naturally contain mercury.

Mercury is reportedly found in hundreds of different components, end products, and processes. Some uses have been phased out by regulations and voluntary efforts, but many mercury-added products are still manufactured, and many older devices and mercury-added products are still in use.

Two methods were used to identify manufacturers for further evaluation. The first is by companies that reported mercury-bearing waste streams or releases to regulatory agencies, including the US Environmental Protection Agency, Washington Department of Ecology, and Washington clean air agencies. The second method, “product association”, involved finding and contacting (to the extent possible) manufacturers that make products that may currently, or have historically contained or used mercury. Both have limitations in positively identifying manufacturers adding mercury to processes or products.

The waste and release data only confirmed four companies that are adding mercury in products or processes. Several were found to have used mercury in the past, but have phased out or changed the product or process. By product association, a few thousand manufacturers were found that may use or add mercury, however, limited time and scope of the project only allowed for direct contact or product literature reviews of a few companies. Of these contacted, six were confirmed to use mercury-added components.

With the extensive variation in mercury use, and the list of over 3,000 Washington manufacturers that could be adding mercury to their products, subjective criteria guided the prioritization of companies or industries for further evaluation. These criteria are:

- Non-mercury or lower-mercury alternatives are available that meet performance specifications, and are economically competitive
- Product(s) have a high probability of releasing mercury to air, land or water, by spillage, breakage, or improper disposal at end of life.
- Industry is not currently researching or otherwise addressing mercury elimination in the product or process.
- Significant number of manufacturers of the product reside in Washington.
- (When data is available) The volume of the waste or release is significant.

The foregoing conclusions are based on the actual manufacturers contacted during this project, or manufacturer websites that indicated products and product types.

- No Washington State manufacturers were found to be adding elemental mercury directly to their products.
- Several manufacturers are purchasing mercury-added components or products, such as adhesive, thimerosal, switches, relays, chemical oxygen demand (COD) test kits, and flame sensors, from outside the state and installing or using these in their products or processes.
- Several manufacturers generate mercury as a byproduct from naturally occurring mercury feedstocks, for which no alternative raw materials are feasible.

Given that there are twelve or more switch and relay manufacturers in the state, the vast array of end use or consuming applications for switches and relays, and the significant global market for switches and relays, this industry presents a good opportunity for further evaluation. Other end use applications of switches and relays that should be evaluated include boat, tank and pump manufacturers, automation and controls on various industrial machinery, and telecommunication equipment service providers.

No Washington manufacturers were found to use mercury in production of these products that have historically been manufactured with mercury; gas flame sensors, barometers, pyrometers, manometers, flow meters, or sphygmomanometers.

Final recommendations are to weigh the value of further evaluation of manufacturers in Washington compared to working with facilities on retrofitting and recycling old mercury-containing devices, and/or working with contractors, repair and maintenance facilities, salvagers, and the likes, to extract existing mercury-containing products out of the current or future waste stream.

The information gathered on Washington manufacturers indicate that efforts would require case by case evaluation of mercury uses, and mercury-added components, rather than any blanket type or drop-in mercury substitutes in manufactured products.
In addition to, or as an alternative to contacting and potentially working with manufacturers or contractors, a notification and/or labeling statute would provide

more detailed information on mercury flows in the state. Another way to reach manufacturers is a grant or incentive program to award financial and technical assistance to businesses trying to replace mercury in their products or processes.

Introduction

This project involved a literature and data review, along with various interviews, to identify manufacturers in Washington state that intentionally add mercury to a product in a manufacturing process, or produce a product containing mercury that was not intentionally added, and/or use mercury in a production process.

The objectives of the project were to:

- assess quality and availability of data on mercury use by Washington State manufacturers;
- identify manufacturers in Washington state that are or may be using mercury in products or production, and if quantifiable, the amount of mercury these manufacturers use annually;
- recommend a targeted list of products, manufacturers, and potentially contractors, to target mercury reduction or replacement alternatives in Washington State.

Boundaries and criteria to maintain focus for this study have limited analysis to manufacturing uses of mercury only. Mercury recovery, retrofit or exchange initiatives are generally excluded. Facilities or sectors not considered product manufacturers are also excluded, such as medical, dental, and laboratory facilities, military and federal facilities, recyclers, waste management companies, repair and maintenance facilities, and companies that mine, process or burn excavated materials or fossil fuels that naturally contain mercury (e.g., coal, petroleum, lime, and silica, and other various ores).

Definition of Terms:

"**Mercury-added product**": a product, commodity, or chemical that contains mercury, a mercury compound, or a component containing mercury, deliberately added to goods and products.

"**Mercury-added process**": a process in which mercury is deliberately incorporated to produce a product. The final product may or may not absorb, adsorb, or otherwise contain mercury. For example, a mercury bath is used in the production of magnetic tape used in flight data recorders, but the mercury is not absorbed or adsorbed on to the tape itself.

"**Mercury-contaminated product**": a product, commodity, or chemical that contains mercury as an unintentional impurity. For example, sodium hydroxide (NaOH) used in pulp and paper production may contain mercury if it was purchased from a secondary lead smelter, or if it was produced by the mercury-cell production process.

Section 1.0 Mercury Use in Manufacturing

Mercury is reportedly used in many components, end products, and processes. Section 1.0 highlights many potential uses of mercury in Washington's manufacturing sector. These examples of mercury use were compiled from the body of literature available from various on-line and published references regarding mercury-added products and from discussions with industry, governmental, and non-governmental contacts knowledgeable on the current uses of mercury.

Categories of mercury-added products and processes used in manufacturing are listed in **Table 1**. Categories of mercury-contaminated products and processes used in manufacturing are listed in **Table 2**. These tables are not intended to be all-inclusive. At the same time, inclusion of a categorical mercury use in either table does not imply that such a use is necessarily present in Washington.

It should be noted that some industries are trending toward eliminating mercury due to high costs of shipping, disposal, regulatory requirements, and adverse environmental impacts.

Table 1 - Mercury-Added Products and Processes

Category	Product Examples	Purpose or End Uses of Product
Measurement Devices	Barometer, manometer, gages, meters, hydrometer, psychrometer, flow meter, pyrometer, sphygmomanometer	Measurement of weather, pressure, airflow, steam or gas or fuel flow, fluid levels, humidity, porosity, electricity distribution, pH meter, blood pressure, motor calibration
Lighting	Fluorescent bulbs	Buildings/facilities, backlit LCD display panels in a host of electronic, navigational screens, vehicle lights, black lights
Lighting	High-intensity discharge (HID), sodium, argon-mercury (certain neon colors), capillary, ultraviolet (UV), xenon-mercury-halide, cold cathode	Facility and outdoor lighting, vehicle headlamps, signs, germicidal, UV curing, bug zappers
Mercury	Various consumables that remain in or on the final product	Sealants and adhesives for ships and aircraft, metal finishing, vaccine preservative
Mercury compounds	Various compounds used in processes where mercury does not remain in the final product	Photo developing solutions, magnetic media for flight data recorders), metal coloring/finishing, tanneries
Mercury	Reagent	Lab and medical analysis, plastic production
Electrodes	Mercury drop electrode, mercury oxide reference electrode	Trace analysis for lead, cadmium, silver and other metals, electroanalysis, battery production, production of manganese dioxide
Control devices	Thermostats, regulators, switches, relays, synchronizers	Temperature control, alarms, gas and electricity distribution, motor calibration
Switches	Float, pressure, motion, tilt, tip-over, vibration, transfer, angle, reed	Test/calibration equipment, appliances, level controls, water treatment equipment, conveying/material handling equipment, aircraft, alarms, anti-tamper devices, pumps, fluid meters, boiler controls, timers, vehicles and motor homes (e.g., light activation, fuel cut-off for roll-over, ride control, suspension leveling), telecommun-ication equipment, laptop screens, riding mowers, bilge/septic tanks, ships and boats, appliance turn-off (when not in use)
Relays	Wetted reed, displacement	Control devices, oven controls, welding, high-current power switching, aircraft, flight simulators, printed circuit boards, consumer electronics, office-automation equipment
Sensors	Flame sensor, acceleration sensor, proximity, tilt sensor with potentiometer, other	Flame: gas fired boilers, commercial and residential gas appliances Acceleration: anti-lock brakes Proximity: security system Tilt: medical equipment, robotics, conveyors
Electronics	Advanced mercury alloys, (e.g., Hg-Cd-Te), and wet deposition process of Hg-Cd-Te on wafers	Semiconductors (especially for use in defense and satellites), solar cells, oscillators, converters

Table 1 (Continued)

Category	Product Examples	Purpose or End Uses of Product
Slip ring	Strain gages, thermocouples, rotating or rolling equipment	Packaging equipment, material handling equipment, paper mill rollers
Valve	Heat-activated	Fire suppression sprinkler heads
Mercury salts	Chemical Oxygen Demand (COD) testing kits	COD analysis in process water by food processors and others.
Operating fluid	Diffusion pumps, weights, vibration dampers	Diffusion and chemical-feed pumps, gastrointestinal tubes, electron microscopes

Table 2 – Products and Processes Using Mercury

Product or Commodity	Mercury Contamination Source	End Use(s)
Hydrochloric acid, caustics, sodium hypo-chlorite, other	Produced by the mercury cell process	Drain cleaner, dish soap, abrasives, bleach, other cleaning products, pulp and paper production, sanitizing food and other products, pesticide formulations
Fuels: fossil, wood, municipal solid waste (MSW), hazardous waste	Naturally occurring in fossil fuels and wood, batteries and other mercury-products in MSW, mercury wastes in hazardous waste stream	Incineration, cement kilns, asphalt production, pulp and paper production, cogeneration, other manufacturers that burn fossil or waste fuels for energy.
Fly ash	Naturally occurring in coal, fuel oil, wood, and MSW that is burned for energy	Cement, wallboard, asphalt.
Appliance and auto shred	Switches in appliances and vehicles	Secondary smelting and production of steel and aluminum
Alkalines and caustics	Secondary production by lead and copper smelters	Water neutralization, various industry processes, bauxite refining
Biosolids	Human release to sewer	Land application.
Spills and improper disposal	End-of-life, broken or spilled mercury and mercury products, failed or broken secondary containment	Thermometers, measurement devices, gages, switch ampoules, slip rings, etc.
Legacy waste	Plumbing and sewers	N/A

Section 2.0 Identifying Mercury in the Washington Manufacturing Sector

2.1 Process of Identifying Mercury Uses in Manufacturing

Section 1.0 highlights many potential uses of mercury in Washington's manufacturing sector. These examples of mercury use were compiled from the body of literature available from various on-line and published references regarding mercury-added products, and from discussions with industry and individuals knowledgeable on current uses of mercury.

Because of the non-mercury alternatives available for many of the products that have historically contained mercury, knowing these uses of mercury in products and processes does not imply that any Washington manufacturers are currently manufacturing mercury-added products or using mercury-added processes or mercury-contaminated materials.

Two methods were used to identify manufacturers for further evaluation:

- **Reported Waste and Release Data –** which identifies manufacturers by those that reported mercury wastes and/or releases to land, air, or water.

- **Product Association** – which identifies Washington manufacturers by the products they manufacturer, and by the standard industrial classification (SIC) codes that cover the products listed in **Tables 1 and 2** (Section 1.0 above).

This body of information is typically not detailed enough to pinpoint specific Washington manufacturers using mercury, specific quantities of mercury used (as opposed to wastes or releases generated) by manufacturers, or the source of the mercury. The exceptions, which are discussed in Sections 3.0 and 4.0, are:

- U.S. EPA's Toxics Release Inventory (TRI) "indicators"
- Interstate Mercury Education & Reduction Clearinghouse (IMERC) Mercury-added database
- Massachusetts Toxics Use Reduction Act's TURAData
- State of Vermont's certified mercury labeling plan process

Section 3.0 Summary Findings from Waste and Release Data

The known data sources for reported wastes and releases by Washington businesses are:

- **US Environmental Protection Agency's (EPA) Toxic Release Inventory (TRI)** requires most manufacturing related industries to report annual releases and wastes of certain toxic chemicals above established threshold quantities for one facility. The data is compiled in a national repository. Companies report release quantities to land, air, and water, and waste quantities managed. Mercury must be reported if more than 10 pounds is generated per annum. (Prior to year 2000, the minimum threshold quantity for mercury was 10,000 to 25,000 pounds). The data is searchable by state, facility, chemical, and reporting year, via TRI Explorer (www.epa.gov/tri/) or the customized TRI search engine (www.epa.gov/enviro/html/tris/adhoc.html). The advantage of using the customized search engine over the Explorer is that it provides indicators of how the mercury was generated (e.g., byproduct, formulation component, etc.).
- **Dangerous Waste Regulations** (DWR) requires annual dangerous waste reporting by all companies who generate, transport, or manage dangerous waste and have an active RCRA Site identification number. The reporting is governed by Washington Administrative Codes (WAC) 173-303-060(5), 173-303-070(8), 173-303-220, and 173-303-390. This compilation of data is not available on the web.
- **Puget Sound Clean Air Agency Permit Data –**a list of permitted facilities in the Puget Sound region that generate mercury air emissions, and their respective release per annum. This data is not available on the web.
- **Olympic Region Clean Air Agency Permit Data** – a list of permitted facilities in the Olympic region that generate mercury air emissions, and their respective release per annum. This data is not available on the web.

In year 2000 **US EPA TRI** data**,** eleven Washington manufacturing facilities reported mercury or mercury compound wastes, and nine facilities reported mercury or mercury compound releases. The preliminary 2001 TRI data is not expected to be officially released or published on the TRI website until early 2003, but the preliminary 2001 data indicates five manufacturing facilities that reported mercury or mercury compound wastes, and eleven that reported releases to air, land, or water.

The Washington **DWR** data for year 2000 shows 15 manufacturing facilities generating a cumulative total of about 7,660 pounds and 345 gallons of mercury-bearing waste believed to be directly associated with use in manufacturing. The main caveat with this data is that, even if the mercury is only a portion of the reported waste quantity, the entire weight of the waste is reported. For instance, if a mercury thermometer is included in a laboratory pack with other non-mercury materials, the entire weight of the lab pack is reported as a mercury waste.

These wastes as described by the reporting companies included expired paint, adhesives, sealants, contaminated wastewater, components that contain mercury (switches), elemental mercury which may be used in production or incorporated into pre-consumer products, thimerosal solution, chemical oxygen demand (COD) test solutions and vials, and lab packs that may have been used for process testing or in internal laboratory research and activities. Additional findings from the DWR data are:

- An additional 32 facilities reported DWR mercury wastes that are not likely associated directly with the manufacturing processes, for instance: spent or contaminated equipment and articles, spent bulbs (fluorescent, mercury vapor, high-intensity discharge, etc.), mercury-contaminated oil and debris, removed paint that contained mercury, and lab packs used in research.
- Although not considered manufacturers, nine military facilities reported over 36,000 pounds of mercury-bearing waste that are likely associated with operations and possibly manufacturing activities within the base.
- A total of 29 facilities reported broken thermometers and lab-packed wastes, for a total of more than 1,136 pounds of mercury-bearing materials.

Table 3 summarizes the number of manufacturing facilities reporting to TRI for year 2000 and (preliminary) 2001, and Washington DWR for year 2000. The data excludes reports from: waste management, utilities, mines, petroleum refineries, educational institutions, medical, dental and laboratories, and military or federal facilities.

An additional data source on mercury releases comes from two Washington Clean Air Agencies, who collect mercury emissions data from permitted facilities. The Puget Sound Clean Air Agency reports emissions from two entities, but neither is considered a “manufacturer” according to the scope of this project. The first is a soil recycler who reported 55 pounds of emissions in 1999. The second is a coal fired steam plant that reported 32, 46, and 33 pounds of mercury emissions in 1999, 2000, and 2001 respectively. The Olympic Region Clean Air Agency’s (ORCAA) region received emissions data from two plywood mills and two pulp mills for Year 2001. The combined release from all four facilities was 8 pounds for 2001.

Table 3 – Summary of Mercury and Mercury Compounds Reported by Washington Manufacturers to US EPA TRI and Washington DWR

	EPA Toxics Release Inventory			Washington DWR Data
	Number of Facilities - 1999	**Number of Facilities – 2000**	**Number of Facilities – 2001 (Preliminary data)**	**Number of Facilities - 2000**
Number reporting mercury or mercury compound **waste**	1	11 (a)	5	15 (d)
Combined **waste** quantity for all reporting facilities (b)	406,000 pounds	133,397 pounds (c)	109 pounds	7,687 pounds (e)
Number reporting mercury or mercury compound **releases**	1	9 (a)	11	N/A
Combined r**eleases** for all reporting facilities (b) (c)	35,807 pounds	23,753 pounds (b)	211 pounds	N/A

(a) The mercury threshold decreased from 10,000 pounds to 10 pounds from 1999 to 2000. This is the speculative reason for the increase in number of facilities reporting mercury in 2000.

(b) Some companies report the same TRI quantities for mercury vs. mercury compounds, as well as the same quantity for wastes vs. releases.

(c) One pulp mill and chlor-alkali plant reported 133,000 pounds of mercury waste and 23,514 pounds of mercury releases in 2000. This facility closed the chlor-alkali and pulping operations and did not report mercury in 2001.

(d) Additional companies reported mercury wastes to Washington DWR in 2000, but do not fall under the scope of this project. Only 15 (of 47 manufacturers) reported waste types that <u>may</u> have originated from manufacturing operations.

(e) This cumulative weight represents the mercury and non-mercury weight of reported wastes. For example, if bulbs or contaminated debris was reported, the weight includes the entire weight of the bulbs or debris, not just the mercury portion of the waste.

Using waste data to identify mercury users falls short for several reasons. Not all manufacturers that could be using mercury are required to report to these available tracking systems, including those that do not generate enough waste to report, and those that purchase mercury-containing components from suppliers and install them into their final product. Also, since the TRI mercury threshold quantity

changed from 10,000 to 10 pounds in 2000, some businesses may be unaware of reporting requirements. Additional limitations on waste and release data for this purpose are included in Appendix A.

3.1 Specific Findings from US EPA TRI Waste and Release Data

The TRI customized search engine does contain information on nature of the use of the mercury by requiring the reporting facility to designate certain indicators of mercury use, some of which are listed and defined here:

- *Imported:* imports the reported chemical
- *Used/Processed:* produces or imports, then further processes or otherwise uses, the chemical
- *Byproduct:* produces the reported chemical coincidentally during the production, processing, otherwise use, or disposal of another chemical substance or mixture, and, following its production, is separated from that other chemical substance or mixture.
- *Reactant:* uses the chemical reported in chemical reactions for the manufacture of other chemical substances or products.
- *Formulation Component:* adds the reported chemical to a product or product mixture prior to further distribution of that product to act as a performance enhancer during the use of the product.
- *Article Component:* uses the reported chemical as an integral component of an article distributed for industrial, trade, or consumer use.
- *Repackaging:* processes or prepares a reported chemical for distribution in commerce in a different form, state, or quantity.
- *Chemical Processing Aid:* adds the chemical to a reaction mixture or synthesis of another chemical substance, without intending it to remain as a part of the mixture.
- *Manufacturing Aid:* uses the chemical to aid a manufacturing process, without intending it to become part of the resulting product or the reaction mixture, during the manufacture or synthesis of another substance.
- *Ancillary:* uses the chemical for purposes other than aiding chemical processing or manufacturing.
- *Manufacture Impurity:* produces the chemical as a result of the manufacture, processing, or otherwise use of another chemical, but does not separate the chemical and it remains primarily in the mixture or product with that other chemical.
- *Process Impurity:* processed chemical but did not separate it and it remains as an impurity in the primary the mixture or trade name product.

For reporting facilities that classify wastes or releases in any of these indicator categories, it is better possible to better surmise if and how they use mercury. Based on TRI data, **Table 4** lists the TRI reporters for year 2000 and preliminary 2001 data, along with the likely or confirmed source of mercury use. Companies preceded by an asterisk (*) are facilities that may be excluded from the prescribed scope of this study but are included as a matter of interest for future consideration. Shaded cells indicate that the facility is no longer operating.

Table 4 - TRI Waste and Release Data Reporters (Ordered by SIC Code)

Facility, City, SIC Code(s)	How Mercury is Introduced, Used, Released	Quantity Reported to TRI 2000 (pounds)	(Preliminary) Quantity Reported to TRI 2001 (pounds)	Notes and Comments
Kimberly Clark Corp Everett SIC 2611, 2621	Byproduct per TRI indicator, from trace mercury in wood that is burned for fuel	52 released 34 waste	14.5 released	Thousands of pounds of wood burned daily. Releases directly measured, not calculated. (Conversation 12/02)
Port Townsend Paper Corp Port Townsend SIC 2611, 2621	Assumed byproduct of fuel combustion		1.53 released	Facility not contacted; mercury source unconfirmed.
Boise Cascade Wallula SIC 2621	Assumed byproduct of fuel combustion	0	1.74 released	Facility not contacted; mercury source unconfirmed.
Georgia Pacific West Bellingham SIC 2621	Produced per TRI indicator, assumed from chlor-alkali production by mercury cell	23,514 released	0	Chlor alkali operations now closed.
Weyerhaeuser Longview SIC 2411, 2421, 2611, 2621, 2631, 2812	Byproduct, per TRI indicator, for logging, milling, sawing, pulp/paper mills, and chlor-alkali production.	44 released 44 waste	37.5 released	No process use identified (Conversation 11/02). Assume all current releases are from wood combustion. Chlor-alkali operations now closed.
General Chemical Anacortes SIC 2819	Imported per TRI indicator. Assume sulfuric acid is contaminated during production, or from secondary feedstocks.	34 released	10 released	Company produces sulfuric acid. Facility did not reply to inquiry; mercury source is unconfirmed.
PQ Corp Tacoma SIC 2819	Assumed from mercury cell production of sodium hydroxide.	41 released 41 waste	0	Facility not contacted; mercury source unconfirmed.
*Shell - Puget Sound Refinery Anacortes SIC 2911	Byproduct and formulation component, per TRI indicator. Naturally occurring in oil.		38.6 released	No mercury is added to formulation, emissions result from trace content in crude. (Conversation12/02)
*Tesoro Refining Anacortes SIC 2911	Imported, per TRI indicator. Naturally occurring in oil.	100 released	42.4 released	Facility not contacted; mercury source unconfirmed.
Ash Grove Cement Seattle SIC 3241	Byproduct per TRI indicator, assumed byproduct of fuel combustion.	62 released 62 waste	76.95 released	Unconfirmed source. Potential contamination from silica, fly ash constituents.

LaFarge NA Seattle SIC 3241	Byproduct & reactant per TRI indicator. Trace mercury in limestone, silica feedstocks for cement. Fuel combustion.	0	73 released	Releases calculated with emissions factors for fuel and limestone, etc. A mercury "reactant" is not added. (Conversation 12/02).

Table 4 (Continued)

Facility, City, SIC Code(s)	How Mercury is Introduced, Used, Released	Quantity Reported to TRI 2000 (pounds)	(Preliminary) Quantity Reported to TRI 2001 (pounds)	Notes and Comments
Birmingham Steel, Seattle SIC 3312	Assumed byproduct for releases to stack air. Wastes are from replaced devices in the facility.	1 released 53 waste	0.43 released 52.5 waste	Air releases calculated from emissions factors for incoming scrap. Wastes are from end of life devices. (Conversation 10/02)
Intalco Aluminum Ferndale SIC 3334	Imported and used /processed, per TRI indicator. Trace mercury in alumina imported from Australia, and petro-leum coke and pitch.	0	0	Petroleum byproducts of coke and pitch are used to make anodes for production of aluminum. Anodes are continually recycled into new anodes. Curtailed operations in 2002. (Conversation 11/02)
Kaiser Aluminum & Chemical Corp Mead SIC 3334	Unknown	34 waste	0	Currently closed.
Reynolds Metals Co Longview SIC 3334	Unknown	4 released 9 waste	0	Unknown
Longview Aluminum Longview SIC unknown	Unknown	0	0.6 released	Plant closed due to energy costs and issues.
Honeywell Electronic Materials , Inc. Spokane SIC 3355, 3471, 3499, 3678	Formulation component and article component per TRI indicator. Was used in alloy for infrared semiconductors and in mercury purification.	0	0.1 released	Company discontinued mercury purification. Changed alloy from mercury-cadmium-telluride (Hg-Cd-Te) to Zinc-CD-Te. (Conversation 12/02)
Honeywell Redmond SIC 3812	Mercury bath used in Vicalloy tape production, a magnetic tape used in flight data recorders	84 releases (42 pounds of phosphoric acid containing mercury reported to DWR 2000).	0	Tape is reported to contain no mercury residual contamination. Production of tape did not occur in 2001, bit did in 2002. Expect permanent discontinuation of this

				line after 2002. (Conversation 10/02).
Graymont Western US Tacoma SIC 3274	Produced, per TRI indicator, assumed from naturally occurring content in mined lime	1 released 1 waste	1.3 released	Facility not contacted; mercury source unconfirmed.

In conclusion, the TRI data provides some indications of mercury use and past use in Washington's manufacturing sector. Excluding closures of Longview Aluminum LLC, Kaiser Aluminum, and the chlor-alkali operations at Weyerhaeuser and Georgia Pacific, the following conclusions are drawn.

To date, there are only two confirmed direct mercury uses or contamination in products or processes from the reporters listed in **Table 4**. Both have discontinued these uses of mercury and do not plan to have future mercury releases.

- Honeywell, Redmond. Honeywell used a mercury bath to produce magnetic tape. They state that the magnetic tape does not contain any mercury contamination after manufacture. They ran this line in 2000 and 2002, not in 2001, and are discontinuing this product line after 2002. (Personal communication 10/02).
- Honeywell Electronic Materials, Spokane. Honeywell no longer produces the HgCdTe alloy that was sold to semiconductor manufacturers. They discontinued the business of mercury purification. No future releases are expected from manufacturing. (Personal communication 12/02).

To date, there are five confirmed manufacturers that release mercury as a result of naturally occurring mercury in feedstocks or fuels:

- Kimberly Clark Corp, Everett. Burning wood is the source of mercury releases. In addition to stack air releases, the fly ash resulting from combustion contains a trace amount of mercury.

  It is assumed that the other reporting pulp and paper mills' main source of mercury emissions is also from fuel combustion.

- *Shell Oil Products, Puget Sound Refinery, Anacortes. Crude is the trace source of mercury. Mercury was reported as a "formulation component", but IS NOT directly added to products and only originates from naturally occurring mercury content in crude. (Personal communication 12/02).

  It is assumed that the other reporting refineries mercury emissions is also from the crude itself.

- LaFarge N.A., Seattle. LaFarge is a major cement manufacturer. They use emissions factors to calculate mercury emissions from fuel combustion, and limestone, which both contain naturally occurring mercury. (Personal communication 12/02).

It is assumed that AshGrove Cement (Seattle), who reported mercury as a byproduct, also releases mercury for the same reasons.

- Birmingham Steel, Seattle. Stack emissions are calculated based on incoming feedstocks and fuels. The reported waste from this company is from retired mercury-containing devices. (Personal communication 10/02)
- Intalco/Alcoa, Ferndale. Trace mercury in alumina imported from Australia is one source of mercury releases. Another source is the petroleum coke and pitch, purchased as a byproduct from refineries, which is used in anodes for the pots in aluminum production process.

One potential case of mercury contamination in products or processes, other than from naturally occurring mercury sources, is:

- Birmingham Steel, Seattle. The mercury contamination could be from auto shred, but they expect zero mercury content from secondary steel suppliers. (Personal communication 10/02).

Companies that reported to TRI in 200 but have not been contacted, and/or have not confirmed the source of mercury wastes and releases, are:

- AshGrove Cement, Seattle
- General Chemical, Anacortes
- Graymont Western US, Tacoma
- PQ Corp, Tacoma
- Reynolds Metals Co, Longview
- Tesoro Refining, Anacortes

3.2 Specific Findings from Washington Dangerous Waste Regulations Data

This data source includes reported waste stream quantities and a description of the waste stream. The quantity reported includes the entire weight of the waste stream, not just the mercury portion. Thus, the actual quantity of mercury is unknown. No releases to air or water are reported to Washington DWR.

Many companies reported only bulbs, batteries, and other materials that are not used directly in and do not introduce mercury contamination in products or processes. These generators are not included here. The remaining manufacturers and wastes are presented in **Table 5**. An asterisk (*) denotes facilities excluded from the scope of this study, but are included here for potential future consideration. Shaded cells represent operations or companies that have closed.

Table 5 - Washington DWR Reported Wastes by Manufacturers (Ordered Alphabetically)

Facility and City	Nature of Business or Product	Waste Quantity and Description per DWR - 2000	How Mercury is Introduced, Used, Released	Notes and Comments
Bio Rad Labs Redmond and Seattle	Clinical diagnostics, research	345 gallons waste water containing thimerosal	Unknown	Potentially used as a fungistat / bacteriostat in clinical tests
Boeing, Auburn	Aircraft	643 pounds sealant/adhesive in tubes	Assumed current and/or past use in aircraft.	Boeing contacts cannot determine past or future use.
Cell Therapeutics Inc, Seattle	Laboratory	25 pounds elemental and contaminated solids	Unknown	
Crown Cork & Seal Co Inc Olympia	Aluminum cans	7 pounds elemental	Unknown	
Genuity Solutions, Everett	Networking services	4 pounds used switches	Assume switches are a purchased component.	Several different locations, no longer in Everett.
Honeywell, Redmond	Electronics, aircraft supplier	42 pounds phosphoric acid containing mercury	Assume this compound used in tape production (see Table 4).	This product line discontinued after 2002.
Immunex Corp, Issaquah and Seattle	Laboratory, biotech	10 pounds mercury, 27 pounds lab pack, 965 pounds thimerosal wastewater	Thimerosal purchased for use in certain production.	Acquired by Amgen, but still operating in same manner.
Itron Spokane	Remote, handheld readers for gas & electricity meters	10 pounds switches	Assume switches are a purchased component.	All products have mercury, but developing non-mercury radio read devices (Personal comm.. 10/02).

Table 5 (Continued)

Facility and City	Nature of Business or Product	Waste Quantity and Description Reported to DWR in 2000	How Mercury is Introduced, Used, Released	Notes and Comments
Kaiser Aluminum and Chemical Works Mead	Primary aluminum production	250 pounds contaminated debris (34 pounds waste also reported to TRI 2000)	Unsure if from legacy wastes or current production practices	Facility has been closed for about two years.
Linear Technology Corp, Camas	Semi-conductors	45 pounds waste including mercury waste, lamps, vials and thermometers	Potentially from advanced alloys or relays used in semiconductors.	
JR Simplot, Moses Lake	Food processor	95 pounds	Spent chemical oxygen demand (COD) digestion fluid (sulfuric acid & mercury sulfate)	Mercury-free alternatives are available, but none are EPA-approved for reporting to NPDES.
Matsushita Kotobuki Electronics, Vancouver	Home video and audio equipment	1 pound elemental	Potentially from relays or switches	
Microchip, Puyallup	Semi-conductor and related devices	2000 pounds waste mercury floats	Unknown if purchased component or manufactured in house	Currently closed - Potential to move all operations Gresham, Oregon facility
Northwest Alloys, Inc., Addy	Magnesium dioxide	1 pound in manufactured articles	Potentially used in electrodes used in magnesium dioxide production	Plant shut down in 2001? This was one of only two mg facilities in the U.S.
Omega Silversmithing, Kirkland	Antique restoration	2800 pounds	Not actually released	An error in the first chemical analysis of a plating solution showed mercury. Follow-up testing shows no mercury.
*Quadra Chemicals Spokane	Chemical distributor	670 pounds	Unknown	Calcium oxide containing mercury
*USN Marine & Reserve Center	Military – naval	75 pounds sealant/adhesive	Assumed use in vessels	

Not listed above are four DWR reporting facilities that confirmed their waste was a result of end-of-life devices related to facility and equipment operation (e.g., gages and manometers). Framatone ANP, Richland, a nuclear fuel production facility disposed of 76 pounds of elemental mercury from replaced devices. Sonico, a salvage yard in Moses Lake, took several manometers out of service and extracted 467 pounds of liquid from the devices. The Pacific Northwest Research Foundation (PNRI) also replaced some facility devices and thermometers and extracted seven pounds of liquid mercury. This company has been trying to remove and replace existing mercury-containing instruments with mercury-free alternatives. (Donelan, 11/02). Lastly, Seattle City Light Moderate Risk Waste Facility accepts expired switches and thermostats from various city facilities. They reported eight pounds accepted in 2000, and are unaware of non-mercury replacement alternatives (Pratt, 12/02).

In summary, confirmed use of mercury directly in manufacturing from the reporters listed in Table 5, and are likely to continue the same products and processes in the future, are:

- Itron, Spokane
- JR Simplot, Moses Lake
- Bio Rad Labs, Seattle
- Immunex (now Amgen), Issaquah and Seattle

The other reporting manufacturers are assumed to be using mercury, mercury-added components, or mercury-contaminated products, however the mercury sources and uses by these manufacturers have not been verified.

3.3 Specific Findings from Clean Air Agency Data

The Puget Sound Clean Air Agency reports emissions from two entities, but neither is considered a “manufacturer” according to the scope of this project. The first is a soil recycler who reported 55 pounds of emissions in 1999. The second is a coal fired steam plant that reported 32, 46, and 33 pounds of mercury emissions in 1999, 2000, and 2001 respectively. The Olympic Region Clean Air Agency’s (ORCAA) region received emissions data from two plywood mills and two pulp mills for Year 2001. The combined release from all four facilities was eight pounds for 2001. Per Simpson Timber, the mercury is a byproduct of hog fuel combustion, and comes from the naturally occurring mercury in wood.

Section 4.0 Findings from Product Association Research

Given the lack of existing use data for mercury in Washington state, lack of notification reporting or labeling requirements for mercury, and the fact that waste and release data is only somewhat helpful in finding manufacturers using mercury, using "product association" can supplement the information gleaned from the waste and release data.

This method first identifies industry sectors and products that have conventionally or are currently likely to use mercury in production or processes. Initially, over 100 Standard Industrial Classification (SIC) codes were identified that cover the gamut of mercury-added products and mercury-contaminated processes or products. A list of Washington manufacturers was obtained for these SIC codes and product types.

Two internet-based business directories and two hardcopy directories provided company information to generate the lists of Washington manufacturers in these SIC code and product areas. The two internet-based directories used were the Thomas Register and ReferenceUSA[SM] (Publisher: *info*USA). The two hardcopy directories were the Washington Manufacturers Register 2002 (Publisher: Harris InfoSource), and the Washington Business to Business Sales and Marketing Directory 2002 (Publisher: USADIrectories.com).

The Thomas Register, ReferenceUSA[SM] and the 2002 Washington Manufacturer Register provide some detail on the nature and size of the businesses, while the Washington Business-to-Business Sales and Marketing Directory is more of a phone book listing by industry and SIC code, and contains only the company name, address and phone number. Typically, the total number of businesses under a SIC code or product type differ with each of the references. The Thomas Register, ReferenceUSA[SM] database and Harris Directory contain only those companies that choose to be listed. As such, the actual number of manufacturers identified under each SIC code or product area differs with each directory, and provides a conservative estimate on the actual number of manufacturers.

To confirm mercury use or contamination in manufacturing, it is necessary to either review the company's product lines via websites or product literature, and/or directly contact company representatives.

4.1 Information Sources

Compilation of the list of SIC codes and products of interest were gleaned from published literature and databases describing uses of mercury and products containing mercury, and from discussions with knowledgeable authorities on mercury use and issues. Additionally, three data sources on mercury use in manufacturing were identified and reviewed for potential products containing mercury. These include:

- Connecticut, Maine, New Hampshire, and Rhode Island require manufacturers of mercury-added products sold in their states to notify the Interstate Mercury Education and Reduction Clearinghouse (IMERC). The notification includes a product description, the amount of mercury, and the purpose of the mercury in the product. To date, no Washington companies have reported to IMERC. The database is available on the web at: http://www.newmoa.org/Newmoa/htdocs/prevention/mercury/imerc/notification/.

- TURAData lists Massachusetts manufacturers' annual quantities of mercury (and other chemicals) used in production. Each manufacturer provides a short description of the purpose of the mercury in the process or product. TURAData is available on the web at http://www.turi.org/turadata/index.html.

- The state of Vermont promulgated a statute requiring any manufacturer from within or outside the state, selling a mercury-added product for any purpose or use within the state, to submit a plan for mercury labeling of the product. This applies if mercury is added to the product itself, or is in a component of the product. Vermont sent out product notification requests and labeling plan requirements to more than 3,000 manufacturers. The state now has over 200 certified labeling plans in place from domestic and global manufacturers. This notification and labeling plan certification process identified two manufacturers in Vermont that use mercury directly in a product; a UV curing equipment manufacturer and a commercial oven manufacturer. The products requiring a label are listed at http://www.mercvt.org/Labeling/statutes.htm#§ 6621d

The IMERC database was released in late 2002, and is not yet fully populated, but useful information is available from the database. Although not necessarily representative of the Pacific Northwest, according to the manufacturers reporting to IMERC, switches and relay type products contain significantly more mercury than any other product category. Sphygmomanometers and flame sensors are also significant uses of mercury in products when considered from the perspective of total quantity of mercury used. As of October 2002, the following annual quantities of mercury used in products and the number of products sold within the four states mentioned above, breaks down as follows:

Product	Number of Products Reported	Annual Quantity (Pounds)
Relay, displacement plunger	1	35,583
Dental amalgams (tytin alloy)	n/a	19,385
Float switches	15	4,212
Sphygmomanometers	3	3,993
Flame sensors	52	2,787
Thermometers, non fever	n/a	1,684
Batteries	16	110
Vehicle switches	n/a	55
Other lamps (not fluorescent)	183	35
Tilt switches	36	25
Manometers	7	15.3
Relay, wetted reed	1	5.3
Wall thermostats	20	4.8
Fluorescent lamps	32	4.6
Film	n/a	0.4

4.2 Selection Criteria and Specific Products or Industries of Interest

Research on uses of mercury in products shows hundreds of products that can contain mercury, intentionally or as a result of an impurity. Additionally, some facilities use mercury as a manufacturing aid. The best resource for identifying the different products containing mercury is in the draft report by the Lowell Center for Sustainable Production (LSCP), produced for the state of Maine. This report lists a number of component-level products that contain mercury, and then hundreds of end products and applications of these products. (Galligan, et al. 2002).

With the extensive variation in mercury use and the list of over 3,000 Washington manufacturers that could be adding mercury to their products, the following criteria were established to narrow down the original list of products and SIC codes:

- Non-mercury or lower-mercury alternatives are available, meet performance specifications, and are economically competitive
- Product(s) have a high probability of releasing mercury to air, land or water, by spillage, breakage, or improper disposal at end of life
- Industry is not currently researching or otherwise addressing mercury elimination in the product or process
- Significant number of manufacturers of the product reside in Washington

- (When data is available) The volume of the waste or release is significant

Based on the reported phase-out of mercury in certain products (e.g., fungicides, pesticides, biocides, paint and ink preservatives and pigments, certain batteries, many pharmaceuticals, others), and the criteria established above, the products and SIC codes analyzed in more detail are presented in Section 4.3.

4.3 Findings by Products Association Using SIC Codes

Table 6 lists the 53 SIC codes of interest in Washington State, a general title for the industry sector, the estimated number of manufacturers in Washington state that fall under these SIC codes, and finally, the likely source(s) of the mercury. Some of the SIC codes are grouped due to similar uses of mercury. **Table 7** follows with a list industries excluded from further consideration at this time and discusses the various reasons.

Table 6 –Washington Industry Sectors and Manufacturers that May be Using Mercury (Ordered by SIC Code)

SIC Code(s)	Industry Code Titles and Additional Inclusions	Estimated Facilities	Likely Mercury Source(s)
2611, 2621, 2631	Pulp, paper, and paperboard mills	35	NaOH, fuels, natural in wood, fungicides
2819, 2869, 2899	Industrial chemicals and preparations	60-108	Chemicals containing mercury or produced by mercury cell process
3443-05 3089 3272	Tank manufacturers, metal (3443) and plastic (3089), concrete (3272)	15	Accessories: Float switches, and pumps that contain float switches
3433, 3585, 3567	Heating equipment, air conditioning, refrigeration equipment	36-61	Controls, switches, relays, stats
3523	Farm machinery & equipment	46	Tilt switches, slip rings
3530, 3537	Construction, mining & materials handling machinery & equipment, industrial type vehicles	33-55	Tilt, limit, level, and other switches and sensors, slip rings
3535	Conveyors and related equipment	22+	Tilt, limit, and other switches and sensors
3561, 3594	Pumps & pumping equipment	19	Fluid in diffusion pumps, float switches
3565	Packaging machinery	29	Sensors, slip rings
3554, 3569	General industrial machinery & equipment (includes fire suppression, paper industry machinery)	27	Switches, controls, sensors

Table 6 – (Continued)

SIC Code(s)	Industry Code Titles and Additional Inclusions	Estimated Facilities	Likely Mercury Source(s)
3571, 3575, 3577, 3579, 3629, 3651, 3679	Electronic products and components: Computers, peripherals (scanners/other), office machines, household audio & video	93-144	Laptop screen shut off, fluorescents in LCDs, relays in circuit boards
3589-04	Carwash equipment	2	Switch, tilt
3599	Machinery & equipment, not elsewhere classified (NEC)	439 - 646	Switches, controls, sensors
3613	Switch gear & switchboard apparatus (includes industrial controls)	12	Switches, relays
3625	Relays & industrial controls	25	Various industrial & HVAC
3631, 3632, 3639	Appliances (ranges, commercial and residential laundry, other)	6	Tilt switches, gas/pilot flame sensors
3643	Current-carrying wiring devices (includes car switches)	7 - 8	Switches, relays
3647	Vehicle lighting	3	Fluorescent bulbs, HID bulbs
3661-02	Telephone equipment & apparatus (including network/web hosting)	18	Switches, relays, controls
3674	Semiconductors & related devices	18	Relays, advanced alloys (Hg-Cd-Te), UV equipment
3699	Electrical equipment & Supplies, NEC	41	Switches, relays, controls
3731	Ship building & repairing	50	Beacon sensors, other sources unknown
3732-01	Boat building	104	Beacon sensors, float switches in tanks
3812	Search, detection, navigation, guidance, aeronautical systems	50	Bulbs in backlighting, switches, relays
3822	Environmental controls	47	Switches, relays
3823, 3825, 3824, 3829	Industrial instruments for measurement, display, control (e.g., thermometers, thermostats, electricity distribution, electrical, fluid/counting meters, NEC	61 - 110	Switches, ampoules, relays, regulators, fluorescent bulbs
3841, 3842, 3844, 3845	Surgical & medical instruments, x-ray, tubes and irradiation apparatus, orthopedic, appliances, electro-therapeutic and electromedical apparatus	82 - 125	Sphygmomano-meters, esophogeal dilators, x-ray apparatus, other

Table 7: Industries and Products Excluded from Further Research

Product or Industry	End Use(s)	Reason for Exclusion Consideration
Aircraft and aircraft part manufacturers	Aircraft	Difficulty in determining where mercury is used due to vast number of suppliers, and stringent design and safety requirements, and federal regulations are barriers to simple changes. Also, no viable alternatives for LCDs.
Argon-mercury bulbs	Neon signs (certain colors only)	Few manufacturers.
Batteries, thermometers, thermostats, fluorescent bulbs	Various household, medical, industrial, other	No or few known manufacturers in Washington. Industries are continually developing lower (or no) mercury alternatives.
Cement	Concrete, concrete products, ready-mix	Releases originate from naturally occurring mercury in silica and coal fly ash, and from fuels burned. No foreseeable fuel alternatives.
Chlor-alkali products contaminated by mercury cell production process	Soaps and detergents	Most state manufacturers make homemade soaps. Proctor & Gamble (Woodinville) is only major manufacturer that could be using mercury-contaminated chemicals. The chlor-alkali industry is working to reduce mercury contamination of these chemicals.
Crematories	Incinerated amalgams	Outside defined scope of project.
Dental amalgam	Dental fillings	No amalgam manufacturers. Efforts by others.
Food products	Consumption	No EPA-approved COD testing alternatives.
LCD & backlit displays using fluorescent bulbs	Computer screens, office equipment displays, airplane seat back displays, navigational display screens	No known alternatives for most LCD displays. Certain applications such as kiosks, ATM machines, and other industrial displays, may be replaceable in the future by xenon technology.
Manometers	Dairy industry	No manufacturers. Washington completed retrofit & education for existing dairies.
Motor vehicles, and vehicle parts	Transportation	Few manufacturers, no known use in trucks (Hayes, 12/02). No automotive switch manufacturers identified.
Pharmaceuticals, medicinal	Vaccine preservative, stains, fixatives	No manufacturers identified. Mercury is phased out of most pharmaceutical products. B5 fixatives remain in use, and thimerosal is still used in a few vaccines and clinical test kits.
Recreational Vehicles (RV)	Recreational road travel	Only four manufacturers: one claims they do not use any mercury products, one converts for handicap van and RV access, and one does conversions (e.g., mobile homes to office space). Fourth manufacturer not contacted.
Secondary Lead and Copper Smelting	Sulfuric acid contaminated with mercury	Few manufacturers and unknown alternatives or solutions.

Tanneries/Taxidermy	Various	Few manufacturers. Unconfirmed Hg use.

Excluding the industries listed in Table 7, the remaining potential areas of interest include 51 different SIC codes, and between 2,100 and 3,300 manufacturers in Washington State. From this list, the SIC codes or groups of SIC codes with the highest estimated number of Washington manufacturer's are listed in **Table 8**.

Table 8 – SIC Codes With the Greatest Number of Manufacturers (Ordered by Decreasing Number of Manufacturers)

SIC Code(s)	Description	Estimated Number of Washington Manufacturers
3571, 3575, 3577, 3579, 3629, 3651, 3679	Computers, peripherals, office machines, consumer audio & video	144
3841, 3842, 3844, 3845	Surgical & medical instruments, x-ray, tubes and irradiation apparatus, orthopedic, and surgical appliances and supplies, electrotherapeutic and electromedical apparatus	82-125
3823, 3825, 3824, 3829	Industrial instruments for measurement, display, control (e.g., thermometers, thermostats, electricity distribution, electrical, fluid/counting meters, NEC	110
3732-01	Boat building	104
3535, 3554, 3565, 3569	General industrial machinery & equipment, conveying equipment, paper machinery, and packaging equipment (a)	>78
3433, 3585, 3567	Heating equipment, air conditioning, refrigeration equipment	61
3812	Search, detection, navigation, guidance, aeronautical systems	51
3822	Environmental controls	47
Total Estimated Number of Manufacturers		>677

(a) The SIC code 3599, Machinery and Equipment, Industrial and Commercial, Not Elsewhere Classified lists an additional 439 manufacturers that may use mercury sensors, detectors, switches or relays in various equipment.

In preliminary contact or website reviews with a few of these companies, most do not appear to be adding mercury to their products, or have confirmed that they do not use mercury in their products. Those that were confirmed to be using mercury, either by direct contact, or products listed on their websites, are listed in Section 4.5.

Quite a number of these businesses were contacted, and only a handful were found to be adding mercury to their products, and those that were identified, install mercury-components into their end product. Therefore, it is questionable how many of the more than 677 manufacturers included in the above SIC code categories are actually using mercury.

4.4 Findings by Product Association Using Product Categories

In a similar method to the identification of manufacturers by SIC codes, the on-line Thomas Register allows a search of businesses by the name of a "product or service" in Washington State. The Thomas Register only contains those businesses that register to be listed; therefore, it does not contain all manufacturers in the state.

In this search of the Thomas Register, many of the product types resulted in no Washington businesses registered. Some of these product types are listed below. Also, there are significant differences in the number of businesses that register with the various directories. Denoted by two asterisks (**), are product types for which the SIC code search did find manufacturers.

- anti-tamper device
- boiler controls
- bulb, mercury vapor
- bulb, UV
- diffusion pump
- electromedical devices
- electronic controller
- fixatives
- flame sensor
- flow meter
- gage, tank
- gage, mercury contactors
- gas plasma display
- hagenmeter
- infrared (IR) detector**
- heat control
- heater, electronic
- hydrometer
- hygrometer
- laptop computer
- manometer
- packaging equipment
- porosimeter
- power tools
- relay, mercury displacement
- sensor, acceleration
- slip ring
- solar cells
- switch, automotive
- switch, tilt
- switch, float
- switch, flow
- switch, reed
- switch, welding
- synchronizer
- tank level indicating**
- thermostat, heat control, appliance, etc.
- vaccines
- water treatment equipment

Table 9 lists products of interest that are manufactured in Washington, by 163 different manufacturers, and the respective individual number of manufacturers of that product listed in the Thomas Register. In some instances, search results included a few distributors also, which are excluded from further consideration.

Five manufacturers produce devices that fit into more than one category. Three of these were confirmed as NOT using mercury, and are shaded in **Table 9**.

Table 9 Manufacturers Listed in the Thomas Register for Various Products

Product Category	Number of Manufacturers	Notes and Comments
Adhesive, aircraft	1	
Barometers	2	One makes aneroid barometers only, which is an alternative to mercury.
Boats	19	SIC code for boat building lists 104 businesses.
Boilers	2	
Calibration equipment	1	For ultrasonic, eddy current, x-ray equipment
Converters	4	For organs, batteries, communication equipment, and power distribution
Conveying equipment	12	Various bulk material handling systems. Another web reference lists 48 more conveyor manufacturers in Washington state, not found in Thomas Register, or ReferenceUSA[SM].
Electrodes	1	For pH meter.
Gage, vacuum	1	No mercury-added products.
Heating, resistance	1	For dry well applications.
Industrial controls	19	
LCD panels	2	
Medical instruments	4	
Medical tubing	2	One manufactures other medical equipment also. No evidence of the mercury weights used historically in tubing.
Meters	3	For battery management, food and consumer goods manufacturing, water related.
Neon signs	2	
Network services	14	More service related than manufacturing, included due to a networking/telecom company that reported 4 pounds of mercury switches to DWR in 2000.
Oscillator	1	
Power switching	1	
Semiconductor	2	SIC code search lists 15 more businesses.
Sensor, proximity	3	Two of these three also make other switches.
Pumps	4	Bilge, sump, chemical feed
Pyrometer	2	
Regulator	1	
Sealant	1	For roof applications.
Security systems	4	
Sphygmomanometer	1	Non-mercury products only.
Switches	12	Various types. One manufacturer confirmed no mercury-added products.
Tanks	19	Four septic tank manufacturers, others vary.
Tannery	1	

Tractors	2	
X-ray equipment	2	Both are non-medical applications

4.5 Confirmed Manufacturers Currently Adding Mercury to products

Due to limited scope and timing of this project, direct contact or review of websites or product literature for the entire group of potential manufacturers that may use mercury was not possible. Only about 100 manufacturers, roughly 3% of the businesses identified in this project as potential mercury users, were directly contacted, and/or their websites reviewed for evidence of mercury-containing products. **Table 10** lists eleven businesses that are confirmed to be adding mercury or mercury-added components to their products. There are likely many more manufacturers using mercury-added components similar to those listed in **Table 10**.

Table 10 - Manufacturers Identified by Product Association

Manufacturer and City	Product	Mercury Source	Notes and Comments
Anonymous, Seattle	Lighted switch assemblies	Custom fluorescent bulbs	Out-of-state supplier.
Anonymous, Seattle	Fire suppression system design and installation	Switch in electronic controller assembly provided by supplier	Out-of-state supplier. May be phasing out mercury switches in this application.
Bio Rad Labs Seattle and Redmond	Unknown	Thimerosal	Byproduct of this process is thimerosal wastewater solution.
Anonymous	Tanks	Float switches, only if specified by customer.	Many customers request sight glass or other non-mercury accessories, but Erickson makes “what the customer wants”.
Anonymous, Seattle	Vehicle lighting assemblies	Fluorescent bulbs used in vehicle lighting assemblies	Not interested in providing further information.
Immunex (now Amgen), Seattle and Issaquah	Unknown	Thimerosal	Byproduct of this process is thimerosal wastewater solution.
Itron, Spokane	Remote, handheld readers for gas & electricity meters	Assume switches in the meters.	All meters contain mercury, future designs may offer non-mercury alternatives.
JR Simplot, Moses Lake	Food products	COD test kits	No alternatives for NPDES reporting
Kenworth, Renton	Trucks	Fluorescent bulbs for interior lighting	Used to have mercury in operating idle control. No other sources identified by engineers.
King Electrical, Seattle	Heaters, furnaces, HVAC equipment	Relay in "Draft Barrier" heater	Potential other sources unconfirmed.
Anonymous, Everett	Commercial ovens and cooking equipment	Flame switch, thermostat controls	Offer solid state thermal controls & manual ignition on most products (Personal communication 10/02)

Section 5.0 Prioritization Areas and Alternatives

Many mercury-free alternative products are available for the mercury-added products. Appendix B provides a list of many mercury-free, or lower-mercury alternatives, and the URL or other references on the specific substitute. Most of the available alternatives would have to be evaluated on a case by case basis depending on end use requirements, design parameters, and costs. Additional manufacturer profiling is necessary to determine if there are some overarching, "blanket" solutions to mercury use in manufacturing in Washington State.

The Lowell Center for Sustainable Production (LSCP) completed a draft report entitled: "An Investigation of Alternatives to Mercury Containing Products", in October 2002. (Galligan, et al., 2002). The draft report established priority products for investigating non-mercury alternatives, and identified their end use applications, non-mercury alternatives, and vendors of both the mercury products and non-mercury alternatives. Additional information is provided on the advantages, limitations, and cost effectiveness of the various alternatives. This resource will provide great insight to viability of alternatives as Washington State begins to work with manufacturers in mercury reduction.

5.1 Switches, Relays, and Wiring Devices

The IMERC data suggests that switches and relays are one of the top uses of mercury in a manufactured component. Estimates of mercury use in the U.S. for wiring devices and switches was about 110 tons in 1999 (Cain, 2000). Another estimate puts mercury use for switches and relays at 36-63 tons per year. (Leopold, 2002).

The Venture Development Corporation (VDC), a technology market research and strategy firm reports the 2001 global market for switches at $3.325 million (Gordon, 2002). The global market for relays at $4.658 million (Gordon & Millette. 2002). The market values include mercury and non-mercury switches and relays.

Based on the estimates of mercury use in switches and relays, the significant global market, and the number of switch, relay, and wiring device manufacturers in Washington (estimated between 45 and 55), this is a high priority component line for further evaluation. There are non-mercury alternatives to most switches and relays, but the viability of the alternative is highly dependent on the end product application, customer specifications, design parameters, cost-effectiveness, and other factors. No simple answer exists in the end use markets. Any mercury reduction efforts in this area would likely be on a case by case basis depending on the application or consuming industry.

The alternatives identified for different types of switches and relays are listed below. Again, these alternatives must be evaluated for suitability in the end use application.

Component	**Alternatives**
Float switch	Mechanical Magnetic dry reed Optical Conductive Metallic ball Sonic/ultrasonic Pressure transmitter Gallium indium alloy Thermal Capacitive
Tilt switch	Metallic ball Electrolytic tilt Potentiometer Mechanical Solid state Capacitive
Pressure switch	Mechanical Solid state
Temperature switch	Mechanical Solid state
Relays: displacement /plunger and wetted reed	Dry magnetic reed Other electromechanical Solid state Silicon controlled rectifier Hybrid (electro-mechanical and solid state)

(Source: Galligan, et al. 2002)

5.1.1 Consuming Applications and Industries for Switches, Relays, and Wiring Devices

The Venture Development Corporation (VDC) evaluated global markets for all types of switches and relays. **Table 11** shows the switch and relay markets by consuming application or industry. The list is ordered in decreasing value for combined global market share for both relays and switches. Of note is that this data includes non-mercury switches and relays, and certain assemblies

containing switches or relays, for which the final assembled product is termed a switch (e.g., lighted switch indicators for cockpit displays, push buttons, etc.).

Table 11 - Global Markets for Relays and Switches

2001 Global Switch and Relay Market by Consuming Application/Industry	Relays	Switches	Combined Total Percent of Market (Normalized to 100%)
Telecommunications	25.3%	8.6%	17.0%
Automotive/Transportation	18.4%	8.1%	13.3%
Appliances (and Power Tools for Switches)	6.5%	19.3%	12.9%
Industrial Automation and Process Controls	12.4%	11.8%	12.1%
Consumer Electronics	3.1%	14.9%	9.0%
HVAC and Energy Management	10.4%	3.4%	6.9%
Computers/Peripherals	1.1%	11.9%	6.5%
Instrumentation	5.4%	4.9%	5.2%
Military/Aerospace	4.9%	4.5%	4.7%
Commercial Equipment	5.7%	3.7%	4.7%
Other	1.6%	6.0%	3.8%
Automatic Test Equipment	4.6%		2.3%
Medical Equipment	0.6%	2.9%	1.8%

Relating the information in Table 11 specifically to potential priorities and alternatives for Washington State:

- **Telecommunications** equipment manufacturers may be a priority, based on the fact that Genuity Solutions, a network services company, reported mercury switch waste in 2000. It is unknown how common mercury switches are in this application. Service providers who install equipment, although not manufacturers, should be included in any efforts.
- No **automotive/transportation** switch manufacturers were identified in Washington, and it is unlikely that the few vehicle manufacturers in Washington are using mercury based on contact with several of these manufacturers. The use of switches and relays in boats is unknown, and remains a potential opportunity area since there are at least 100 boat manufacturers in the state.
- There are only a handful of **appliance** manufacturers, several of which are gas stove/fireplace manufacturers. There is one confirmed use of mercury-added controls by a commercial oven manufacturer, Lang Manufacturing in Everett. This manufacturer could also be categorized in the **commercial equipment** category. The only other potentially applicable manufacturer might be a hot water tank manufacturer in

Renton. **Power tools** appear to be a low priority because there are only about five manufacturers in the state, and no information was found verifying the use of mercury-added switches in power tools.

- **Industrial automation, process controls** and **instrumentation** could be a significant opportunity area, especially for conveying and material handling equipment. Switches and sensors are commonly used for motion, leveling, vibration, etc. in material handling and conveying equipment and machinery, fire suppression pump controllers, and many other industrial applications. There are a significant number of manufacturers of these types of systems, as well as manufacturers of the controls themselves. More than 60 businesses are identified as manufacturers of various control instrumentation manufacturers, including heat or temperature controls, electricity distribution controls, an infrared equipment manufacturer and others.
- **Consumer electronics and computers** are not expected to offer much opportunity for non-mercury for alternatives. No laptop computer manufacturers were identified in the state, which is one use for a tilt switch. One audio and video manufacturer reported one pound of elemental mercury waste in 2000, which is probably not related to manufacturing. Microchip of Puyallup, a semiconductor manufacturer who is no longer operating in Washington State (and may not actually be suppliers to the consumer electronics or computers market), reported 2,000 pounds of unwanted switches in year 2000 under DWR.
- **HVAC and energy management** offer a significant opportunity in the area of services and contractors that are maintaining or upgrading older equipment, especially boiler controls and thermostats. However, few manufacturers of original equipment were identified.

  One Washington manufacturer uses a mercury relay in temperature control equipment in their heaters.

  There are only a handful of boiler manufacturers, and one power switching product manufacturer, none of which are confirmed to use mercury in their products. Boiler controls include: high limit steam pressure control (with manual reset), high temperature limit controls, firing rate controls, limit controls, sump pump (to detect high heat blowdown), and low water cutoff. These are very common especially in older boilers and are well protected so do not pose a present danger.

  Alternatives for some of the above switches are available. An electronic system is available for the high limit steam pressure control. The low water cutoff switch, has mechanical, snap or electronic alternatives. A snap switch is an alternative to the mercury switch in the boiler feed pump controller.
- **Military/Aerospace** does not appear to provide any readily available alternatives, due to stringent design and safety requirements.

- **Commercial Equipment** is another area in which older equipment may contain mercury switches and relays, and offer good opportunity for replacement during maintenance and repair activities. Depending on the chosen definition of "commercial equipment", the number of manufacturers in this area varies. For instance, there are more than 500 manufacturers of general industrial equipment and machinery, such as conveyors and material handling equipment, packaging equipment, paper making equipment, and many other types of equipment that may utilize mercury switches and relays.

  Another category is tanks and pumps using float switches. Alternatives for this application include ultrasonic and mechanical or electro-mechanical switches. The number of tank manufacturers in Washington is unknown because of the variety of materials used to make tanks, e.g., concrete, plastic, and metal. The estimate for tank manufacturers is well above 20. One tank manufacturer commented that they install what the customer orders, indicating the customer drives the type of fluid leveling indicators used on a tank. (Erick, 10/02).

  Other types of equipment in this category could include all kinds of industrial machinery, conveying systems, etc., for which there are which hundreds of manufacturers in the state.
- **Medical equipment** looks to have low relative market share for switches and relays. Although the number of manufacturers identified in the SIC grouping for medical and surgical equipment and supplies is between 82 and 125, the number of these manufacturers making non-equipment supplies such as bandages, prosthetics, etc., is high.

5.2 Flame Sensors

Flame sensors are covered under SIC code 3822 (Environmental Controls). No flame or gas sensor manufacturers were identified in Washington state through the Thomas Register and the other directories are not specific enough to tell whether the business specifically manufacturers these sensors.

The alternative to mercury flame sensors is an electronic ignition flame detection unit. This is fairly commonly used or offered in the industry, is typically cost competitive and offers equivalent performance. The electronic ignition is not recommended in remote locations where electricity is not available.

5.2.1 Consuming Applications and Industries for Flame Sensors

The consuming applications could be residential and recreational vehicle (RV) gas appliances and furnaces, and gas and oil fired furnaces and appliances.

An HVAC contractor in Washington stated that the only known mercury-containing sensors for furnaces are made are by White Rodgers. These have all but been

phased out, but White Rodgers still supplies them for older systems that do not work with newer sensors. These furnaces are becoming rare and are being replaced. (Cofchin, Air Systems Engineering, Inc, 10/02).

One commercial cooking equipment manufacturer uses flame sensors on their gas appliances. They do offer solid state thermal controls and manual ignition on most products. No residential gas range or hot water heater manufacturers were identified. There are one hot water tank manufacturer and a few boiler manufacturers; however, it is uncertain whether these applications would utilize flame sensors.

Only three RV manufacturers have currently been identified in the state, and none of these are likely to be using any mercury switches in gas ranges, hot water heaters, or other RV applications. One confirmed they do not use mercury switches, and the other two do custom conversions of vans and mobile homes for disability access, applications that are not likely to commonly require mercury flame sensors.

5.3 Barometers

Barometers are under SIC code 3829-03 (Measuring and Controlling Devices). Two alternatives to mercury barometers are digital and aneroid, both of which are comparable in cost and performance. Another alternative design is a helicoids unit. The only barometer manufacturer found in Washington makes an aneroid, mercury-free unit. End uses for barometers are extremely varied and are not analyzed further here.

Instruments such as pyrometers, barometers and manometers are examples of product lines that may require significant effort and capital investment to change an entire production line from mercury to aneroid, optical, or digital because the designs are very different with respect to production. In cases like this, unless a major customer or proven market for the alternative product is certain, a manufacturer is unlikely to make such a change.

5.4 Pyrometers

Pyrometers are under SIC code 3823 (Industrial Instruments for Measurement, Display and Control). Alternatives to mercury-added pyrometers are optical and digital units. Two pyrometer manufacturers were identified and remain unconfirmed whether they are using mercury in this product. End use applications measure extremely hot temperatures, which include industries like foundries, and have not been evaluated.

5.5 Manometers

Manometers are under SIC code 3823 (Industrial Instruments for Measurement, Display and Control). Alternatives to mercury manometers include the needle/bourbon gage, aneroid, and digital. No Washington manufacturers were identified. One consuming application for manometers is the dairy industry, in their milk collection and pumping systems. The state has worked with all Washington dairies in replacing older mercury manometers with mercury-free alternatives. Other consuming applications are laboratories, outboard and motorcycle motor calibration, and certain HVAC uses for testing, balancing, and servicing equipment, and potentially in pipelines. These industries have not been evaluated in this project.

5.6 Sphygmomanometers

Sphygmomanometers are covered under SIC code 3823 (Industrial Instruments for Measurement, Display and Control). Alternatives include aneroid, electronic vacuum gage. One manufacturer was identified and they produce an aneroid unit. Efforts by the Medical Industry Roundtable (MIRT) are expected to further assist the buying community in evaluating and purchasing non-mercury sphygmomanometers.

5.7 Flow Meters

Flow meters are covered under SIC code 3823 (Industrial Instruments for Measurement, Display and Control). Alternatives to mercury flow meters are digital and ball-actuated. Few or no US manufacturers are still manufacturing mercury models anymore, however, many older flow meters still in use contain mercury. (Galligan, et al. 2002).

5.8 Thimerosal

Thimerosal, a medical bacteriostat and fungistat used as a preservative in clinical tests and test kits, contains mercury. It was reported in waste water solutions by two biotech laboratories in Washington. The purpose of the thimerosal and whether alternatives are possible are unknown. Production of any non-homeopathic pharmaceutical product requires approval from the Federal Drug Administration, which is a lengthy process, up to two years or longer.

Appendix C is an excerpt case study from the MASCO Mercury Work Group's Mercury Management Guidebook . The case study shows how a clinical testing laboratory implemented pollution prevention techniques to reduce the mercury (resulting from thimerosal use), in the facility's wastewater treatment system by approximately 90 percent; (MWRA/MASCO, 1999).

5.9 Chemicals

Two chemical manufacturers reported mercury in TRI 2000, one produces sulfuric acid and the other, sodium hydroxide (NaOH). The source of the mercury and whether alternatives or alternative processes are possible are unknown.

An opportunity for any consuming industries and applications for sulfuric acid and NaOH, including pulp and paper, and any facilities using NaOH in water neutralization, would be to require from their suppliers that the sulfuric acid and NaOH contain extremely low, or no mercury content.

5.10 Chemical Oxygen Demand (COD) Testing Compounds

One food processor reported a waste stream of used COD test materials. Although this is the only manufacturer that reported this waste stream, any manufacturer having to report COD levels under the National Pollutant Discharge Elimination System (NPDES) is likely using mercury-containing test kits because the U.S. EPA has not approved any non-mercury alternatives for NPDES reporting. One reason may be that some of the non-mercury alternatives are not accurate for testing solutions with high chloride ion content. Non-mercury alternatives are available for process control purposes; one uses a dichromate reagent and another uses manganese III chemistry.

5.11 Adhesives and Sealants

One Washington manufacturer of aircraft adhesives was identified in the Thomas Register. One sealant manufacturer was also identified, whose product is applicable for roofing.

Boeing (Auburn) reported 642 pounds of mercury-containing sealant in cans, and the USN Marine & Reserve Center in Tacoma reported 75 pounds of adhesive/sealant solid that contains mercury, under the DWR for year 2000. Alternatives for such products are unknown, and, if these reporters sent the material for disposal, it may be a discontinued use of the product. However, this may be an opportunity for further investigation.

5.12 Medical Tubes

Esophageal dilators and gastrointestinal (GI) tubes have traditionally used mercury as a flexible weight. Alternatives to mercury weights are a tungsten gel or saline. Mercury weights are no longer widely available, and the GI tubes are rarely used (Galligan, et al. 2002). No Washington manufacturers were identified.

5.13 Other/Miscellaneous

Although not considered manufacturers, laboratories and internal labs within manufacturing companies could be an opportunity since 1,136 pounds of mercury-bearing waste in the form of lab packs and broken thermometers or other instruments was reported under DWR for year 2000.

Federal facilities generated more than 36,000 pounds of mercury bearing wastes that may be related to manufacturing. This total does not include reported batteries and fluorescent bulbs from federal facilities, but includes such items as contaminated debris and articles, transformer oil, liquids and compound wastes. Adversely, a comment from one manufacturer illustrates a challenge to change government procurement and product usage, “If we are talking about a government rig, they put on all the gadgets with no thought of the price or maintenance.” (Anonymous, 10/02).

Section 6.0 Conclusions and Recommendations

6.1 Summary of Findings on Washington Manufacturers Using Mercury

The foregoing concluding statements are based on the actual manufacturers contacted during this project, or manufacturer websites that indicated products and product types.

- No Washington State manufacturers were found to be adding elemental mercury directly to their products.
- Several manufacturers are purchasing mercury-added components or products, such as adhesive, thimerosal, switches, relays, chemical oxygen demand (COD) test kits, and flame sensors, from outside the state and installing or using these in their products or processes.
- Several manufacturers generate mercury as a byproduct from naturally occurring mercury feedstocks, for which no alternative raw materials are feasible.

6.2 Recommendations for Manufacturing

Further contact with manufacturers in the priority product and SIC code areas is necessary to determine the value of opportunities to affect mercury use. With the information at hand, it appears that efforts with most manufacturers would require case by case evaluation of mercury uses, and mercury-added components, rather than any blanket type or drop-in mercury substitutes in manufactured products.

Switches, relays, and flame sensors are the major component level products evaluated within this study. The rest of the mercury-containing products are larger assemblies, some of which use switches, relays, and flame sensors. Of these three component-level items, no relay or flame sensor manufacturers were identified in the state. At least twelve switch manufacturers do reside in Washington, and a few of these are significant volume producers and sell across the country and internationally. Only one of these twelve were contacted directly, and they confirmed that they do not use mercury in any of their products. The remaining switch manufacturers are listed in Appendix D, and present a good starting point for further contact and evaluation.

Other products that appear to be high priority areas include:

- boat, tank and pump manufacturers that may still be installing mercury float switches.
- automation and controls on various industrial machinery, e.g., conveyors, packaging equipment, paper making equipment, and other.
- Telecommunication equipment and service providers

In addition to, or as an alternative to contacting and potentially working with manufacturers, a notification and/or labeling statute would provide more detailed information on mercury flows in the state. Mercury notification regulations could require all manufacturers (e.g., Washington, U.S., and international) selling mercury-added products or chemicals, for any purpose or use in Washington State, to report their annual use of mercury, and the amount of mercury in the products sold within Washington State. Similar statutes have been passed in Connecticut, New Hampshire, Maine, and Rhode Island and have been proposed in a number of other states. To reduce reporting requirements for manufacturers, such a statute could require that they report to the Interstate Mercury Education and Reduction Clearinghouse (IMERC), which has developed streamlined multi-state reporting system.

As far as an incentive, a grant program to award financial and technical assistance to businesses trying to replace mercury in their products or processes, could help identify additional manufacturers using mercury, as well as priorities for future efforts in mercury source reduction.

6.3 Recommendations Beyond Manufacturing

Because this evaluation covered manufacturing uses of mercury in Washington, some of the opportunities for retrofit or replacement or clean up of existing mercury sources, or influencing purchase of non-mercury products are not addressed. Listed below are potential opportunities that may offer more 'bang for buck' in mercury quantity reduction in Washington State than working with individual Washington manufacturers on a case-by-case basis.

- Educate buyers/customers on purchasing mercury-free or extremely low mercury content products. A pertinent example is water treatment chemicals such as sodium hydroxide (NaOH) and potassium hydroxide (KOH), that can contain as much as 10-300 parts per billion (ppb) and 7 ppb mercury, respectively, if made with the mercury cell process. These same chemicals produced by ion-exchange membrane process results in less than 1 ppb mercury. Another example is sulfuric acid purchased as a byproduct from secondary industrial processes, specifically from a lead smelter, can contain mercury in the range of 100-10,000 ppb. (Huber, 1997).

- Work with facilities to:
  - replace existing mercury-containing controls, gages, manometers, switches, boiler controls, barometers, ignitrons, thyrotrons, etc.
  - evaluate feasibility and cost-effectiveness of installing new bulbs
  - replace exit signs using fluorescent bulbs with light-emitting diode (LED) signs
  - flush or replace waste piping infrastructure to collect waste mercury in facilities and industry sectors where mercury legacy wastes may be prevalent.

- Replace existing HID lighting used in exterior and security applications, with non-mercury alternatives

- Work with fleet maintenance facilities and automotive repair shops, to replace mercury vehicle switches and headlights

- Work with auto and appliance salvagers and shredders to remove mercury switches

- Work with boat yards, marina shops, and boat repair facilities that could offer mercury-free float switches and pumps

- Work with HVAC contractors, who can in turn educate their customers, on recommending and replacing mercury devices in facilities, such as boiler and other industrial controls, flame sensors, thermostats, etc.

- Offer education or incentives to distributors, especially electrical and instrument suppliers, on alternatives for a variety of mercury containing devices.

- Work with tank maintenance contractors (e.g., inspectors, cleaners, repair and maintenance), on replacement of mercury float switches.

- Work with federal facilities in mercury reduction.

6.4 Further Research Opportunities

The alternatives listed in Section 5.0 above are based on published literature. Opportunities for additional investigation and future potential alternatives may exist for:

- "Newmerc" which is a nontoxic, liquid metal alloys to replace mercury in electrical switching applications. Bethlehem Apparatus Company , Inc is researching an alloy. This alloy is not yet fully tested and commercially available, however a German company produces an alloy that replaces mercury in thermometers. (Lawrence, 10/02).

- Replacement of batteries with fuel cells

- Use of mercury catalysts by Washington state plastics manufacturers

- Use of mercury in ships and vessels

- Feasibility and timeline for thimerosal alternatives currently used in the biotech industries

- Prevalence of mercury in semiconductor and infrared sensor manufacturing, and opportunities for source reduction in the wet deposition process (spraying) of Hg-Cd-Te on the substrate.

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Appendix A – Limitations on Using Waste and Release Data to Determine Actual Mercury Use

The following comments relate to the limitations of using the US Environmental Protection Agency's Toxic Release Inventory (TRI) data to determine mercury use by manufacturers.

- For releases, the TRI system indicates the media in which the release occurred, e.g., stack air, water, surface. But, otherwise, there is no customized description field of the nature of the release or waste, which limits the ability to confirm where the mercury originated. The indicators (e.g., reactant, formulation component, etc.), do give some intimation of the nature of the mercury, but do not confirm the source.
- Because the reporting threshold for mercury is currently ten pounds per year, some companies may use mercury components which do not generate wastes or releases, and/or generate less than ten pounds annually, but remain exempt from TRI reporting.
- The reporting threshold changed from 10,000 pounds of mercury, to ten pounds of mercury between 1999 and 2000. Despite outreach efforts by the US EPA, some companies may still be unaware of the lower threshold reporting requirements for mercury.
- Some companies report the same TRI quantities for mercury vs. mercury compounds, as well as the same quantity for wastes as releases. This introduces possibility for double-counting when using the TRI data.
- Some companies state that they cannot directly measure stack emissions or emissions from volatilization of mercury as it is incorporated into pre-consumer products. Therefore, they may perform calculations based on emissions factors, or use one-half detection limits to estimate mercury releases. These methods can introduce error compared to actual generation amounts.
- Per a consultant that assists metal finishing companies in TRI reporting, the TRI threshold determination system is somewhat confusing and subject to interpretation.
- In two cases, companies within the same industry, reported differently on the TRI indicators (e.g., reactant, formulation component, etc.), even though the companies are generating the same type of mercury releases from the same sources. The two cases for Washington, in year 2000, where same industries reported different indicators are in cement production and crude refining.
- It is likely that some manufacturers incorporate encapsulated or otherwise contained mercury or mercury components into products without generating any wastes or releases. Then the manufacturers sell the mercury containing products to customers, and the mercury chain information will never need to be reported by the original manufacturer as a waste or release until the end of the products' useful life. This limits the number of manufacturers that can be identified through TRI mercury reporting.

The following comments relate to the limitations of using the Washington State Dangerous Waste Regulations (DWR) reporting. The DWR requires annual dangerous waste reporting by all companies who generate, transport, or manage dangerous waste and have an active RCRA Site identification number. The reporting is governed by Washington Administrative Codes (WAC) 173-303-060(5), 173-303-070(8), 173-303-220, and 173-303-390. The Washington DWR data provides a weight and description of the mercury waste stream. This regulation does not require reporting of any releases to air.

Limitations on use of this data in determining mercury quantities and use in Washington State are:

- Small quantity waste generators are exempt from reporting to DWR, so some mercury waste streams are not accounted for in the DWR database.
- The reported weight of the mercury waste includes the entire weight of the waste, not just the mercury portion. The data therefore does not reflect the actual weight of mercury in the waste.
- It is likely that some manufacturers incorporate encapsulated or otherwise contained mercury or mercury components into products without generating any waste. Then the manufacturers sell the mercury containing products to customers, and the mercury chain information will never need to be reported by the original manufacturer as a waste or release until the end of the products' useful life. This limits the number of manufacturers that can be identified through Washington mercury reporting.

Appendix B - Alternatives to Mercury-Added Products

Disclaimer: Listing of products and suppliers in this appendix does not indicate any endorsement of the supplier, or the product, and does not validate the performance of the alternative product.

Product (and Use)	Alternatives	References and Notes
Zanker's solution (brand) and B5 fixative	Zinc formalin, zinc chloride	http://www.newcomersupply.com/fixatives.html. Same procedure as regular B5, no mercury pigment removal.
Batteries	Battery-free products	www.informinc.org/fsmercalts.pdf
Electrode, mercury reference	Blood analyzer	Equipment with Mercury, National Institutes of Health, http://www.nih.gov/od/ors/ds/nomercury/equipment.htm
Arterial plethysmography & phlebodynamometry (measure venous capacity or peripherals)	Filtrass angio sensors	http://www.domed.com/english/faqs/main.html
Bulb, argon- mercury (some neon bulb colors)	Mix of other gases	www.namkwong.com.hk/download/neon-catalogue.pdf
Bulb, fluorescent	Low mercury	Uses chemical buffer to slow mercury absorption - requires less hg than conventional) "Alto" lamps by Phillips Lighting, "Ecolux" by GE
Bulb, fluorescent (in Exit signs)	Light-emitting diodes (LED)	
Bulb, fluorescent and LCD-type displays	VUV phosphor	In research phase - http://www.chem.uu.nl/gm/www/VanLoef/research.html
Bulb, fluorescent, backlight	Light-emitting diodes (LED) where visualization in a dark room is needed	http://155.103.6.10/cgi-bin/sic/sicser1?sickey=photograph&maxhits=500
Bulb, germicidal	Fluorescent lights certified to pass EPA TCLP for mercury and lead	http://www.nih.gov/od/ors/ds/nomercury/systems.htm
Bulb, HID	Mercury-free high-pressure sodium lamps	"Lumalux" made by Osram-Sylvania, available up to 150 watts
Bulb, HID	Metallic zinc	http://www.iop.org/EJ/S/UNREG/hSDjYVwZZ6vzYTpFijyZbg/abstract/0963-0252/11/3A/308

Product (and Use)	Alternatives	References and Notes
Bulb, HID - LCD backlight	Xenon excimer	http://www.sylvania.com/press/05302001b7.html - efficiency ~30% of conventional fluorescent lamp, thus not suitable for general lighting applications.
Bulb, high pressure sodium (arc-discharge)	Arc-tube technology	Proprietary technology
Bulb, LCD backlight (in slim-type televisions and large screen information terminals)	High luminance amorphous silicon thin film transistor (TFT), color LCD module	http://www.ic.nec.co.jp/english/news/0009/2702.html
Bulb, LCD backlight (dimmable-flat screen)	PLANON, mercury free, xenon gas excimer (dimmable, flat)	OSRAM Sylvania, http://www.i-sft.com/e/prod/prod_con006.html
Bulb, mercury for food sterilization	Pulsed, light - Xenon's Steripulse	http://www.xenon-corp.com/sterilization.html
Bulb, mercury vapor (UV curing)	Pulsed xenon light for curing	http://www.xenon-corp.com/achieve.html
Cell and particle counter	Electrical sensing zone	Beckman, http://www.beckman.com/products/instrument/partChar/pc_z1.asp
Chlorine, NaOH, and other chemicals produced by mercury cell process	Ion-exchange membrane, or porous diaphragm process	Wisconsin: Blueprint for Reducing Mercury, http://www.wlssd.duluth.mn.us/Blueprint%20for%20mercury/HG6.HTM
COD digestion testing (not EPA-approved)	Environmental Express micro-vials	http://www.envexp.com/cod_vials.html
COD testing (not EPA-approved)	Manganese III, or dichromate reagent	http://www.hach.com/corporate/news_and_notes_newsletter/nn602/techtips602.htm
COD digestion testing (not EPA-approved)	Accu-test – accuracy limited to low chloride ion content solutions)	http://www.bioscienceinc.com/COD/Other_Info/COD_Tech_Bulletin_Spectrophotometric_Mercfree.htm
COD digestion testing (not EPA-approved)	mercury-salt-free reagents	Hach Solutions Series: Oxygen Demand, http://www.lamotte.com/pages/common/newprod/smart2.html
Hydrometer	Spirit filled	Galligan, et al. 2002.
Hygrometer, psychrometer	Spirit filled, digital	Galligan, et al. 2002.
Insulation (for ship building)	Non-halogen formulation, mercury free	http://www.armacell.com/www/armacell/ACwwwAttach.nsf/ansFiles/030-001-NA(NA)(2-02).pdf/$File/030-001-NA(NA)(2-02).pdf

Product (and Use)	Alternatives	References and Notes
Lamps, tungsten	mechanical switches	
Manometer	Aneroid Electronic/digital	Galligan, et al. 2002.
Manometer	Liquid filled (stainless steel Bourdon tube), helicoids, Omega Type 'S'	http://www.epa.gov/bns/mercury/Draft_Report_for_Mercury_Reduction_Options.pdf, HAENNI products
Mercuric nitrate (as a chloride/medical use)	Ion-specific electrodes	Reagents with Mercury, National Institutes of Health, http://www.nih.gov/od/ors/ds/nomercury/reagents.htm
Mercuric nitrate (stain)	Cupric sulfate	Reagents with Mercury, National Institutes of Health, http://www.nih.gov/od/ors/ds/nomercury/reagents.htm
Mercuric oxide (oxidizing agent in Harris hematoxylin)	Sodium iodate	Reagents with Mercury, National Institutes of Health, http://www.nih.gov/od/ors/ds/nomercury/reagents.htm
Pump	Non-mercury float	http://www.oasis-pumps.com/s25.html
Rectifier, ignitron	Solid state rectifiers	http://www.delta-institute.org/publications/Steel-Hg-Report-0627011.pdf
Slip rings	Silver and other alloys	http://www.engineeringtalk.com/news/idm/idm108.html
sphygmomanometer	electronic vacuum gauge, aneroid	Galligan, et al. 2002. "Dura Shock" by Welch Allyn (new aneroid design)
sphygmomanometer	Oscillometric	Galligan, et al. 2002.
Relays, plunger / displacement, and wetted reed	Dry magnetic reed, electro-mechanical, solid state, silicon controlled rectifier, hybrid (electromechan-ical + solid state)	Galligan, et al. 2002.
Switch, float	Mechanical, magnetic dry reed, optical, Conductive, metallic ball, sonic, ultrasonic pressure transmitter, gallium indium alloy, thermal, capacitive	Galligan, et al. 2002.

Product (and Use)	Alternatives	References and Notes
Switch, pressure and temperature	Mechanical Solid state	Galligan, et al. 2002.
Switch	Hard contact switches	Waste Reduction and Proper Waste Management of Products Containing Mercury, http://www.p2pays.org/ref/01/00127.htm
Switch, accelerometer for anti-lock brakes	Analog accelerometer	www.watoxics.org/pdffiles/MercuryInCars.pdf
Switch (auto trunk or hood light)	Ball bearing	www.watoxics.org/pdffiles/MercuryInCars.pdf
Switch, boiler low water cutoff	Electronic	http://fhaspapp.ittind.com/homeowners/B-Low-Water-Cut-off.htm , http://www.johnsherman.com/level/warrick.html
Switch, float	Bubble troll	see www.informinc.org/fsmercalts.pdf
Switch, float	Float-tilt	see www.informinc.org/fsmercalts.pdf
Switch, float	Electromechanical contact	http://www.partech.co.uk/products/mkj/fs7030.htm
Switch, float in bilge and sump pump	Automatic or electronic	http://www.bearcreekoutdoors.com/store/page13.html, http://ecatalog.squared.com/catalog/html/sections/20/17220023.htm
Switch, tilt (chest freezer lid)	Internal light instead of tilt-switch activated	
Switch (fire pump controls)	Electronic	Potter Company
Switch (boiler, low water cutoff for boiler)	Snap action	McDonnell Miller – MM 63M (model) http://www.alexbauer.com/mcdonn.htm
Switch (boiler, High Limit Steam Pressure)	Electronic	P7810D1008
Switch (boiler, feed pump controller)	Snap switch	MM 150SMD
Relay (On-off power switching)	Solid state	http://www.watlow.com/products/guides/controls/cosg_ovr.cfm
Thermometer	Solar powered	http://www.technika.com/Sper/s800018.htm
Thermometer	Compact digital	http://www.allheart.com/ommc110.html
Thermometer, clinical	Phase-change	http://www.temperatures.com/phasevendors.html
Thermometer, fever	Tympanic (IR), ear	http://www.alarismed.com/clinical/tympanic.htm
Thermometer, fever	Liquid galinstan (gallium/indium/tin alloy)	http://www.epa.gov/grtlakes/bnsdocs/hg/thermfaq.html
Thermometer, non fever	Digital	Galligan, et al. 2002. May contain button cell battery with up to 25 miligrams mercury.

Product (and Use)	Alternatives	References and Notes
Thermometer, non fever	Spirit-filled Bimetal	Galligan, et al. 2002.
Thermometer, non fever	Teflon encapsulation	http://www.millerweber.com/faq.htm#part3
Thermometer	Infrared thermographic scanner	Mannix - www.mannix-inst.com
Thermostat	Energy Star programmable thermostats	http://yosemite.epa.gov/estar/consumers.nsf/content/prgtherm.htm, more expensive than mercury, and existing stats last 20-30 years
Thermostat	Hybrid/solid state	www.airpaxtsp.com/tspsite/pdfs/6024.pdf
Thermostat	Digital	Galligan, et al. 2002.
Thermostat	Light sensing	oikos.com/esb/32/thermostat.html
Thermostat (temperature control)	Snap switch,	http://www.p2pays.org/ref/01/00127.htm
Thermostat for extreme conditions	None	
Thimerosal	Methyl paraben or propyl paraben	Sustainable Hospitals http://www.uml.edu/centers/LCSP/hospitals/HTMLSrc/IP_Merc_AP_LabChem.html

Appendix C – Mercury Reduction of Thimerosal in a Clinical Laboratory

Excerpted in Full from MWRA / MASCO Mercury Work Group Phase II Mercury Management Subcommittee. 1999. Mercury Management Guidebook. Appendix F. http://www.masco.org/mercury/phase2/appendixf.html#CASE%20STUDY%207

CASE STUDY 7 - Clinical Testing Laboratory

Introduction
Under a compliance order from the MWRA, a 250-employee clinical testing laboratory reduced its mercury discharges from 0.3 mg/L (ppm) to less than 0.001 mg/L (ppm) or 1.0 µg/L (ppb). This reduction was achieved through a two-pronged approach:

1. Source reduction techniques were used to reduce the mercury entering the facility's wastewater treatment system by approximately 90 percent; and

2. A sophisticated treatment system was then installed to remove the residual mercury.

These steps enabled the facility to meet the 1.0 µg/L (ppb) mercury discharge standard several months ahead of the MWRA compliance deadline. The Office of Technical Assistance (OTA), a branch of the Massachusetts Executive Office of Environmental Affairs, provided confidential, nonregulatory assistance with the project at no charge.

Background
After the laboratory received an MWRA compliance order to eliminate mercury from its wastewater discharge, it was found that the source of the mercury was thimerosal, a mercury salicylate salt used as a bacteriostat/fungistat in many clinical tests and could not readily be replaced. Clinical test equipment and test kit manufacturers, aware of the problem and under pressure from their customers, are working to develop reagents with alternative preservatives. However, the removal of mercury from a test kit involves revalidation of the test kit with subsequent approval by the US Food and Drug Administration. This is a time-consuming process that can require several years to complete.

Source Reduction Efforts
Having determined that thimerosal was the source of the mercury, the facility undertook a program to identify which analytical instruments generated wastewater discharges that contained mercury. Samples from all point-of-source discharges were sent to an environmental testing laboratory for mercury quantification. Approximately 50 potential sources were identified, sampled, and tested. About 30 percent of the potential sources were found to contain measurable quantities of mercury, some as high as 1.0 mg/L (ppm) or 1,000 µg/L (ppb).

Once the analyses were completed, several source reduction efforts (including toxics use reduction (TUR) and wastewater sequestering) were carried out to prevent mercury from entering the wastewater. The primary TUR technique was to contact test kit manufacturers to find the availability of suitable mercury-free alternatives. Some manufacturers said that revalidation of reformulated kits would take a minimum of two years. Other manufacturers, including Technicon and Hybritech, were already aware of the mercury issue and could supply alternative kits. The effort resulted in the replacement of four of the 15 test kits used by the facility after validation studies were performed (a one to two month process).

At OTAs prompting, the facility pursued several other TUR options, including worker training and improved housekeeping techniques, to prevent mercury from entering the facilities wastewater. All employees were informed of the problem and the efforts being taken to correct it. Signs and labels are now posted throughout the facility describing the proper handling and disposal of mercury-containing materials, with emphasis on what should not be discharged down the drain. These efforts are particularly important since only a very small amount of mercury (about 0.2 grams) could raise mercury concentrations in the facility wastewater to about 0.3 mg/L (ppm) or 300 µg/L (ppb).

Because of the investigations, about five gallons per day of wastewater is now sequestered at the sources, collected in containers, and transported off-site as hazardous waste. This sequestered wastewater consists of all equipment discharges containing mercury that can be easily collected at the sources in small containers. While the sequestered wastewater is not a large volume of water, it does include many instrument discharges containing high concentrations of mercury.

From these source reduction efforts, the mercury level in the wastewater discharge was reduced to about 0.03 mg/L (ppm) or 30 µg/L (ppb). Although this represented a significant reduction in mercury concentration, it was not sufficient to comply with the MWRA enforcement limit. Consequently, the facility investigated additional wastewater sequestering and offsite disposal (up to and including the entire facility discharge) and wastewater pretreatment. The pretreatment options explored included evaporation, ion exchange, precipitation, and carbon adsorption. Based on an economic analysis of the various approaches, carbon adsorption was chosen as the most cost-effective technique.

Wastewater Pretreatment

A pilot study was conducted to learn the effectiveness of carbon adsorption. In this study, about 450 gallons per day of wastewater were pretreated using Disposorb™ carbon. This is a reactivated carbon sold by Calgon in plastic drums. When the carbon bed reached saturation, the entire drum would be sent offsite for disposal. Carbon adsorption was found effective in removing mercury: mercury levels were reduced from about 0.06 mg/L (ppm) or 60 µg/L (ppb) upstream of the carbon bed to nondetectable levels downstream.

Based on these results, the facility decided to treat approximately 1,800 gallons per day of wastewater in a full-scale carbon adsorption pretreatment system. The system consisted of three parallel trains of carbon beds, with each train consisting of two drums of Disposorb™ carbon in series. The system was effective in removing mercury but only to a concentration of approximately 0.02 mg/L (ppm) or 20 µg/L (ppb) - well above the MWRA enforcement limit. The facility also noted extensive bacterial growth on the carbon beds.

At this point, the facility asked OTA for assistance with the adsorption system. Following a site visit, OTA prepared several recommendations intended to optimize system performance:

- Operate the system with constant optimum flowrates through the carbon beds by using an equalization tank and pumps upstream of the carbon beds to provide storage capacity. The system had been installed without any provision for control of flow rates, and this was resulting in channeling in the beds, which led in turn to poor mercury removal. OTA suggested that the facility contact Calgon to learn optimal flow rates.

- Install bag filters upstream of the carbon beds to avoid plugging with solids that decrease the adsorptive capacity of the carbon.
- Investigate the use of an ultraviolet (UV) light sterilization unit or silver-impregnated carbon to control bacterial growth in the carbon adsorption system. (Silver is a bacteriostatic material, *i.e.*, it inhibits bacterial growth).

Based on these recommendations, the facility installed a 500-gallon equalization tank upstream of the carbon beds and flow control valves on each of the three trains to maintain optimum flow through the carbon beds. The valves were sized based on information supplied by Calgon. Calgon also suggested that the adsorptive capacity of the carbon is greatest when the pH of the water is maintained between 4.0 and 5.0. The pH of the influent wastewater is now adjusted to this range in the equalization tank. Bag filters (15 micron rating) were added upstream of the equalization tank, and ultraviolet lights were installed between the filters and the equalization tank to control bacterial growth. The pH of the activated carbon system effluent is adjusted to the range of 5.5 to 10.5 before it flows into an existing final neutralization tank.

Results

Once these changes were made, effluent mercury levels of less than 1.0 µg/L (ppb) were achieved - meeting the MWRA enforcement limit. The facility successfully completed the required compliance testing several months before a MWRA-stipulated deadline.

While toxics use reduction (TUR) efforts were not themselves sufficient to achieve compliance, they did lead to a 90 percent reduction in the mercury that had to be removed in the pretreatment system. This reduction translated into lower pretreatment system capital and operating costs.

Capital expenditures to achieve compliance were more than $60,000. This figure includes the costs of both the pilot and full-scale carbon adsorption systems and of replumbing the facility. According to facility calculations, the operating costs of the new system are more than $7,500 per month. However, the facility would have faced higher costs for offsite disposal of the wastewater and could have been liable for fines of $10,000 per *day* if it had not met the MWRA deadline for elimination of the mercury from the wastewater.

Appendix D – Switch Manufacturers in Washington State

Note: This information was provided by the Thomas Register. If specific product information for a manufacturer was available from the Thomas Register, it is included here.

Allied Signal Aerospace -- Redmond, WA

Allied Signal Instrument Systems -- Redmond, WA

Crest Industries, Inc. -- Pacific, WA

Cutler-Hammer, Sensor Div. -- Everett, WA
Photoelectric, inductive, capacitive, limit switch & safety product sensing products including safety key interlock

Index Sensors & Controls, Inc. -- Redmond, WA
Bi-metal snap-action switches, electronic temperature

Kistler-Morse Corp. -- Bothell, WA
Systems for bulk inventory level & weight monitoring, batching & control applications

Lowell Technologies Inc. (LTI) -- Marysville, Washington
Custom non-contact magnet activated, proportional position sensors

Masterpress, Inc. -- Seattle, WA

Red Dot Corp. -- Seattle, WA

Sea-Dog Line, Div. Sea-Dog Corp. -- Everett, WA
Marine, automotive & RV, 12-volt electrical accessories. including aluminum & plastic switch panels, stainless & brass

Talkie Tooter -- Sedro Woolley, WA dba Rothenbuhler Engineering

X10 Wireless Technology, Inc.® -- Seattle, Washington