A Guide to Mercury Assessment and Elimination in HealthCare Facilities

DEPARTMENT OF HEALTH SERVICES

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It is anticipated that the use of this document will lead to the elimination of mercury at hospitals throughout California.

Sincerely,

Jack McGurk, Chief
Environmental Management Branch

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CHAPTER I
INTRODUCTION

The U. S. Environmental Protection Agency (EPA) and the American Hospital Association (AHA) signed a Memorandum of Understanding (MOU) in 1998 implementing pollution prevention actions within hospitals.[1] One of the goals of the MOU was to virtually eliminate mercury-containing waste from hospital waste streams by 2005. This goal is important because of the toxic effects of mercury on human health and the environment. The MOU was also the impetus for the initiation of this pollution prevention (P-2) in healthcare facilities project and contributed to the willingness of the six Bay Area hospitals to be participants.

Mercury occurs in several forms. It may occur naturally in the environment as elemental mercury (Hg^0 or quicksilver); it may be dissolved in rainwater as (Hg^{+2}); it may appear in a solid mineral form as cinnabar (HgS); and as methyl mercury ($HgCH_3$), an organo-metal. Biotransformation of inorganic mercury in the environment to methyl mercury enables entrance into food chains. Methyl mercury is the most toxic form of mercury to animals and humans. Mercury can cause human health problems when it accumulates in the tissue of fish and other aquatic animals that are used as a human food source. Elimination of methyl mercury occurs very slowly with various half-lives of months to years.[2]

Methyl mercury primarily attacks the nervous system and is more acute in children since their brains do not complete development until after five years of age. Mild mercury poisoning in adults can include loss of sensation in the hands and feet, tiredness and blurred vision. Severe poisoning can result in hearing and speech impairment, vision problems, and over time can lead to coma and death. Long-term exposure to methyl mercury may cause kidney damage.[3]

Public health advisories on fish consumption have been issued in the California fishing regulations from the Department of Fish and Game for certain waters of California because of elevated levels of mercury. Fish consumption advisories include restricted eating limits for all individuals with special criteria for pregnant women, nursing mothers, and children under six years of age because of the increased sensitivity of fetuses and young children to methyl mercury. Fish consumption advisories have been issued in 30 states due to elevated levels of methyl mercury.[3] Recently, fish caught near gold mining sites in the Sierra Nevada mountains of California were found to have mercury levels above the federal Food and Drug Administration allowable limit of one part per million for commercially caught fish.[4] Mercury is of concern to the environment because of the damage it can cause to fish, birds and plants. Mercury can cause reproductive problems, impaired growth and death in fish. Mercury exposure can cause reproductive problems in birds and death in plants.

Reducing mercury emissions from medical waste incinerators is desirable because of mercury's toxic effects. Mercury in the incinerated waste occurs as a result of improper disposal of mercury in red medical waste bags.[5] However, as a result of stringent air emission standards enacted in 1990 by the California Air Resources Board (ARB) for controlling dioxin production, only a few medical waste incinerators remain in operation in California. In 1991 the ARB identified 146 medical waste incinerators in California, including 9 off-site treatment facilities. Today, there are less than a dozen medical waste incinerators including one off-site treatment facility that uses incineration as a treatment method.[6] Additional reduction of mercury wastes can be anticipated by assessment of mercury in healthcare facilities.

While most people in California are aware of the "Gold Rush" in the mid-1800s that brought people to California and led to statehood, few people are knowledgeable of the great environmental damage caused through the use of mercury in gold mining operations during the late 1800s through the early part of the 1900s. Sediments incorporating mercury from hydraulic gold mining were transported into the Bay-Delta waters of California. The Central Valley Regional Water Quality Control Board has estimated that approximately 7,600 tons of refined quicksilver or elemental mercury were deposited in the Mother Lode region during the Gold Rush era.[7] Virtually all of the mercury brought into the Sierra Nevada to extract gold from ore was lost into the watersheds.

To make matters worse, mercury was mined during this same period of time from the Coast Mountain Range and transported across the Central Valley to the Sierra Nevada Range for use in placer gold mining. Today, many of the mercury mines are abandoned and their debris piles contribute to the mercury contamination problem. Natural deposits of mercury in the form of cinnabar still exist in the Coast Mountain Range along the western portion of the Central Valley. Natural springs in this mountain range discharge mercury that is mobilized through geothermal processes.[4] Mercury contamination has occurred on the watersheds of both mountain ranges that form the Central Valley of California and the Bay-Delta waters that flow through it. The problems created from the use of mercury in gold mining operations over 125 years ago persist today. Studies are currently being conducted that will quantify changes in methyl mercury production caused by restoration activities. Results from these studies will be used to develop ecosystem restoration to minimize the production of methyl mercury.[5]

Although the amounts of mercury waste produced by hospitals appears to be minimal when compared to the thousands of tons of mercury waste created years ago by the gold mining industry, it can not be overlooked and must be eliminated where possible. The healthcare industry has an opportunity to assume a leadership position through implementing the EPA/AHA memorandum of understanding relating to eliminating mercury waste from their hospital facilities. This opportunity is actually an obligation for not only will it improve the environment; but more importantly, it is a demonstrated action to protect public health. It is the intent of this document to assist the healthcare industry, and hospitals in particular, to implement the MOU for elimination of mercury wastes and in doing so, contribute to the betterment of California's communities.

Following an introduction to mercury in Chapter I, this document is arranged so that the reader is presented with information as to where mercury may be found in healthcare settings, how it should be handled, how to assess where it is located and plan for its removal, and the impacts from mercury spills. Chapter II discusses what pieces of equipment and devices found in healthcare facilities may contain mercury and what non mercury-containing replacements or alternatives are available. Chapter III discusses how to handle mercury safely within healthcare facilities to reduce spills and contamination. The chapter also includes spill response information. Chapter IV presents the findings from the mercury assessments conducted at the six Bay Area healthcare facilities that participated in this project. Included in Chapter IV is a business plan for each facility for mercury removal. Chapter V provides insight as to where mercury-containing equipment and devices are typically found in healthcare facilities. The use of the mercury assessment tool is discussed in Chapter VI. The mercury assessment tool was developed during the project and used for the assessments conducted at each participating facility. Chapter VII covers the impact from a mercury spill at a healthcare facility on the University of California, Los Angeles campus. Other data is also presented from their campus spill response activities.

During 1999 the American Academy of Family Physicians, the American Academy of Pediatrics, the Advisory Committee on Immunization Practices and the United States Public Health Service established a goal to move rapidly to vaccines which are free of thimerosal as a preservative. Thimerosal is a derivative of ethylmercury and has been used as a preservative in vaccines since the 1930s. These organizations have declared that until an adequate supply of thimerosal-free vaccines is available, the use of vaccines containing thimerosal as a preservative is acceptable.[8]

No pharmaceuticals with mercury as an active ingredient were found in the pharmacies surveyed as part of this project. This report is supportive of the goal to move to vaccines that are free of thimerosal and has recommended that unit doses, requiring no preservative, be used where feasible. Additionally, it has been recommended that stock be minimized by applying "just-in-time" inventory practices in the pharmacies.

Several cities within California have recently adopted resolutions to reduce the environmental and public health dangers caused by mercury. Residents of these cities have been urged to use non mercury-containing thermometers and retail facilities have been requested to sell only mercury-free thermometers. The mercury assessments conducted as a part of this project found that the participating hospitals were not sending mercury-containing thermometers home with newborns. One of the participating facilities was making plans to be the site for residents to return their mercury-containing thermometers.

This document has been designed to be either read cover to cover or on a chapter subject basis. Quantification has been provided where available as to the amounts of mercury found in specific types of equipment or devices and the costs for their replacement with non mercury-containing equivalents. It is the intent of this document to assist the reader to better understand how to assess, handle and remove mercury from healthcare facilities.

LESSONS LEARNED

- The risk of mercury spills is high. The cost to remedy spills has proven to be very expensive.
- Ninety-nine percent of a typical hospital's mercury is contained in esophageal dilators, sphygmomanometer services kits, and barometers.
- Total cost to replace mercury devices is modest, especially in light of the cost of spills.
- Non-mercury replacements are usually no more expensive than their mercury counterparts.
- Removal of a mercury device must mean "get it out of the hospital", not merely out of service.
- Purchasing Departments and associated staff must be vigilant in purchasing and accepting shipments of supplies. Vendor substitution could bring mercury back into the facility.
- Training for mercury auditing is best done on a one-on-one basis, large groups make the process difficult.
- Mercury assessments must be performed in a safe and open atmosphere, which encourages the discovery of <u>all</u> sources of mercury.

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CHAPTER II
HOSPITAL EQUIPMENT AND DEVICES CONTAINING MERCURY

Sphygmomanometers

The sphygmomanometer that traditionally has been used in hospitals to monitor blood pressure contains mercury. Until recently, this was the only accurate sphygmomanometer on the market. Although technical developments have given the mercury-free aneroid sphygmomanometers an accuracy rating similar to the mercury units, it is often difficult to convince some practitioners to change. Arguments are made that aneroid sphygmomanometers add to the burden of hospital maintenance staff because of the need for periodic calibration. The fact is that mercury sphygmomanometers also need periodic maintenance. The expense and time of managing maintenance, spills and disposal of mercury sphygmomanometers can outweigh the time needed for calibration of the aneroid units.

Many hospitals are in the process of replacing mercury sphygmomanometers and have found that companies that manufacture aneroid sphygmomanometers have policies that make replacement more economically feasible. These companies may take back and recycle mercury units on a one-for-one basis when their aneroid units are purchased. The purchasing department of a hospital can negotiate with these companies to get the best price for the number of mercury sphygmomanometers they want to replace and not to be burdened with additional mercury disposal costs.

Figure 1
Bedside mercury sphygmomanometer commonly found in hospitals. (Pollution Prevention Project Photograph)

Figure 2 **The bedside mercury sphygmomanometer has been replaced with an aneroid unit. (Pollution Prevention Project Photograph)**

Baumanometer® Safety Devices

By far the most commonly used sphygmomanometer found in hospitals is the Baum brand wall-mounted sphygmomanometer. Manufactured in New York since 1916, the Baum sphygmomanometer was a technological breakthrough at that time. Since then, it has undergone many modifications and improvements and is considered by some a standard for blood pressure measurement.

Indeed, a testament to the quality of this instrument is the fact that many in use are up to 30 years old. However, this is also one of the problems with the "Baumanometers". The majority of instruments in use in the hospitals visited by California pollution prevention staff were manufactured before Baum began including safety features that greatly diminish the chance of a mercury spill.

Baumanometers are found in many uncharacteristic places. In fact, many patient areas that have been turned into offices may still be found with the Baumanometers mounted on the walls next to desks. Additionally, alternative types of sphygmomanometers may be found, but the Baumanometers are not removed from the walls. These wall-mounted sphygmomanometers are seen in many emergency rooms, treatment rooms, and doctors' offices.

The safety issues with these older model sphygmomanometers include two items that are inexpensive and easy to fix. One is replacement of the glass mercury tube with a mylar-coated tube. The other is the insertion of a small "L" shaped metal "lever lock" that prevents accidental release of the mercury from the tube. Both are included on new Baumanometers.

Older models of the Baum sphygmomanometers used a clear glass tube. Although it is somewhat recessed in the instrument's face, it has always been a potential source of a spill if the tube were broken. Now, hospital personnel can replace the glass tube with one coated with mylar. In event of the tube breaking, the mylar coating will prevent shattering and maintain the integrity of the tube. The mylar sheath ends close to the tube's top end, and a fingernail can detect the change in the tube's outer diameter. This check can be used to see if existing tubes are mylar coated or not. The mylar coated tubes can be purchased from Baum and replacement is not difficult. They are available for all models of Baum brand sphygmomanometers.

The second safety device is provided free of charge from Baum. On the wall mounted Baumanometer, the mercury-containing tube is held in place by a lever on top of the device. The lever is only supposed to be moved when the sphygmomanometer is removed from the wall and lying on its right side. If this lever is inadvertently flipped back while the instrument is upright on the wall, the tube is released and the mercury spills out of the bottom of the tube.

The "L" shaped lever lock is a simple strip of angled metal that is easily slipped behind the lever to immobilize it. The lock can still be removed with no problem using a screwdriver, but spills are prevented because patients cannot remove the lever lock without some effort. The lock simply eliminates the potential to idly flip the lever, which bored and/or curious patients may do. Vigorous cleaning of the sphygmomanometer can also allow inadvertent flipping of the lever.

Figure 3 **Unless recycled, the 90 sphygmomanometers, along with thermometers and bougies not seen, would have to be managed as hazardous waste at great expense. There are programs to exchange both bougies and sphygmomanometers. (Pollution Prevention Project Photograph)**

The lever locks can be ordered from Baum, Inc. and will be sent free of charge upon request. Another benefit of inserting these lever locks is that one person in the facility can make a detailed accounting of where and how many Baumanometers are in the facility, and can make a quick visual maintenance check as well.

Sphygmomanometer Service Kit

One significant source of mercury that must not be overlooked when conducting a mercury audit of a hospital is contained in the sphygmomanometer service kit. Typically, along with spare parts and fittings, such a repair kit will come with one or more one-pound bottles of triple-distilled mercury. If the service kit has been used at all, there may well be another bottle of waste mercury. The service kit may be all that remains at a facility that has changed out all its mercury sphygmomanometers. Extra bottles of mercury have also been discovered separate from the kit. One pound of mercury is about 33 milliliters, or about the volume of a nasal or ophthalmic solution bottle. One can see how easily such a small container could be overlooked in the engineering department of a large hospital.

Figure 4 **This sphygmomanometer service kit is provided for the Baum sphygmomanometer. The mercury from this kit may be consolidated with that from other sources to be recycled. Sphygmomanometer exchange programs may agree to accept this source of mercury. (Pollution Prevention Project Photograph)**

Figure 5 **The bottle of "new" mercury (left) weighs 500 grams (454 grams is a pound). The waste mercury (right) was estimated at 0.3 pound. (Pollution Prevention Project Photograph)**

Esophageal Dilators (Bougies) and Feeding Tubes

Esophageal dilators, feeding tubes and other devices may use mercury as a weight. There are non-mercury replacements available for all the mercury-containing devices that have historically been used in hospital endoscopy departments. The most common of these is the esophageal dilator or bougie. This device is a long, flexible tube containing mercury. It is passed down the patient's esophagus and used to dilate this structure if there are constrictions from various disease processes. Patients may return periodically to the hospital for this procedure if they have a chronic problem. There is a mercury-free alternative available containing tungsten gel for weight instead of the mercury. Additionally, the outside surface is silicone which is non-slip when dry and slippery when wet, making handling easier. The mercury-containing bougies are made of rubber.

Figure 6 This set of esophageal dilators (bougies) weighs about 12 pounds. The weight is necessary to insert the device into the patient's stenosed (constricted) food tube. These mercury-weighted bougies have been replaced with tungsten gel filled models. (Pollution Prevention Project Photograph)

Figure 7 A complete set of tungsten gel-weighted bougies, stored in the leather zippered case that formerly held the mercury ones. (Pollution Prevention Project Photograph)

The silicone tungsten gel bougies are green, easily differentiating them from the orange rubber mercury bougies. At least one company has a trade-in policy that gives a 10 percent rebate toward purchase of a new mercury-free bougie and also includes free recycling of the old one.

Gastro/Esophageal Tubes Containing Mercury

Miller Abbott tubes are passed down a patient's esophagus, through the stomach and into the small intestine to help unblock intestinal obstructions. Historically, these tubes had a balloon containing mercury to guide the tube into place through gravity. It has been recommended that the mercury balloon be replaced with a water-filled balloon, or a different procedure used. Most practitioners have stopped using the Miller Abbott tubes in favor of a combination of drugs and surgery for obstructions.

Figure 8 **A Blakemore tube has three connections. One inflates the bulb, one inflates the tube, and one is for gastric lavage and administering fluids. (Pollution Prevention Project Photograph)**

The Blakemore tube (Sengstaken-Blakemore tube) (shown above) is a device used to stop the bleeding of esophageal varices varicose veins in the esophagus. It consists of two balloons; one inflated in the stomach to hold the device in place, the other inflated inside the esophagus to compress the bleeding vessels. The Blakemore tube is an absolute necessity in the emergency room, older devices have a mercury-weighted tube allowing it to be placed in a similar fashion as the Miller Abbot tube. A solid rubber weight replaces the mercury in the mercury-free device.

Barometers in Respiratory Therapy

Respiratory therapy may not seem like a place to find mercury. In several hospitals visited, this department had one of the single largest repositories of mercury in the facility. A mercury barometer has historically been used to calibrate blood gas analyzers in hospitals. One popular brand of barometer found in use holds 14 ounces of elemental mercury. The manufacturer does not sell any kind of safety devices for this barometer.

Some hospitals have replaced barometers with aneroid units, or call their local airport periodically for barometric pressure readings.

Figure 9 This mercury barometer, used to standardize blood gas measurements, can be replaced with an aneroid device. (Pollution Prevention Project Photograph)

Thermometers

A possible source of mercury thermometers in the household can be newborn nurseries. Most hospitals give the new mother a kit with commonly needed baby items upon discharge after delivery. Previously, these kits would typically include a new mercury thermometer. This practice is no longer as common, but providing non-mercury substitutes should be encouraged wherever it is found.

A potential method to “get the word out” about mercury is through childbirth classes. Many hospitals require classes on childbirth and newborn care prior to delivery. Educators can be encouraged to teach expectant mothers about alternatives to mercury thermometer use in the home.

Figure 10 **Every hospital refrigerator must have a thermometer. This mercury thermometer could easily be replaced with an alcohol/spirit thermometer. (Pollution Prevention Project Photograph)**

Figure 11 **On the bottom shelf of this refrigerator are (left) a mercury minimum/maximum thermometer, and (center) a non-mercury recording thermometer. Upper shelf, at 1 o'clock, a home refrigerator alcohol/spirit thermometer. At 11 o'clock, a "lab quality" mercury one. Mercury thermometers should be replaced with non-mercury thermometers and the number of thermometers in use could be reduced (Pollution Prevention Project Photograph)**

Intraocular Pressure Devices

Prior to ophthalmic surgery, pressure within the eyeball can be reduced to simplify surgery. Historically mercury-filled balloons have been used for this procedure. Approximately 175 grams of elemental mercury is poured into a small balloon the size of a large egg, then double or triple bagged. When placed on the eye, the weight of the mercury on the eyeball keeps fluid from accumulating at the normal rate, softening the eyeball prior to surgery.

Newer micro-surgical procedures have relegated this device to forgotten drawers in most facilities because pressure reduction is not always necessary. The stored pressure reducer may create a waste problem because it may be easily discarded inappropriately due to its small and inconspicuous size.

As use decreases, these devices have been found shoved to the back of cabinets or drawers, often in the Outpatient Surgery area, and forgotten. Effort must be exerted to search for these unused items and to properly dispose of them while the hospital is actively involved in their mercury elimination project. A similar device has been seen consisting of a hard, formed plastic egg with one convex side that snapped to a headband. Many staff consider the device inferior. The concern is that a less adequate device, like the hard plastic egg will not be used and the mercury-filled devices will be brought back into service. Without a replacement available, physicians may request repair of one of the old-style mercury pressure reducers, unnecessarily exposing staff and patients to possible elemental mercury exposure.

No manufacturer could be found that is still making mercury pressure reducers, and no recycling programs are in place for them. It is the responsibility of the facility to find, recycle, and replace these devices. If a replacement is desired, the Lebanon Corporation offers the Honan Intraocular Pressure Reducer or Eye Softener. It is a pneumatic device with a pressure gauge to maintain even pressure on the eyeball.

B-5 Fixative

One of the compounds widely used in laboratories is B-5 fixative. This mercury-containing fixative has been used in histology to aid in identification of certain cell types. The tissue would be placed in a container with the B-5 fixative and left until the solution had penetrated the tissue. Then the tissue would be stained and placed onto a slide for microscopic examination. During the rinse process some mercury was discharged into the facility sewer system.

Several brands of B-5 fixative have been developed using zinc chloride instead of mercury. Laboratory suppliers should be able to provide a listing of possible substitute brands.

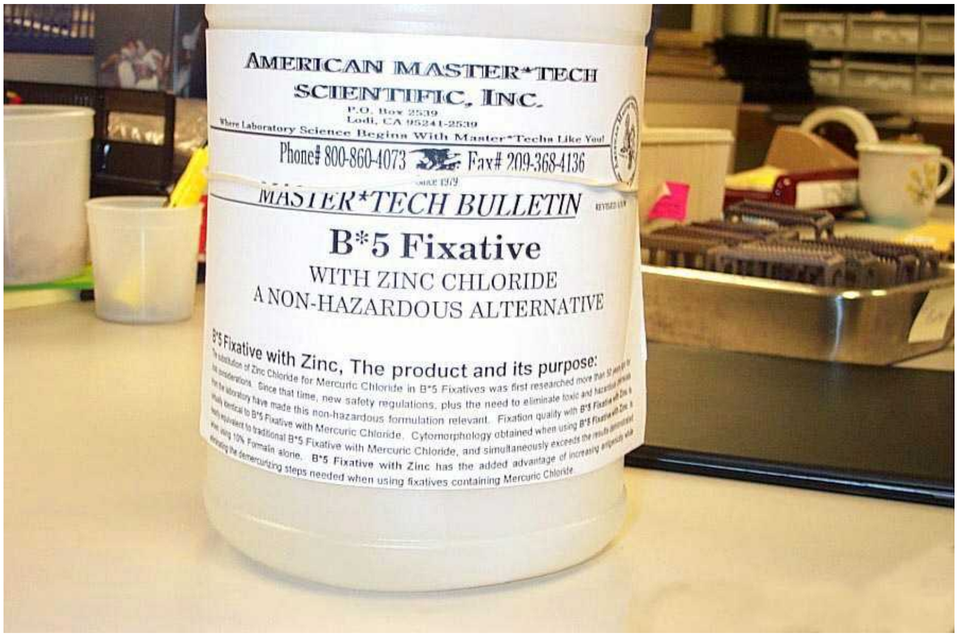


Figure 12 **"B-5" Fixative previously containing mercuric chloride has been replaced with zinc chloride as noted on the label. (Pollution Prevention Project Photograph)**

Mercury-Free Cleaning Products

Small, and potentially overlooked, sources of mercury in the hospital are cleaning products. The electrolyctic process of chloralkali production (manufacture of chlorine products and sodium hydroxide products) often relies on mercury electrodes, resulting in mercury contamination of the products. Many cleaning products consequently contain low levels of mercury. Although these products contain mercury in quantities that are in parts per million or billion, the amount of cleansers used in hospitals can result in a contribution to mercury in wastewater through normal use. Hospital purchasing departments should be aware of this situation and request mercury-free product verification from their suppliers.

CHAPTER III
MERCURY CONCERNS IN HEALTHCARE OPERATIONS

In order to ensure safety and contamination control, activities which remove mercury from the facility must be consistent and predetermined. This may involve establishing a facility-wide, dedicated mercury management program. The suggested elements of such a program, which would also include spill reaction and mercury exclusion policies, are set forth below.

Mercury-Containing Devices In Medical Waste or Sharps Containers

Staff must clearly understand that any broken mercury-containing device must be managed as hazardous waste even if contaminated by medical waste. Whether broken or intact, mercury devices must never be placed in red bag medical waste containers or sharps containers, but rather collected for recycling or hazardous waste disposal. Even though the increased use of digital and other non-mercury substitutes has drastically reduced the incidence of broken fever thermometers, this principle applies to clinical, laboratory, and to all other sources within the healthcare facility.

Mercury Collection Areas

Mercury-containing material will ultimately either be recycled or disposed as hazardous waste. To assure all devices earmarked for removal actually leave the hospital, a single dedicated, secure pre-collection location for consolidation of mercury, mercury-contaminated waste from spills and mercury-containing devices is a virtual necessity. Procedures for removal of mercury-containing material to consolidation locations must also be established. To preclude scenarios such as that depicted in Figure 14, where a mercury sphygmomanometer was cached away for use by practitioners who refused to use the new aneroid device, change out procedures must dovetail with the established transport system.

This example serves to confirm a generally accepted perception that there will be opposition to change which directly impinges on the practitioner’s professional delivery of healthcare. Not unlike the cultural resistance, met among some neonatologists to the removal of mercury fever thermometers from newborn nurseries, impressions, repeatedly reinforced, that the mercury product is in use because it is superior to all other alternatives are difficult to overcome.

Transporting Mercury Devices

Change-out activities, whether for bedside sphygmomanometers, mercury thermostats, or replacement of mercury devices in the boiler room should also be coordinated with planned secondary containment and transportation to a prescribed storage location, arranged in advance. *Ad hoc* improvements or changes are to be discouraged. Ultimately, mercury-containing items will be consolidated at the facility's hazardous waste storage area to await recycling. Procedures should clearly state proper storage methods at each storage area and scheduled transportation to the consolidation area.

Spill Clean Up

It is important to have individuals available at all times who are trained and familiar with management of mercury spills and the use of a spill kit. Notices should be adequately posted throughout the facility listing these individuals and how they may be contacted. A mercury spill must be treated as a hazardous waste spill. Staff throughout the facility must be informed of procedures for notification of the trained personnel for mercury clean-up. Training and clear communication on the importance of proper procedures in mercury clean up are imperative.

Spill Clean-Up Kit

Spill clean up kits should be easily accessible to staff on call for mercury clean up. Any laboratory or safety supplier will have choices of spill clean up kits available. Some of the components the kits should include are:

- Mercury Suppressant – a solution that will prevent vaporization of elemental mercury.

- Mercury Indicator – a powder that changes color to indicate the presence of mercury.

- Mercury Absorbent – a powder that amalgamates with mercury to facilitate clean up.

- Mercury Aspirator or Vacuum – ranging from a syringe to a dedicated vacuum for mercury and used to suction mercury from surfaces. It is very important that regular vacuum cleaners are not used on spilled mercury, as they spread the contamination through aerosolization of the mercury particles.

- Gloves, safety glasses, screw cap containers, plastic bags, paper towels, and similar clean up aids.

Mercury spill clean up kits can be made in-house out of separate components or purchased from a safety equipment supplier. It is important to have the kits on hand and available for use by trained clean up crews in the facility.

A vacuum specifically for mercury can be purchased but the cost may be prohibitive for small or single facilities. Hospital groups may purchase one to share between facilities. Hospitals in a city or region could also cooperatively purchase one mercury vacuum to share. Some governmental agencies and university hazardous materials emergency response departments or companies have mercury vacuums available. Be prepared and know whom to contact before the spill occurs.

Keeping Mercury Out of the Facility

After removal of mercury sources from the facility it will be important to keep new sources from being brought into the hospital. To help keep mercury from entering the hospital, purchasing personnel need to become knowledgeable and committed to buying mercury-free items when available. It would be helpful if procedures were in place to require departments to determine and inform the purchasing department when items requested contain mercury and why available alternatives are not appropriate. Conversely, personnel involved in purchasing must continually update their familiarity with the availability and applicability of new mercury-free alternatives being developed.

CHAPTER IV
CASE STUDIES

Mercury Assessment Project History

During the month of October 1999, each of the six participating hospitals signed a commitment to join the Pollution Prevention in Healthcare Facilities Project (Project). This project, managed by the California Department of Health Services (DHS), received its first year of funding from an EPA grant and an interagency agreement with the California Department of Toxic Substances Control (DTSC). The pollution prevention (P-2) project was designed to develop a partnership of state agencies including DHS, DTSC and the California Integrated Waste Management Board, local government and members of the waste industry to assist healthcare facilities in assessing and reducing their solid and medical waste streams and eliminating sources of mercury. Top administrators at all participating facilities agreed to implement minimization strategies, commit staff and data resources, and empower assigned staff leaders to complete the project.

Project staff from DHS arrived at each facility equipped with what has come to be known as the “tool kit.” This simply consisted of a “map” of the facility listing departments where mercury was anticipated and a “checklist” of mercury-containing devices and their approximate mercury contents, by weight. The data were recorded in an Excel spreadsheet and summarized on a linked chart. Throughout the project items not on the checklist have been discovered and the listing continues to be expanded.

Mercury Assessment

Prior to conducting the mercury assessments, two one-day mercury training sessions were held at participating hospitals. Staff from other facilities participating in the project as well as representatives from the EPA, state agencies, local government, and community groups attended the training. The session consisted of a didactic presentation and a two-hour physical walk-through of the hospital. The purpose of the walk-through was to point out areas where mercury was likely to be found and the risks associated with the continued use of specific mercury-containing devices in the hospital. This concept mimicked a small portion of the actual mercury assessment that was conducted at each facility at a later date.

The mercury assessments were found to be much more thorough and effective when a limited number of people participated in conducting the assessment. A three person team was found to be an ideal number for conducting the assessments as that number did not crowd the area being surveyed or, more importantly, stifle staff interaction. Incidental comments from staff working in the area being surveyed often led to the discovery of mercury-containing devices in those areas that may have been overlooked without their input. Where larger assessment teams were used comment information from staff and supervisory personnel was reduced. The smaller team also was able to cover more areas of the facility in a rapid fashion. When smaller teams were used areas not previously targeted were surveyed in addition to the areas where staff had planned to visit. This often resulted in fewer follow-up activities by the hospital staff because a more comprehensive survey had been conducted.

The findings from the mercury assessment from each facility are noted in the following case studies. The mercury inventory for each facility is shown in a table for each case study. An accompanying Pareto Chart graphically displays the percent each category of inventoried mercury represents for the facility. This makes it easy to determine where to start taking action to begin to eliminate mercury from the hospital.

Plumbing Traps

Residual mercury from past disposal practices in hospitals has been known to collect in plumbing traps. Awareness of this fact is important since, unlike other mercury sources, the hidden mercury is unpredictable because it serves no practical purpose. Spills could result during plumbing or demolition activities if the appropriate staff does not provide secondary containment when disassembling a trap. This can easily be accomplished by placing a shallow bucket or other similar container below the plumbing traps prior to initiating disassembly of the trap. Through training of staff, the risk of uncontained contamination is greatly lessened.

Fluorescent Lighting

Obtaining an actual measurement of mercury contributed by fluorescent lighting is a formidable task. Facility 1's Engineering Department provided a complete inventory of all fluorescent fixtures, from which project staff could calculate a conversion factor of 0.57 milligrams per square foot (mg/ft^2) for use throughout the project. This was based on the premise that, due to mutual compliance with a wide variety of regulations, lighting in each of the participating hospitals could justifiably be approximated to be the same level as found at Facility 1. Effective March 7, 2000, DTSC adopted emergency regulations (the universal waste rule) that require all fluorescent tubes be either recycled or disposed of as hazardous waste.

Electrical Supplies

The electrical supply for a large facility may employ certain mercury-containing devices such as high-current service cutoff switches, relays, and mercury vapor circuit breakers. These devices are certainly not healthcare specific, and there is no substitute available. These devices, common to many large commercial and industrial facilities, are self-contained and physically isolated so as to minimize risk of mercury escape. They are also very long-lived, to the point that their replacement, and the resultant generation of waste mercury, typically occurs coincidental with other major electrical changes. If in service, recycling of these devices should be referenced in the facility plan along with the prescribed avenue for disposal.

Calculations and Quantification

For quantification of mercury contained in a particular device the project relied on several sources. Factory specifications were particularly difficult to acquire, since the project goal, mercury elimination, seemed at odds with those of the manufacturer—to market a mercury-containing product. The capacities of the two kinds of barometers found were also estimated volumetrically, by calculation from the measured heights and internal diameters of the cisterns and columns. Although no mercury was actually found, measurement of bulk mercury from plumbing traps was to be done volumetrically. After decanting off the majority of the trap aqueous liquid, the mercury and any remaining water would be poured into a graduated cylinder, the volume of the denser mercury was to be read directly.

The weight of mercury for light fixtures was based on an actual fixture inventory performed by one participant facility. The mercury per tube was taken from information published by a manufacturer of low-mercury fluorescents. This information stated that conventional fluorescent tube production technology could achieve no less than 22 milligrams of mercury per four-foot tube. Since an underestimate would be counter to the best interests of their advertising the P-2 Project accepted that number as a conservative minimum. The facility inventory yielded a multiplier of 24,156 linear feet of tube. The facility's mercury total from fluorescent light was calculated to be 133 grams. This facility contained 233,900 square feet of floor area, from which it was then calculated that the mercury in fluorescent lights was 0.57 mg/ft^2. The P-2 Project staff assumed that all hospitals would be required to meet the same lighting standards and therefore used the 0.57 mg/ft^2 factor in calculating fluorescent tube mercury for all other facilities based upon their square footage.

Business Plan

PREMISES

The 1999 Memorandum of Understanding between the EPA and the AHA targeted the year 2005 for the virtual elimination of mercury in waste streams from hospitals. This P-2 Project ascribes to that goal. The business plans for the six facilities consider three matters of fact that may impact on the processes that they may choose in eliminating mercury from their facilities.

- The practical feasibility, based on use, change-out and disposal costs and the ability to overcome resistance to new devices sometimes present in the healthcare culture may drive the rate at which change can occur.

- Certain devices or products, particularly diagnostic lab packs and multi-dose vaccines (preserved with thimerosal) are often simply not available without mercury. Mercury reduction can proceed only at a pace determined by the emergence of suitable substitutes in the marketplace.

- New earthquake standards developed by the Office of Statewide Health Planning and Development may require structural changes that include demolition or remodeling of the facility. If demolition or remodeling of the facility is undertaken, caution must be exercised for the removal of mercury-containing fixtures. Many of these mercury-containing fixtures may be presently unknown, such as mercury in plumbing traps and silent mercury light switches which are virtually indistinguishable from their non-mercury counterparts. Discovery and change-out of such fixtures where appropriate is advised, so that they are not present when demolition or reconstruction commences.

FOLLOW UP

Along with reduced use of mercury-containing items, and their removal from the hospital, comes another responsibility—that of keeping new mercury sources out. It is recommended that the Purchasing Department in each facility be educated to be alert for the possibility of reintroduction of mercury and that vendor agreements are scrutinized. In addition, other departments must be alert that devices that have been removed are not replaced with other mercury-containing devices. The laboratory must continue to use zinc-based fixatives, and to be alert for thimerosal preservatives in commercially prepared stains. Wherever possible the pharmacy should try to encourage the use of thimerosal-free vaccines. Rarely, resistance for these changes from professional staff has been observed. Administration staff at each facility however, should be ready to step in if mercury-containing devices appear at locations from where they had once been removed.

Mercury Elimination Case Study
Facility 1

FACILITY 1

Facility 1 is a 280-bed not-for-profit medical center affiliated with a Northern California non-profit health system. Facility 1 offers a full range of medical, surgical and rehabilitation services and a variety of specialty programs, including a trauma center, adult psychiatry, skilled nursing and health education and wellness classes, as well as traditional hospital services. Facility 1 includes an acute rehabilitation and transitional care center and a skilled nursing facility. The hospital was built in the mid 1950s. In its last reference year Facility 1 had approximately 9,000 admissions, conducted 6,000 surgeries and 1,000 births.

The facility's medical waste is treated off-site by steam sterilization. At the time Facility 1 became part of the project, there existed a paper and cardboard recycling program, but no active in-house P-2 committee.

Although, this facility had no formal mercury-free purchasing policy prior to this project, staff had made decisions to begin moving away from purchasing mercury-containing equipment. The facility had purchased tungsten gel bougies to replace the mercury models and had changed out a majority of its mercury sphygmomanometers. These sphygmomanometers were replaced with aneroid devices, except in areas where electronic monitoring technology has lessened the need for sphygmomanometers. The Intensive Care Unit (ICU) is an example of where such a technological changeover has occurred.

In the last year, the facility had also replaced its boiler system, and in the process, reduced the number of mercury pressure sensors (barostats) from nine to two. These barostats contain approximately 5 grams of mercury each, so the reduction, though small, would have been reflected in our data.

ASSESSMENT

The mercury assessment for this facility was preceded by a one-day mercury training session held on-site. Following the training session the actual assessment was scheduled. It was anticipated that limiting the number of participants would enhance the assessment, so only one project member joined the two hospital staff assigned to the assessment activity. This anticipation appeared to be accurate. A great amount of data was collected and areas not previously targeted were surveyed in addition to the areas where staff had planned to visit. In comparison to other facilities in the project, the depth of information acquired during this assessment definitely exceeded the norm. Assessments at facilities where there were additional participants or observers were generally not as thorough. It was noted that hospital staff were less open or candid. Incidental comment information from staff or supervisors that could lead to the discovery of otherwise unknown mercury-containing devices, generally was stifled when larger assessment teams were used at other facilities.

The initial audit process itself was accomplished in five hours. This figure does not include time required to process the raw data, or time spent in follow up of questionable or incomplete data. The session began with an initial meeting with representatives from the Environmental Services and Infection Control Departments to discuss the use of the "tool kit", and to decide (or rather to let hospital personnel decide) how it would be best employed in this specific facility. Based on experiences during a pre-survey performed by staff from the Infection Control Department a few days prior to the arrival of project staff, it was decided that appraisal was not to be done "by department" but rather simply geographically. Thus the participants were well prepared to scour the facility for undiscovered mercury-containing devices, but they also knew beforehand where a great majority of devices were likely to be found. The result was a highly time-efficient audit. The resulting raw data required some organization before processing which must be considered in the time necessary for the audit. An audit, like an inspection, is an opportunity for "fresh eyes" to see a facility. Following the assessment facility staff continued to be vigilant and reported late findings, which included a one-pound container of mercury for sphygmomanometer maintenance. This mercury had been easily overlooked originally, for it was in a very small container—a pound of mercury is just over 33 cubic centimeters.

The Laboratory and Engineering Departments completed their own inventories. The Laboratory Department reported information on fixatives and stains, and the Engineering Department developed and completed an inventory of fluorescent fixtures located in the facility.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 1. Because this data contains many approximations, it has carefully been presented so as to reflect a precision of only two significant figures. The P-2 Project staff feel this is justified, as there is a range of several orders of magnitude among classes of data.

As may be seen on the accompanying Pareto Chart (Chart 1), the on-site mercury profile revealed a strong emphasis on gastroenterological (GI) devices. One major reason for this was that old mercury bougies were still in use pending the arrival of newly purchased tungsten gel bougies. The primary locations housing the older bougies were the operating rooms and outpatient surgery. GI devices represented approximately 62 percent of the facility's total mercury, or nearly 7.2 kilograms of mercury.

Sphygmomanometers made up the next highest percentage of mercury in the facility. In-place mercury sphygmomanometers make up slightly over 15 percent of all facility mercury, a total of 2.4 kilograms. Most of the mercury sphygmomanometers were found in the Coronary Care and Intensive Care Units, while some were found in Outpatient Surgery and the Emergency Room.

Two individual significant sources of mercury were counted together (as “non-clinical”) solely on the basis of their size and location not directly related to clinical activities. The Engineering Department houses a sphygmomanometer service kit including bulk mercury, a total of 1.6 kilograms. This quantity of mercury is necessary only if mercury sphygmomanometers are in use in patient care areas. The Blood Gas Laboratory also used a mercury barometer, containing 0.8 kilograms. The barometer is used to correct blood gas measurements for variation in atmospheric pressure.

Mercury in fluorescent tubes used for lighting represented less than 1 percent of in-house mercury, about 133 grams. This mercury is contained in fluorescent tubes and would only be released if the tubes were broken. The Engineering Department retains original packing sleeves and boxes, and compacts intact boxes of used tubes for disposal. Effective March 7, 2000, DTSC adopted emergency regulations that require all fluorescent tubes be either recycled or disposed of as hazardous waste. Recycling this waste stream would bring the facility into compliance with this new regulation while also reducing this mercury waste stream.

X-ray machines also typically contain small mercury leveling switches, intended to assure that the X-ray beam is perpendicular to the film. These account for approximately three to four grams per machine, and are included in the Pareto Chart as switches. Also present are laboratory stains and dyes that contain minute quantities of mercury. Certain pharmaceuticals may contain a small percentage (0.1 to 1.0%) of mercury as a preservative. These combined were estimated to total less than ten grams of mercury.

Information elicited from the house plumbers indicated that approximately ten traps had been removed within the past year, none of which contained any mercury. However, it remains possible that there could be a significant amount of mercury in the traps within the facility.

The electrical supply was evaluated to determine if mercury-containing devices such as high-current cutoff switches, relays or mercury vapor circuit breakers were in use. Such devices have been mentioned in many mercury elimination lists, but were not found to be in place at Facility 1 during the audit.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 1 are entered below in the same order as they are shown in Chart 1. As can be seen from the cumulative percent plot on that chart, replacement with non mercury-containing items for the first three classes of devices shown as: (GI Devices, Sphygmomanometers, and the “non-clinical” class (barometer and bulk mercury) will result in a greater than 99 percent reduction of the mercury inventoried, at Facility 1.

- **Bougies.** Facility 1 has already earmarked mercury bougies for replacement with tungsten gel devices. The mercury bougies should be returned to the manufacturer according to existing protocol when their service date is reached. The cost to replace a set of bougies is approximately $3,000. Because the hospital has already replaced one of its two sets of bougies, the total expense for bougie replacement would be $3,000.
- **Other GI:** Non-mercury substitutes for many other gastroenterologic devices are in place. Blakemore tubes which use a dense rubber end, rather than a mercury-weighted end, are available to replace the four mercury-containing tubes that were inventoried. Their individual cost is $202; total replacement would be $808.
- **Sphygmomanometers:** The survey revealed that Facility 1 had replaced all but about 30 of its mercury sphygmomanometers. Replacement of the remaining sphygmomanometers is expected to continue and should not cost more than $148.50 per unit. The total amount required to implement this portion of the Business Plan would be $4,455. Proprietary exchange agreements are available that will take care of the disposal of removed mercury units and recycling of the mercury. Facility 1 should explore the feasibility of using such an arrangement for replacing their mercury sphygmomanometers.
- **Barometer:** Replacement of the mercury barometer with a one-millibar precision aneroid unit should not cost more than $250.
- **Engineering bulk mercury:** Removal of the bulk mercury kept for sphygmomanometer maintenance may be included in the sphygmomanometer exchange agreement. Otherwise it may be consolidated with any mercury obtained from sink traps and sent for recycling.
- **Other Engineering mercury devices.** This class consists of fluorescent tubes (plotted separately), and switches (including barostats). The four mercury thermostats should be replaced. Solid state control and limit sensors providing steam pressure control are available on the market to replace the two remaining mercury pressure sensors. The six boiler-level control valves (McDonald valves) will cost $400 each to replace. The price is similar for pressure control switches. Room thermostats cost approximately $35, there are four of these at this facility. Total cost to the hospital for switching replacement will be approximately $3,340.
- **Thermometers:** Alcohol/spirit thermometers are available for all but the highest temperature applications. Liquid buffered appliance thermometers

cost approximately $20. Laboratory thermometers average $30. The cost to replace the two refrigerator and seven laboratory thermometers would be approximately $250.

- **Pharmaceutical:** No pharmaceuticals with mercury as an active ingredient were found in the pharmacy. A preservative for the replacement of thimerosal is not yet available. Unit doses (requiring no preservative) if feasible, are the recommended alternative. Minimize stock by applying “just-in-time” inventory practices.
- **Laboratory:** Bulk mercury-containing fixatives are not present. “Test Packs”, made to perform a single test, and containing thimerosal, are in use, and there is no substitute available. Minimize stock by applying “just-in-time” inventory practices.
- **Traps:** Sink and hopper traps should be opened and cleaned. Mercury remaining after decanting water present should be consolidated and recycled.

REPLACEMENT EXPENSES

The total cost to replace all of the mercury devices found at Facility 1 would be approximately $12,103.

ATTACHMENTS

CHART 1. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 1. Mercury assessment data. Facility 1.

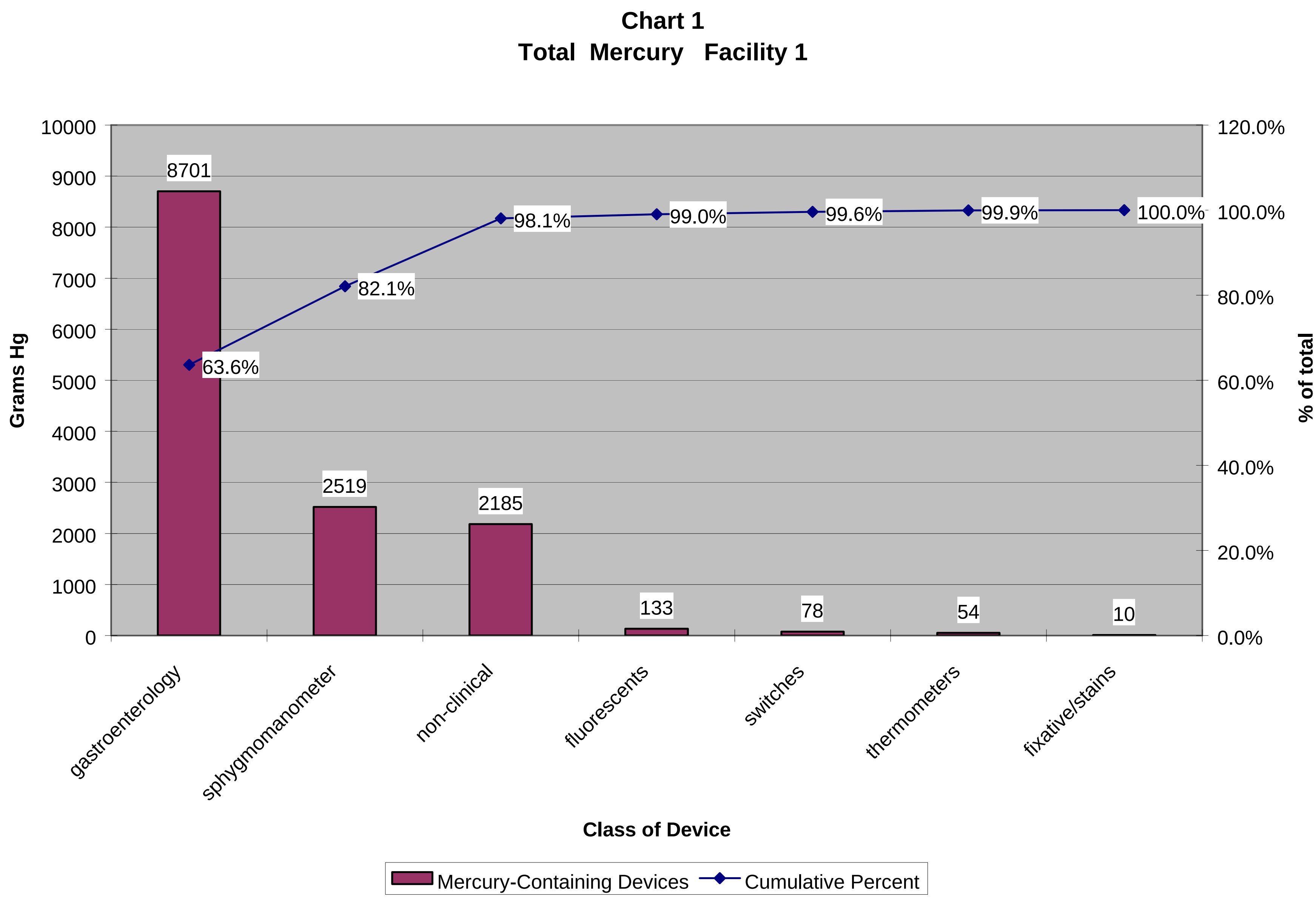


Chart 1
Total Mercury Facility 1
Grams Hg
% of total
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
8701
2519
2185
133
78
54
10
63.6%
82.1%
98.1%
99.0%
99.6%
99.9%
100.0%
gastroenterology
sphygmomanometer
non-clinical
fluorescents
switches
thermometers
fixative/stains
Class of Device
Mercury-Containing Devices
Cumulative Percent

Facility name Facility 1

Mercury Assessment Work Sheet

Survey Date February 7, 2000

		Count or Unit of Measure												
Hg Item	grams per unit	dialysis	pre-op	CCU	psych rec room	nursery, OB/GYN	emergency, ICU, outpatient surgery	engineering, laboratory	supply	subtotal (grams)	source class	class total	% of total	cumulative %
bougies, set	454.0	gm/pound	10	pounds			9	pounds		8,626				
Cantor tube	15.0						1			15				
Blakemore tube	15.0						4			60				
											gastro-enterology	8,701	63.6%	63.6%
Baum sphygmomanometer	83.0			11		1	1			1,079				
Trimline sphygmomanometer	70.0						8			560				
Empire sphygmomanometer	90.0						8			720				
desktop sphygmomanometer	80.0						2			160				
											sphygmo-manometer	2,519	18.4%	82.0%
bulk Hg, Lb.	454.0	gm/pound					1.8		1.3	1,385				
barometer	800.0						1			800				
											non-clinical	2,185	16.0%	98.0%
fluorescents	0.57	mg/sq ft						233,900	sq ft	133				
											fluorescents	133	1.0%	99.0%
boiler level switches	4.0							6		24				
thermostat (wall)	3.0				4					12				
boiler barostat	5.0							2		10				
X-ray tube	4.0		2	2		2	2			32				
											switches	78	0.6%	99.5%
refrigerator thermometer	1.0	1	1							1				
fever thermometer	0.5					50				25				
laboratory thermometer	4.0						7			28				
											thermometer	54	0.4%	99.9%
fixatives and stains	0.1%							10,000	ml	10				
											fixatives and stains	10	0.1%	100.0%
								TOTAL Hg	(grams)	13,680		13,680		

Prepared by the California Department of Health Services

Table 1

Mercury Elimination Case Study
Facility 2

FACILITY 2

Facility 2 is a 205 bed comprehensive pediatric medical center supporting, in addition to patient care, nationally recognized pediatric teaching and research programs. One of only 45 freestanding children's hospitals in the nation, Facility 2 serves as both the medical "safety net" and pediatric medical center in its region with specialized staff and facilities to treat rare illnesses and complex problems. During its last reference year, Facility 2 had nearly 9,000 inpatient admissions while its specialty outpatient clinics received more than 165,000 outpatient visits. As a regional referral center, Facility 2 treated patients from 56 of California's 58 counties during the same period.

The facility's medical waste is treated on-site by steam sterilization. Sharps, pathology waste and chemotherapy waste are treated off-site. At the time the facility became part of the project, its recycling program had been discontinued and there was no active in-house P-2 committee.

Although, this facility had no formal mercury-free purchasing policy prior to this project, it had made decisions to begin moving away from purchasing mercury-containing equipment. Facility 2 had used an aneroid barometer to replace a mercury barometer and a majority of the mercury sphygmomanometers had been changed out. These sphygmomanometers were replaced with aneroid devices. Most significantly, Facility 2 was the only acute care facility that had completed change-out of mercury-weighted esophageal dilators with tungsten gel dilators. As a result, their total mercury found during the audit was less than one-fifth that of other facilities participating in the P-2 Project.

ASSESSMENT

Based on experience at another project facility, it was determined that this assessment should be performed by a limited number of people. The actual mercury assessment was conducted on March 7, 2000. Two project members and one hospital representative conducted the mercury audit. A great amount of data was collected and areas not previously targeted were surveyed in addition to the areas where staff had planned to visit. Floor staff provided a great deal of candid and valuable information.

The initial audit process itself was accomplished in approximately five hours. This figure does not include time required to process the raw data, or time spent in follow up of questionable or incomplete data. The session began with an initial meeting with the facility Safety Officer to discuss the use of the "tool kit", and how it would best be employed in this specific facility. The appraisal was not organized geographically, but with recognition of unique department characteristics. The result was a highly time-efficient audit. The resulting raw data required some organization before processing which must be considered in calculating the total time necessary for the audit. The process at Facility 2 was particularly comfortable for both assessor and the hospital's representatives, to the point that, during lunch, staff from various departments came up to the Safety Officer and volunteered leads to mercury devices in their departments. The facility bioengineer also contributed the following very useful information: Since1974 and until very recently, Federal Regulation (21 CFR Part 1020) has required automatic beam leveler switches to be present in virtually all x-ray machines. This system, known as positive beam limitation (PBL), uses four miniature mercury switches to assure perpendicularity between the x-ray beam and the film, thus reducing artifact. The total mercury quantity is small.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 2. Because this data contains many approximations, it has carefully been presented so as to reflect a precision of only two significant figures. As may be seen on the accompanying Pareto Chart (Chart 2), the on-site mercury profile revealed the major component to be "non-clinical" devices—so-called because they tend to stay at one location and do not directly affect patient care. At Facility 2 that class consisted solely of a small barometer and the mercury in the sphygmomanometer repair kit. The barometer is used to correct blood gas measurements for variation in atmospheric pressure. This source represented 59 percent of the facility's total mercury, or about 1.7 kilograms of mercury. The amount of mercury found during the audit at Facility 2 was the lowest of all the participating hospitals in the project. One major reason for the difference from other facilities was that the mercury bougies had been returned to the manufacturer prior to the audit and only tungsten gel bougies were in use.

Sphygmomanometers made up the next highest percentage of mercury in the facility. Mercury sphygmomanometers made up roughly 30 percent of all facility mercury, a total of about 1 kilogram. Most of the mercury sphygmomanometers were found in the Pulmonology, Pediatric Rehabilitation, and Pulmonary Function Departments. Three out-of-service sphygmomanometers were located. Mercury was carefully drained for recycling from a mobile stand sphygmomanometer found in the Engineering Department. The empty sphygmomanometer was given to staff of the P-2 Project and named "Sylvester Sphygmomanometer" for the project's future education presentations.

The common conversion factor of 0.57 mg/ft^2 developed by the P-2 Project to approximate the mercury contributed by fluorescent lighting was used to estimate the mercury from this source at Facility 2. At 390,000 square feet of space for the facility, the amount of mercury calculated represented slightly more than seven percent of the mercury inventoried at Facility 2. This relatively large percentage must be viewed from the perspective that Facility 2 had a total mercury inventory of less than one-fifth the average inventory of all the hospitals in the project. The assessment at Facility 2 also revealed a total of 101 thermometers, mostly in laboratory use, representing about 3 percent of the total mercury found at the facility.

At Facility 2 the small amount of mercury contained in X-ray machines in leveling switches has been shown in the data. Mercury from the X-ray machines was eight grams per machine. Also present are laboratory stains and dyes that may contain minute quantities of mercury . Certain pharmaceuticals may contain a small percentage (0.1 to 1.0%) of mercury as a preservative in each product. These combined were estimated to total less than ten grams of mercury.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 2 are entered below in the same order as they are shown in Pareto Chart 2. At this facility it was found that, due to their advanced stage of mercury reduction, fluorescent lighting—an essential feature—represented a very significant proportion of the mercury source. This contrasts with other facilities, which averaged, less than one percent mercury from fluorescents due to the higher percentages of higher volume mercury sources. Because eliminating lighting fixtures is not an option, that information was excluded from the facility's Pareto chart.

Left with the remainder of the mercury sources, the cumulative percent plot on the Pareto chart indicates that replacement of the first three classes of devices; Non Clinical, Sphygmomanometers and Thermometers with non-mercury-containing items would result in reduction of nearly 98 percent of the mercury inventoried at Facility 2. The remaining mercury is found in the positive beam limitation switches in the X-ray machines.

- **Barometer:** Replacement of the mercury barometer with a one-millibar precision aneroid unit should not cost more than $250.
- **Engineering bulk mercury:** Removal of the bulk mercury kept for sphygmomanometer maintenance may be included in the sphygmomanometer exchange agreement. Otherwise it may be consolidated with any mercury obtained from sink traps and recycled. It would not need to be replaced because there would be no sphygmomanometers to be serviced.
- **Sphygmomanometers:** The survey revealed that Facility 2 had replaced all but a dozen of its mercury sphygmomanometers. Continued replacement is expected, and should not cost more than $148.50 per unit, or $ 1,782. The existing exchange agreement with Welch Allyn/Tycos will take care of the disposal of removed mercury units and recycling of the mercury.
- **Other Engineering mercury devices.** This class consists of fluorescent tubes and switches (including barostats). Solid state control and limit sensors

providing steam pressure control are available on the market to replace mercury pressure sensors.

- **Thermometers:** Alcohol/spirit thermometers are available for all but the highest temperature applications. The cost of a laboratory thermometer averages $30. The cost to replace the 37 laboratory thermometers would be approximately $1,110.
- **X-Ray tubes: The** Positive Beam Limitation (also know as automatic collimation) switches may be overridden by the operator. This fact led to the suggestion by one technician that, since they are no longer required by regulation, they may simply be removed and need not be replaced.

REPLACEMENT EXPENSES

The total cost to replace all of the mercury devices found at Facility 2 would be approximately $3,142.

ATTACHMENTS

CHART 2. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 2. Mercury assessment data. Facility 2.

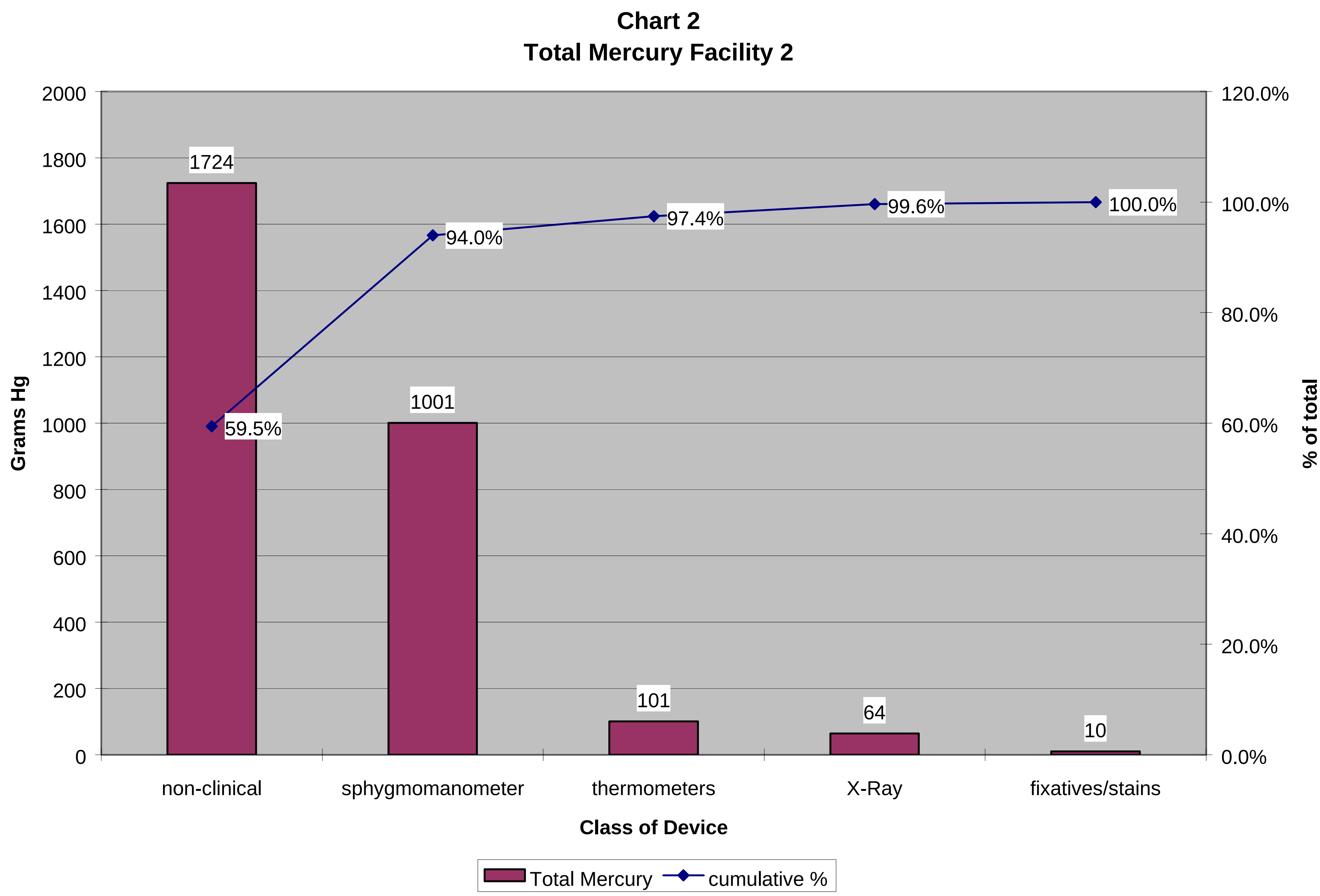


Chart 2
Total Mercury Facility 2
Grams Hg
% of total
2000
1800
1600
1400
1200
1000
800
600
400
200
0
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
1724
1001
101
64
10
59.5%
94.0%
97.4%
99.6%
100.0%
non-clinical
sphygmomanometer
thermometers
X-Ray
fixatives/stains
Class of Device
Total Mercury
cumulative %

Facility name Facility 2

Survey Date March 7, 2000

Mercury Assessment WorkSheet

Hg Item	grams/unit	Count or Unit of Measure: laboratory	bioengineering	pediatric ICU	Day Stay	special hemotology	pulmonology	pediatric rehab	pulmonary function	medical surgical	subtotal (grams)	source class	class total	% of total	cumulative %
barometer	816.0								1		816				
sphygmomanometer repair kit	454	gm/pound	2	pounds							908				
												non-clinical	1724	55.2%	59.5%
trimline sphygmo-manometers	70.0		1				2		3		420				
baum sphygmo-manometer	83.0						2	2	1	2	581				
												sphygmo-manometers	1001	32.1%	94.0%
thermometers															
fever	0.5					3				2	3				
small lab	2.0	22				2					48				
laboratory	4.0	9			1						40				
mini-max	2.0	3			2						10				
												thermometers	101	3.2%	97.4%
lighting															
hospital	0.57	mg/sq ft	275,000	sq ft							157				
outpatient	0.57	mg/sq ft	115,000	sq ft							66				
												fluorescents	222	7.1%	excluded, see text
X-ray tube	2.0		32								64				
												X-ray	64	2.1%	99.6%
fixatives and stains	0.1%	10,000									10				
												fixatives and stains	10	0.3%	100.0%
									TOTAL Hg	(grams)	3122		3,122		

Prepared by the California Department of Health Services

Table 2

Mercury Elimination Case Study
Facility 3

FACILITY 3

Facility 3 is a highly complex healthcare institution known for its integration of medical research and clinical care for the benefit of patients. Healthcare professionals provide a broad spectrum of services from routine exams to highly specialized diagnosis and treatment. Facility 3 provides outpatient services in more than 75 specialty areas, and primary care at two medical campuses as well as at satellite facilities in the greater San Francisco Bay Area.

The Clinical Laboratories provide services to the 460-bed facility where they are located and to a related medical center. The Laboratory also serves as a reference laboratory to various hospitals in the northern California area for some of the more esoteric tests such as factor assays and activity levels, and molecular diagnostic tests such as Huntington's and Fragile X. The Clinical Laboratories include the Departments of Chemistry-Immunology, Hematology, Microbiology, Blood Bank, and Blood Donor Center. The Laboratories employ approximately 200 medical staff, technologists, laboratory assistants, and clerical personnel. In Fiscal Year 1998-99 the Laboratory performed approximately 2,700,000 tests.

Much of the Laboratories' medical waste is treated on-site (in laboratory autoclaves) by steam sterilization, which may be disposed of as solid waste. At the time Facility 3 became part of the project, it boasted a well-developed recycling program including paper, glass, aluminum, cardboard and laboratory glassware, under the oversight of a full-time recycling coordinator.

As early as seven years prior to joining this project, Facility 3 had made decisions to begin moving away from purchasing mercury-containing equipment. Results apparent in the Laboratories included a definite movement toward the use of alcohol/spirit thermometers and the virtual absence of mercury-containing fixatives and stains. A discussion of the other mercury-containing devices which remained may be found below.

ASSESSMENT

The initial audit process at Facility 3 was accomplished in about three hours. This figure does not include time required to process the raw data, or time spent in follow up with questions regarding the completeness of the data. The session began with an initial meeting with the Director of Environmental Services the Director of Environmental Health and Safety and their staff to explain the use of the “tool kit”, and to discuss how to best utilize it in this limited venue. Each of the laboratory chiefs was interviewed, after which laboratory staff helped project staff find mercury sources in their particular areas. The result was a concisely-organized and thorough audit. The raw data required some organization before processing which must be considered in assessing the total time necessary for the audit.

Participants at the assessment were limited to two project staff and the minimum (at times one or two) staff from Facility 3 to provide access to essential laboratory personnel. Limiting the number of participants conducting the assessment appeared to facilitate obtaining the cooperation of busy laboratory personnel. The process went very smoothly at Facility 3 partially because the Environmental Health and Safety Director, by his presence, tacitly delegated his authority to inspect to the project staff. Project staff were thus allowed to inspect areas without being directed by laboratory management, and as a result, unforeseen mercury-containing devices were added to the inventory. Follow-up data came both from the Laboratories and the Engineering Department. Data for fluorescent lighting was calculated from square footage using the uniform multiplier developed as part of the project.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 3. As may be seen on the accompanying Pareto Chart (Chart 3), the on-site mercury profile revealed the vast majority (nearly 2 kilograms, 88%) of the mercury in the laboratories was contained in the barometer. Another nine percent was found in the mercury thermometers. The assessment encountered virtually no alcohol/spirit thermometers, although the manager acknowledged that they would be just as accurate except at the highest of temperatures. An unusually high proportion (2%) of the total mercury at the Clinical Laboratories was contributed by three large mercury-switched barostats, which maintain constant vacuum in the vacuum system.

Mercury in fluorescent tubes used for lighting represented roughly 0.5 percent of total mercury, less than 10 grams. These tubes are collected by Environmental Services and recycled. Also of note is the absence of preservatives in laboratory stains and dyes consisting of small percentages of mercury. These are formulated on site by the laboratory itself, and hence contain no such preservative.

Even though Facility 3 had the highest use of an electrical supply in the project (14 megawatts), they had no mercury-containing devices such as high-current service switches, relays and/or mercury vapor circuit breakers. The Engineering Department of Facility 3 confirmed this fact in response to an inquiry by project staff made during the assessment.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 3 are entered below in the same order as they are shown in Chart 3. As can be seen from the cumulative percent plot, replacement of the first three classes of devices on that chart (the barometer, thermometers, and barostats) with non mercury-containing items will result in a greater than 99 percent reduction of the mercury inventoried at Facility 3.

- **Barometer:** Replacement of the mercury barometer with a one-millibar precision aneroid unit should cost no more than $250.
- **Thermometers:** Alcohol/spirit thermometers are available for all but the highest temperature applications. Liquid buffered appliance thermometers cost approximately $20. Laboratory thermometers average $30. The cost to replace the 53 refrigerator and 25 laboratory thermometers would be approximately $1,810.
- **Barostats:** Electronic pressure sensing and switching devices are readily available on the market. An average non-mercury vacuum control switch will cost $400. Replacement of the three barostats would cost approximately $1,200.
- **Laboratory:** Bulk mercury-containing fixatives are not present. “Test Packs,” made to perform a single test, and containing thimerosal, are in use, but there is no substitute available. Minimizing stock would maintain mercury at the minimal quantity.
- **Traps:** A facility-wide schedule for opening and cleaning sink and hopper traps should be implemented. Mercury remaining after decanting water present should be consolidated and recycled.

REPLACEMENT EXPENSES

The total cost to replace all of the mercury devices found at Facility 3 would be approximately $3,260.

ATTACHMENTS

CHART 3. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 3. Mercury assessment data for Facility 3.

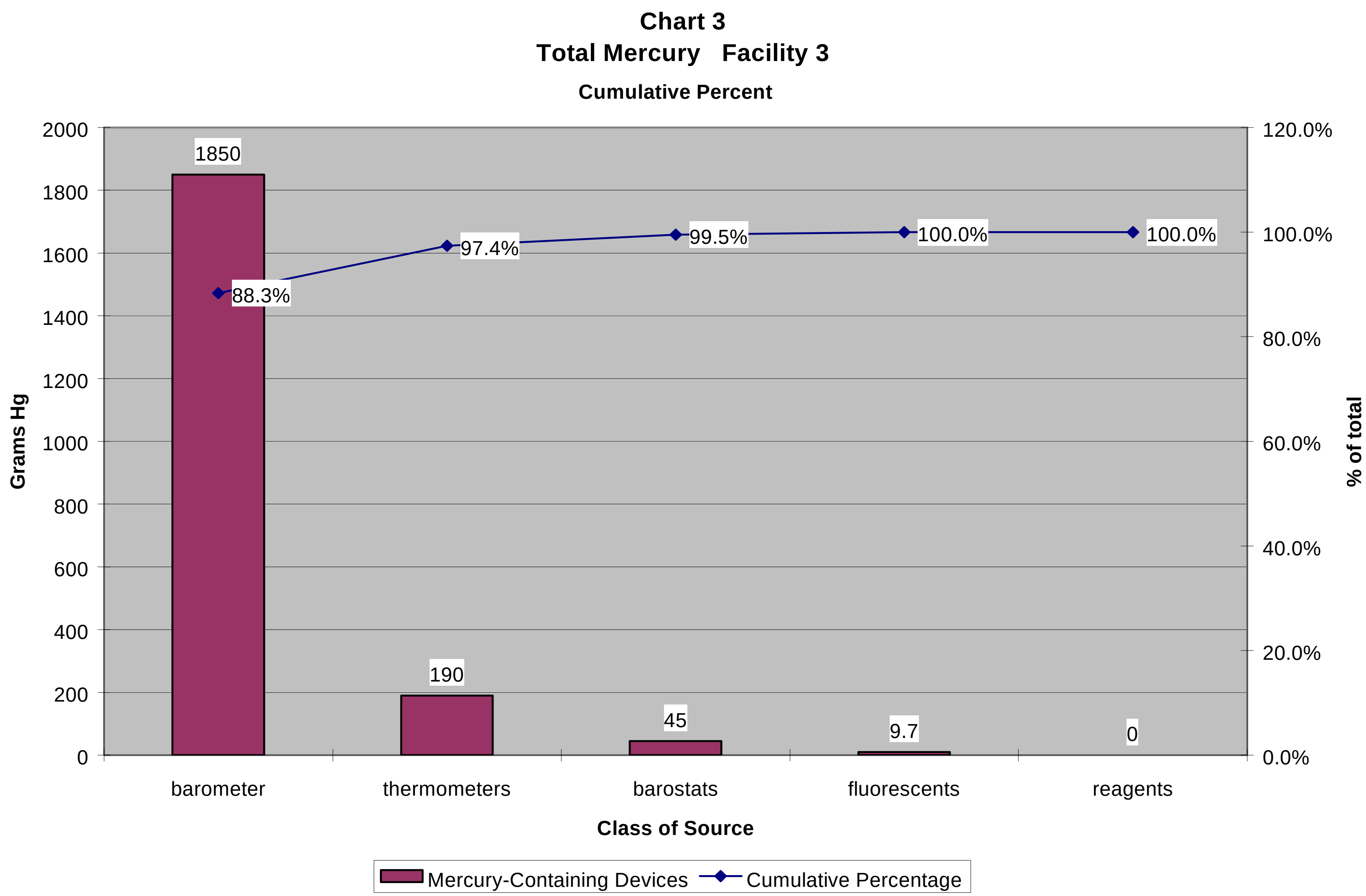


Chart 3
Total Mercury Facility 3
Cumulative Percent
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Grams Hg
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
% of total
1850
190
45
9.7
0
88.3%
97.4%
99.5%
100.0%
100.0%
barometer
thermometers
barostats
fluorescents
reagents
Class of Source
Mercury-Containing Devices
Cumulative Percentage

Mercury Assessment WorkSheet

Facility name Facility 3 (Clinical Laboratories)

Survey Date March 6, 2000

Hg Item	grams/unit	Count or Unit of Measure				subtotal (grams)	source class	class total	% total	cumulative %
		Laboratories								
barometer	1,850.0	1				1,850.0				
							barometer	1,850.0	88.3%	88.3%
6 inch thermometer	2.0	53				106.0				
10 inch thermometer	6.0	4				24.0				
4 inch thermometer	2.0	16				32.0				
7 inch thermometer	4.0	1				4.0				
12 inch thermometer	6.0	4				24.0				
						0.0	thermometer	190.0	9.1%	97.4%
vacuum system barostat	15.0	3				45.0				
						0.0	barostats	45.0	2.1%	99.5%
fluorescent lighting	0.57	mg/ sq ft	17,000	sq ft		9.7				
							fluroescents	9.7	0.5%	100.0%
fixatives and stains			0.0			0.0				
immunoassay reagent packs			not reported							
							reagents	0.0	0.0%	100.0%
				TOTAL Hg	(grams)	2,094.7		2,094.7		

Prepared by the California Department of Helath Services Table 3

Mercury Elimination Case Study
Facility 4

FACILITY 4

Facility 4 is a 321-bed acute care facility and designated trauma center for Contra Costa County and portions of Solano County. Recognized as one of the region's premier health care providers, areas of distinction include high and low risk obstetrics, neurosciences, orthopedics, cardiac care and cancer care.

The facility's medical waste is treated on-site by steam sterilization. Sharps, pathology, chemotherapy and pharmaceutical waste are all incinerated off-site. Facility 4 has had a cardboard recycling program with Pacific Rim Waste Management since prior to joining the project.

Although, this facility had no formal mercury-free purchasing policy prior to this project, it had made decisions to begin moving away from purchasing mercury-containing equipment. Plans to implement change-out of all mercury sphygmomanometers had not yet been implemented. Throughout the hospital there had been a significant conversion to alcohol/spirit thermometers. The only remaining mercury thermometers were the reference thermometers in the laboratory.

ASSESSMENT

For the assessment at Facility 4, arrangements were made for a limited number of representatives of other agencies from federal, state and local government to be observers of the process. Two project members also joined the Director of Environmental Services, one of his staff, the facility's Chief Engineer, and the Laboratory Manager in conducting the mercury assessment. Although the facility staff manifested strong motivation to contribute the best possible data and items were unearthed in bioengineering not found at other facilities, the structure necessary to maneuver a larger group through the facility impeded spontaneity. The result of the large group participating in the assessment was a lack of "depth" in the database, necessitating numerous follow up calls.

The initial audit process itself was accomplished in about six hours. This figure does not include time required to process the raw data, or time spent in follow up of questionable or incomplete data. Based on our experiences during previous surveys at other facilities the assessment was organized "by department" but structured geographically. This was accomplished by having a significant amount of data returned to project staff after the audit by the Laboratory and Engineering Departments. Staff from Facility 4 continued to make themselves available to discuss findings, including the provision by the Laboratory of a detailed inventory of "test packs"—individually prepared reagents in minute amounts for the single performance of a specific test. These data, along with thimerosal-preserved pharmaceuticals, were deemed representative and support their being characterized throughout the project as below threshold levels.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 4. As may be seen on the accompanying Pareto Chart (Chart 4), the on-site mercury profile for Facility 4, like that of most other facilities, revealed a strong emphasis on GI devices. Mercury bougies were still in use in the Surgery Department and a single Blakemore tube was available in the Emergency Room. No other mercury-weighted GI devices were observed. The 11.4 kilograms of mercury found from these sources represented approximately 29 percent of the in-house mercury inventoried.

Since the facility had not yet begun to implement its change-out of sphygmomanometers, these devices made up the highest percentage of mercury in the facility. In-place mercury sphygmomanometers make up two-thirds of the facility's mercury, a total of 25 kilograms. Most of the mercury sphygmomanometers were found in the Coronary Care and Intensive Care Units, while a few were found in Outpatient Surgery and the Emergency Room.

Two individual significant sources of mercury were counted together (as "non-clinical") solely because they were both large single sources, in locations not directly related to clinical activities. The Engineering Department houses a sphygmomanometer service kit including bulk mercury, a total of 1.6 kilograms. This quantity of mercury is necessary only if mercury sphygmomanometers are in use in patient care areas. The Blood Gas Laboratory also used a mercury barometer containing 0.8 kilograms of mercury. The barometer was being used to make corrections to blood gas measurements to allow for variation in atmospheric pressure.

Obtaining an actual measurement of mercury contributed by fluorescent lighting is a formidable task. For this study, it was deemed appropriate to assign a common conversion factor for use throughout the project. Because each hospital must comply with the same regulations, mercury in lighting was approximated to be 0.57 mg/ft^2. The size of Facility 4 is 368,000 square feet using this approximation the mercury in the facility's fluorescent lighting was calculated to be about 210 grams. This represented less than 1 percent of in-house mercury inventoried.

X-ray machines often contain small mercury leveling switches to assure that the X-ray beam is perpendicular to the film. These account for approximately three to four grams per machine. The number of X-ray machines containing these switches was not available from this facility.

Laboratory stains and dyes may contain minute quantities of mercury used as preservative. The Laboratory Manager of Facility 4 provided the project with a great deal of specific information on laboratory immunoassay single test "test packs", containing thimerosal mercury in the microgram range which clearly showed this contribution was quantifiable, but very small. Certain pharmaceuticals also contain a small percentage (0.1 to 1.0%) of mercury as a preservative in each product. These combined were estimated to total less than ten grams of mercury.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 4 are entered below in the same order as they are shown in Chart 4. As demonstrated by the cumulative percent plot, replacement of the first three classes of devices shown as: Sphygmomanometers, GI Devices and the "non-clinical" class (barometer and bulk mercury) with non mercury-containing items will result in a greater than 99 percent reduction of mercury inventoried.

- **Sphygmomanometers:** The survey revealed that Facility 4 had in place 309 mercury sphygmomanometers. Their replacement is anticipated and should cost no more than $148.50 per unit. The total amount required to implement this segment of the Business Plan would be $ 45,886.50. Proprietary exchange agreements are available that will take care of the disposal of removed mercury units and recycling of the mercury. Such an arrangement for replacing their mercury sphygmomanometers should be explored.
- **Bougies:** This facility has earmarked mercury bougies for replacement with tungsten gel devices. Arrangements should be made with the manufacturer to exchange mercury bougies when their service date expires. The cost to replace one set of bougies is approximately $3,000. Total expense for replacement of the two sets of bougies at this facility would be approximately $6,000.
- **Other GI:** Non-mercury substitutes for many other gastroenterologic devices are in place. A Blakemore tube with a dense rubber end, rather than a mercury-weighted end, is available as a replacement. Replacement of one Blakemore tube would be $202.
- **Barometer:** Replacement of the mercury barometer with a one-millibar precision aneroid unit should cost no more than $250.
- **Engineering bulk mercury:** Removal of the bulk mercury on site for sphygmomanometer maintenance should be included in the sphygmomanometer exchange agreement.
- **Other Engineering mercury devices:** This class consists of fluorescent tubes and a small number of mercury tip switches on patient devices. Electronic replacements for the latter are bound to be developed under current market pressure. The facility is presently actively seeking vendors that will provide recycling of their fluorescent tubes.

REPLACEMENT EXPENSES

The total cost to replace all of the mercury devices found at Facility 4 would be approximately $52,338.

ATTACHMENTS

CHART 4. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 4. Mercury assessment data for Facility 4.

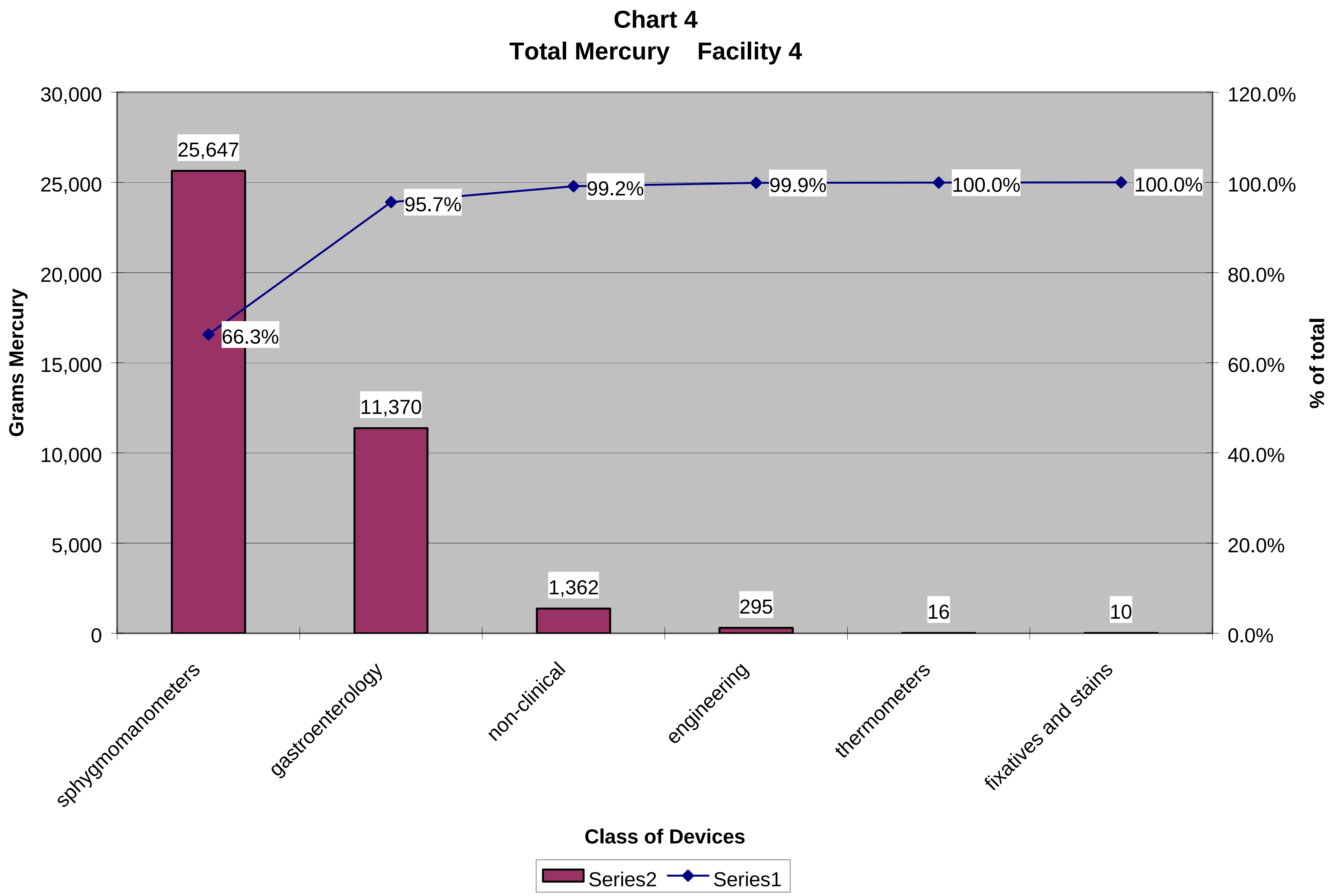


Chart 4
Total Mercury Facility 4
30,000
25,000
20,000
15,000
10,000
5,000
0
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Grams Mercury
% of total
25,647
11,370
1,362
295
16
10
66.3%
95.7%
99.2%
99.9%
100.0%
100.0%
sphygmomanometers
gastroenterology
non-clinical
engineering
thermometers
fixatives and stains
Class of Devices
Series2
Series1

Facility name Facility 4

Survey Date March 12, 2000

Mercury Assessment WorkSheet

Hg Item	grams/unit		Count or Units of Measurement: engineering	patient floors	surgery	mobile sphygmo-manometers	laboratories	(subtotal)	source class	class total	% of total	cumulative %
Baum Sphygmomanometerss	83.0			277	17	15		25,647				
									sphygmo-manometers	25,647	66.3%	66.3%
bougies	454.0	gm/pound			25	pounds		11,350				
Blakemore tube	20.0				1			20				
									gastro-enterology	11,370	29.4%	95.7%
barometer	817						1	817				
sphygmomanometer repair kit	454.0	gm/pound	1.2	pounds				545				
									non-clinical	1,362	3.5%	99.2%
Seaabrook heating pads	2.0		20					40				
fluorescents	0.57	mg/sq ft	368,000	sq ft				210				
boiler controls	5.0		9					45				
									engineering	295	0.8%	99.9%
refrigerator thermometers								0				
reference thermometers	8.0						2	16				
								0	thermomometer	16	0.0%	100.0%
fixatives and stains	0.1%						10,000	10				
									fixatives and stains	10	0.0%	100.0%
						Total	(grams)	38,700		38,700		

Prepared by the California Department of Health Services Table 4

Mercury Elimination Case Study
Facility 5

FACILITY 5

Facility 5 is a 229-bed, 254,000 square foot member of a national health maintenance organization. It provides conventional services including Ob/Gyn, Pediatrics, Surgery, Radiology, Oncology, Med/Surg and has an Intensive Care Unit (ICU). It also provides considerable outpatient services, and its pharmacy serves both hospitalized and ambulatory patients.

The facility's medical waste is treated off-site by steam sterilization. At the time the facility became part of the P-2 Project, an extensive recycling program had been in place for approximately six years. Recycled materials included plastics (HDPE), mixed paper, glass, and cardboard. The facility has a cardboard bailer and ships approximately five bales of cardboard per week for recycling. There has been an active in-house P-2 committee since 1999.

The P-2 committee is made up of several small groups of volunteer representatives of different operational segments of the facility who meet periodically during their lunch break. Common to all groups is the head of Facility Services, and participating in one or more of the groups are the Environmental Health and Safety Manager and representatives of the Recycling Team and Infection Control.

Facility 5 has had a mercury elimination program in place since 1994 and has purchased no mercury-containing products for which there was a satisfactory substitute since that time. The facility is also a Greenlights partner. Its fluorescent tubes are recycled by SafetyKleen or Salesco. Recently, the facility replaced, but had not yet disposed of, some mercury barostats in its boiler system.

ASSESSMENT

The mercury assessments for the project were preceded by a one-day mercury training session held in January 2000. Unfortunately, Facility 5 staff were unable to join this session. Project staff felt that this may have been an obstacle because staff from the other hospitals in the project who received the training appeared to be well-prepared to audit their facilities.

The facility assessment for Facility 5 took place March 17, 2000. Limiting the number of participants to only one or two project members and two hospital staff was not possible, and as a consequence, the group was too large to be allowed into many clinical areas. Instead, the Environmental Health and Safety Manager went into each area alone and counted mercury-containing devices. Incidental comments or information from staff and supervisors from the areas being assessed was limited because such contact was precluded by the size of the group. Ultimately, considerable follow-up with the Environmental Health and Safety Manager resulted in what project staff believes to be an accurate and thorough survey.

The initial audit process itself was accomplished in five hours. This figure does not include time required to process the raw data, or time spent in follow up of questionable or incomplete data. The session began with an initial meeting with the facility Environmental Health and Safety Manager—whose duties include hazardous materials management—to discuss the use of the "tool kit" and to determine how it would best be employed in this specific facility. Because of the size of the group, it was clear that the appraisal was to be done as simply and by the most expedient way possible. Hence, a blend of department and geographical organization was used. Key non-clinical departments (Engineering, Food Services, Bioengineering and Hazmat) were taken separately, followed by the clinical floors. The adjacent Medical Office Building was excluded from the survey.

An audit, like an inspection, is an opportunity for "fresh eyes" to see a facility. Except for the inability to visit patient-care areas, the process at Facility 5 went smoothly. However, because the audit was conducted relying only on one person's observations, project staff left with the concern that unseen items may have been missed. Project and facility staff spent significant phone time adding to the original data to rectify this concern.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 5. As may be seen on the accompanying Pareto Chart (Chart 5), the on-site mercury profile revealed a strong emphasis on GI devices. One major reason for this was that old mercury bougies were still on-site, despite the current use of non-mercury bougies. These devices represented approximately 80 percent of the facility's total mercury, or over 11 kilograms of mercury. These out-of-service devices were being stored pending recycling.

Two individual significant sources of mercury were counted together (as "non-clinical") solely on the basis of their size and location not directly related to clinical activities. The Engineering Department houses a sphygmomanometer service kit including bulk mercury, a total of about 0.5 kilograms. This quantity of mercury is necessary only if mercury sphygmomanometers are in use in patient care areas. The blood gas laboratory also used a mercury barometer, containing 0.8 kilograms. The barometer is used to correct blood gas measurements for variation in atmospheric pressure.

Sphygmomanometers made up the next highest percentage of mercury in the facility. In-place mercury sphygmomanometers account for just under nine percent of all facility mercury, totaling about 1.2 kilograms—only slightly less than the prior category. Facility staff indicated that, in patient rooms, mercury sphygmomanometers had been entirely replaced with aneroid devices. Mercury sphygmomanometers were found in Nuclear Medicine, Surgery, and the Exercise Room.

Mercury in fluorescent tubes used for lighting represented just 1 percent of in-house mercury, about 145 grams, and the principal contributor to the 169 gram total shown in the Pareto chart as “Engineering”. The fluorescent tubes are periodically collected by outside transporters for recycling. Effective March 7, 2000, the DTSC adopted emergency regulations that require all fluorescent tubes be either recycled or disposed of as hazardous waste. Facility 5 is one of only two facilities surveyed by the P-2 Project that is already in compliance with this new regulation.

Also present are laboratory stains and dyes that may contain minute quantities of mercury as well as certain pharmaceuticals which contain small percentages (0.1% to 1.0%) of mercury as a preservative. These combined were estimated to total less than ten grams of mercury for Facility 5.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 5 are entered below in the same order shown in Chart 5. As can be seen from the cumulative percent plot, replacement of the first three classes of devices shown as: the GI Devices, “non-clinical” (barometer and bulk mercury) and sphygmomanometers with non mercury-containing items will result in a greater than 99 percent reduction of mercury inventoried at the facility.

- **Bougies:** This facility has removed mercury bougies and replaced them with tungsten gel devices. The mercury bougies are being held for recycling.
- **Sphygmomanometers:** The survey revealed that Facility 5 had replaced all but 17 of its mercury sphygmomanometers. Continued replacement is expected, and should not cost more than $148.50 per unit. The total amount required to implement this portion of the Business Plan would be $ 2,524.50. Proprietary exchange agreements are available that will take care of the disposal of removed mercury units and recycling of the mercury. The facility should explore the use of such an arrangement for replacing their remaining mercury sphygmomanometers.
- **Barometer:** Replacement of the mercury barometer with a one-millibar precision aneroid unit should not cost more than $250.
- **Engineering bulk mercury:** Removal of the bulk mercury kept for maintenance of sphygmomanometers should be included in any sphygmomanometer exchange agreements.

- **Other Engineering mercury devices:** At this facility, this class consists only of fluorescent tubes and barostats. The mercury in the barostats which have been taken out of service should be recycled. Solid state control and limit sensors providing boiler-level and steam pressure control are available on the market to replace the remaining mercury pressure sensors. The boiler level control valve (McDonald valve) will cost $400. The price is similar for each of two pressure control switches. Total cost to the hospital for switching replacement will be approximately $1,200. Current recycling of fluorescent tubes should be continued.
- **Thermometers:** The mercury thermometers found in the Dietetics and Clinical Laboratory Department should be replaced. Liquid buffered appliance thermometers cost approximately $20. Laboratory thermometers average $30. The cost to replace the 14 refrigerator and 11 laboratory thermometers would be approximately $610.
- **Laboratory:** Bulk mercury-containing fixatives are not present. "Test Packs," made to perform a single test, and containing thimerosal, are in use, and there is no substitute available. Stock of these items should be minimized.

REPLACEMENT EXPENSES

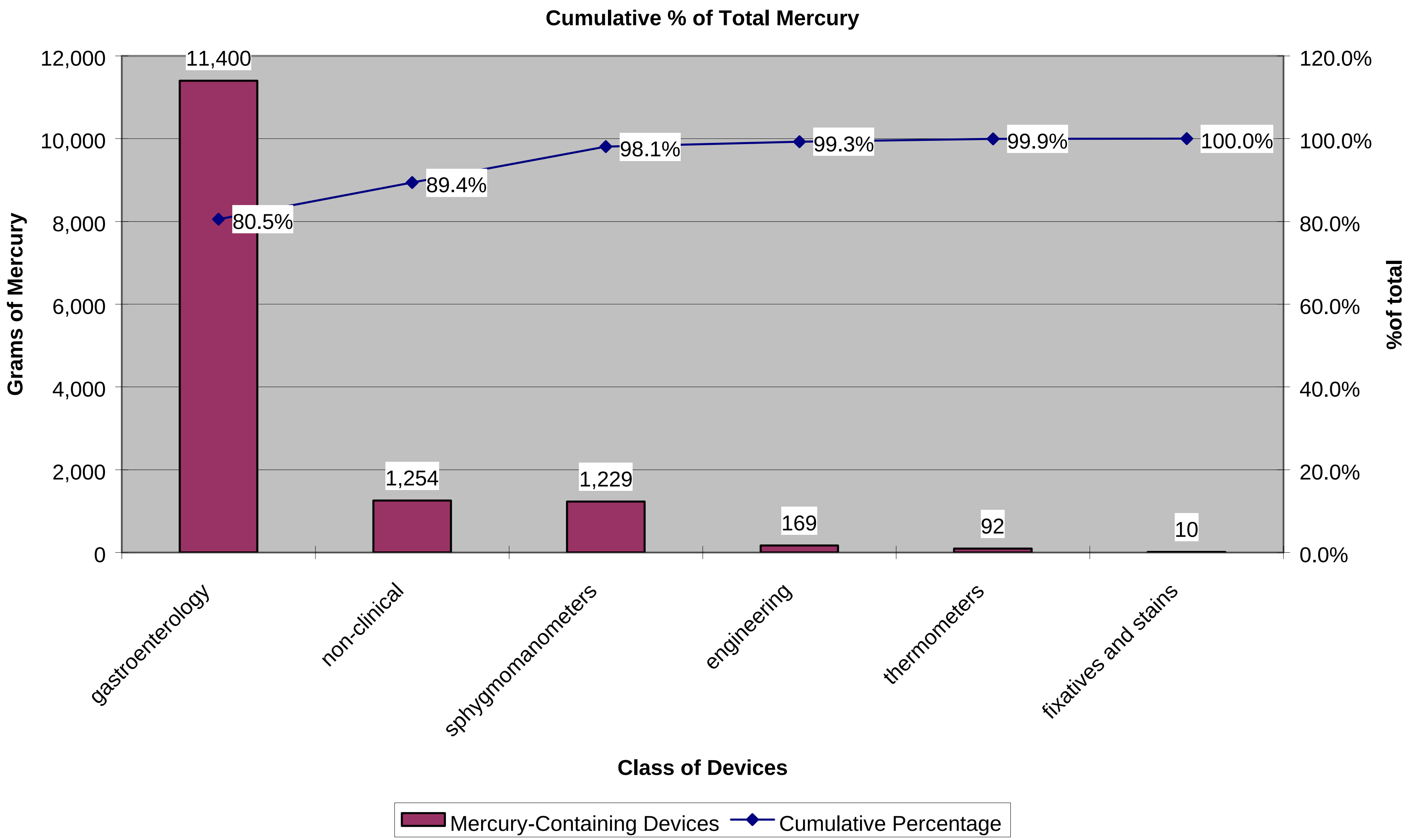
The total cost to replace all of the mercury devices found at Facility 5 would be approximately $4,584.

ATTACHMENTS

CHART 5. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 5. Mercury assessment data for Facility 5.

Chart 5
Total Mercury Faciltiy 5



Facility name Facility 5

Survey Date March 17, 2000

Mercury Assessment WorkSheet

Hg Item	grams/unit	Count or Unit of Measure: newborn nursery	engineering	dietetics	nuclear medicine	ultrasound	surgery	chemistry	pathology	exercise room	hazardous waste	subtotal (grams)	source class	class total	% of total	cumulative %
bougies	5,700.0										2	11,400				
													gastroenterology	11,400	80.5%	80.5%
sphygmomanometer service kit	454.0	gm/pound	1.0	pounds								454				
barometer	800		1									800				
													non-clinical	1,254	8.9%	89.4%
Baum sphygmomanometer	83.0				1					2		249				
Trimline sphygmomanometer	70.0						14					980				
													sphygmo-manometers	1,229	8.7%	98.1%
fluorescent tubes	0.57	mg/sq ft	254,000	sq ft								145				
boiler barostats	4.0		6									24				
													engineering	169	1.2%	99.3%
fever thermometer	0.5	20										10				
minimax thermometer	2.0					1						2				
food thermometer	2.0			1								2				
laboratory thermometer	2.0							14	1			30				
laboratory thermometer	4.0							4	2			24				
calibrating thermometer	8.0							3				24				
													thermometers	92	0.7%	99.9%
fixatives and stains	0.1%								10,000	ml		10				
													fixatives and stains	10	0.1%	100.0%
										TOTAL Hg	(grams)	14,154		14,154		

Prepared by the California Department of Health Services Table 5

Mercury Elimination Case Study
Facility 6

FACILITY 6

Facility 6 is a 111-bed not-for-profit medical center that offers comprehensive services including: 24 hour emergency care, surgery, family centers, obstetrics, pediatrics, acute rehabilitation, diagnostic imaging, occupational health, physical therapy, and intensive care and coronary care. In expanding to meet the needs of a rapidly growing community, the facility has added an ambulatory service center, an expanded emergency department, a sexual assault response team, on-site magnetic resonance imaging, a perinatal clinic, and outpatient surgery. Its physician staff numbers 206; the facility has 566 employees. In its last reference year the facility had 65,642 outpatient visits and 38,991 Emergency Department visits.

The facility's medical waste is treated off-site by steam sterilization or incineration. At the time the facility became part of the Project, there existed a cardboard-only recycling program in cooperation with the "Many Hands" community group. Facility 6 has also had an active hazardous and medical waste minimization team in place for two years. Facility 6 has had a mercury elimination policy in place for two years and is presently moving away from purchasing mercury-containing equipment. The facility had purchased tungsten gel bougies to replace the mercury models and had changed out a significant number of its mercury sphygmomanometers. These sphygmomanometers had been replaced with aneroid devices.

ASSESSMENT

The mercury assessment for this facility was preceded by a one-day mercury training session held during January 2000, including an on-site walk-through. Staff from other facilities participating in the project as well as representatives from EPA, state agencies, local government, and community groups attended the training. The session consisted of a didactic presentation held at the Contra Costa County Health Department, followed by a two-hour physical walk-through of Facility 6. The purpose of the walk-through was to point out areas where mercury was likely to be found and the risks associated with the continued use of specific mercury-containing devices in the hospital. This activity left staff well prepared for the actual mercury assessment that was conducted on April 6, 2000.

By the time of this, the final assessment in the project, it had been observed that limiting the number of participants appeared to positively effect the quality of the assessment. Two project members joined the two hospital staff assigned to the assessment activity. Non-assessment hospital staff present were quite cooperative in refraining from activities which would distract assessors or clinical staff from the task at hand. A thorough review of the entire facility was successfully completed, and substantial data were collected from unanticipated locations. In comparison to other facilities in the project, the depth of information acquired during this assessment appeared to be quite thorough. Of particular note was the careful inclusion of construction/remodel areas and the segregation and storage of out-of-service mercury-containing devices.

The initial audit process itself was accomplished in approximately four hours. Some follow up time was spent on-site reviewing data and confirming findings. This figure also does not include time required to process the raw data, or time spent in follow up of data whose importance was apparent only after the assessment.

The session began with an initial meeting with Administration, Housekeeping, and Infection Control Department representatives to discuss the use of the "tool kit" and to discuss how it would best be employed in this specific facility. Because Facility 6, at 111 beds, is a smaller facility, the group chose to perform a top-to-bottom walk-through, recording data directly onto the form. The result was an audit recognized by all participants as efficient and thorough. Participants were well prepared and were aware where a great majority of devices were likely to be found. They were also motivated to comb the facility for undiscovered mercury-containing devices. In the GI Laboratory, where it was noted they used non-mercury Blakemore tubes (used to stop esophageal bleeding), a mobile mercury sphygmomanometer was found. The technician explained the mercury device was necessary because the pressure of saline in the two balloons, one in the stomach and one in the esophagus, must be monitored in millimeters of mercury. She then produced the instruction sheet packed with the device as proof. Later contact with the infection control nurse confirmed that she had contacted the manufacturer regarding the misleading instructions and the mercury device had been changed out for an aneroid unit the following day.

Processing the raw data for Facility 6 became the most straightforward use of the tool kit, amounting to very little more than keying in the data and developing the chart. Follow-ups were necessary in only a few circumstances. The pharmacy provided a careful model inventory of thimerosal-preserved vaccines and other injectables, which was used as a basis for estimates at other facilities. The chief of the Engineering Department also contributed representative sewer trap samples to assist the project in estimating the extent to which historically sewered metallic mercury might contribute to the expense of total mercury elimination.

Assessment Findings

The complete mercury inventory for the facility is presented in Table 6. As may be seen on the accompanying Pareto Chart (Chart 6), the on-site mercury profile revealed a strong emphasis on GI devices, representing approximately 55 percent of the facility's total mercury, or nearly 12 kilograms of mercury. Although they had been replaced with tungsten gel bougies, the old mercury bougies which had been taken out of service were still in storage at the facility pending recycling.

Sphygmomanometers made up the next highest percentage of mercury in the facility. Mercury sphygmomanometers make up nearly 40 percent of all facility mercury—a total of 8.7 kilograms. Most (80%) of the mercury sphygmomanometers had already been replaced with aneroid devices, and were found in storage along with the other mercury-containing devices awaiting recycling. Those remaining were found on one of the nursing floors, in the Intensive Care Unit and in the old Recovery Room, which was in the process of undergoing remodeling.

A single source of mercury was found in the Engineering Department. This source of mercury was a sphygmomanometer service and cleanup kit including bulk mercury which totaled approximately one kilogram. Such a kit is needed only if mercury sphygmomanometers are in use in the hospital.

At 275,000 square feet, the mercury fluorescent lighting for Facility 6 was calculated to be about 157 grams, representing less than one percent of in-house mercury. Bilirubin lights used to treat neonatal jaundice were only at this facility. The calculation of mercury in these lights indicated that their contribution to the total mercury was negligible.

Mercury thermometers were still in use in the laboratory. Although the Engineering Department's thermometers had been replaced by non-mercury models, the mercury thermometers were being held in storage awaiting recycling. Together they totaled about 120 grams of mercury. Also present in minute quantities is the mercury used as a preservative in laboratory stains and dyes as well as that found in certain pharmaceuticals such as multiple-dose vaccines. These combined were estimated to total less than 10 grams of mercury.

Residual mercury from past disposal practices in hospitals has been known to collect in plumbing traps. Awareness of this fact is important since, unlike other mercury sources, the hidden mercury is unpredictable because it serves no practical purpose. Spills could result during plumbing or demolition activities if the appropriate staff does not provide secondary containment when disassembling a trap. After the initial survey it was deemed appropriate to perform a representative survey of traps. Facility 6 volunteered to carry out such a survey and six traps (four in medication rooms and two in the laboratory) were disassembled and examined for mercury. The traps were emptied into basins from which most of the water could be decanted. The small amount of remaining water and any mercury could then be poured into a graduated cylinder and the mercury volume read directly. At Facility 6, no visible amounts of mercury were found. The facility has been in service since 1967.

BUSINESS PLAN RECOMMENDATIONS

The mercury sources found at Facility 6 are entered below in the same order of descending magnitude as they are shown in Chart 6. As can be seen from the cumulative percent plot, replacement of the first three classes of devices shown as: GI Devices, Sphygmomanometers, and the “non-clinical” class (barometer and bulk mercury) with non mercury-containing items will result in 99 percent reduction of mercury inventoried. Change-out of the remaining thermometers would bring the reduction to well over 99 percent.

- **Bougies:** Facility 6 has already replaced mercury bougies with tungsten gel devices. The mercury bougies held in storage should be returned to the manufacturer or recycled.
- **Sphygmomanometers:** The survey revealed that Facility 6 had replaced all but 14 of its mercury sphygmomanometers. Continued replacement is expected and should cost no more than $148.50 per unit, or $2,079. The existing exchange agreement with Welch Allyn/Tycos will take care of the disposal and mercury recycling of the removed mercury units.
- **Engineering bulk mercury:** Removal of the bulk mercury kept for sphygmomanometer maintenance may be included in the sphygmomanometer exchange agreement.
- **Thermometers:** Alcohol/spirit thermometers are available for all but the highest temperature applications and should replace the laboratory mercury thermometers. Liquid buffered appliance thermometers cost approximately $20. Laboratory thermometers average $30. The cost to replace the 13 refrigerator and 4 laboratory thermometers would be approximately $380.
- **Fluorescent Lights:** Fluorescent lights were not being recycled. Effective March 7, 2000, the California Department of Toxic Substances Control adopted the universal waste rule. This requires that all fluorescent tubes be either recycled or disposed of as hazardous waste. Recycling this waste stream would bring the facility into compliance with the regulation. The Engineering Department at the facility has been seeking vendors who will accept returned fluorescent tubes for recycling.
- **Pharmaceutical:** No pharmaceuticals with mercury as an active ingredient were found in the pharmacy. A preservative for the replacement of thimerosal is not yet available. Use of unit doses (requiring no preservative) where feasible, are the recommended alternative. Stock containing thimerosal should be minimized.
- **Laboratory:** Bulk mercury-containing fixatives are not present. “Test Packs,” made to perform a single test, and containing thimerosal, are in use and there is no substitute available. Minimize stock by applying “just-in-time” inventory practices.
- **Traps:** A schedule for opening and cleaning the remaining sink and hopper traps should be implemented and any mercury found should be recycled.

REPLACEMENT EXPENSES

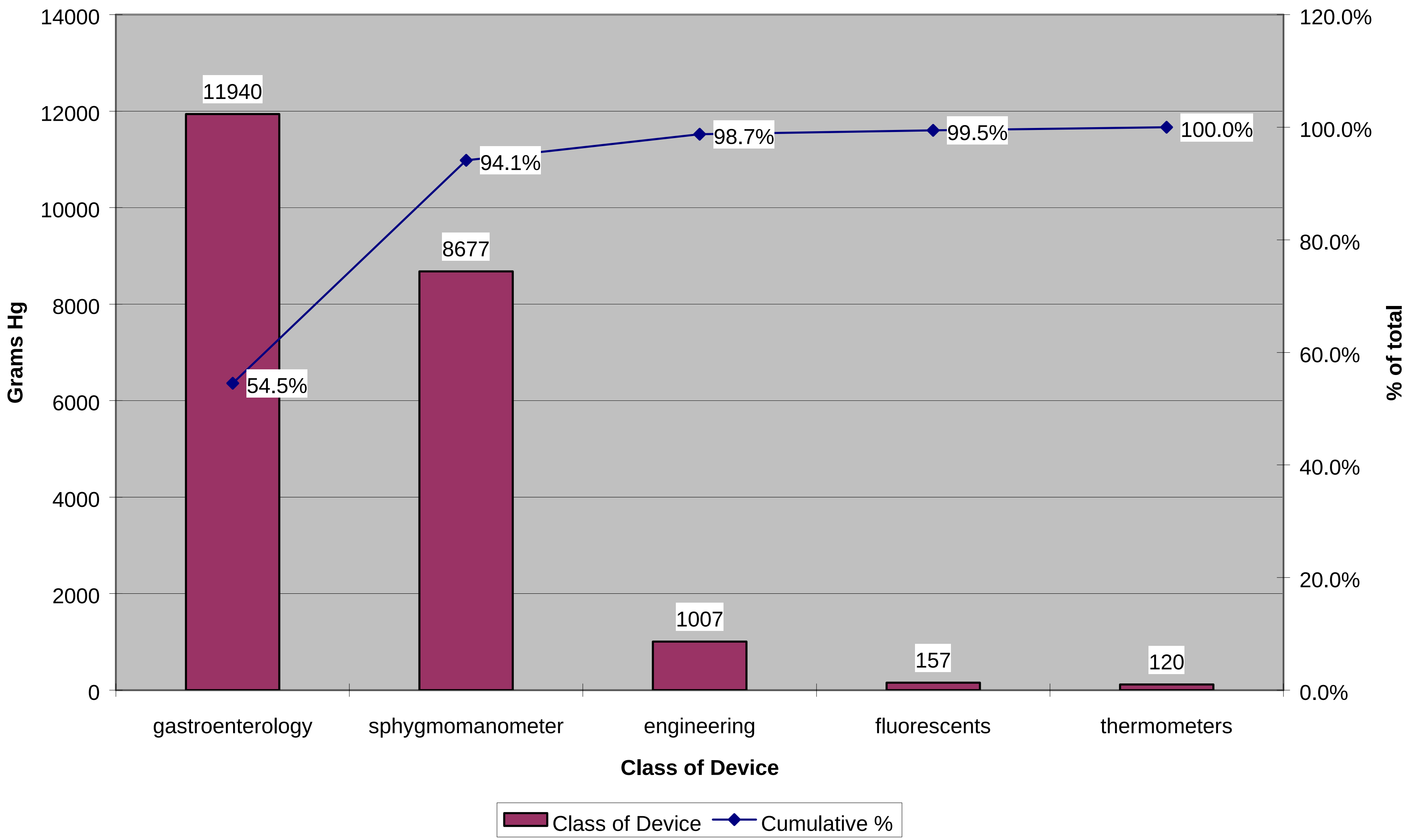
The total cost to replace all of the mercury devices found at Facility 6 would be approximately $2,459.

ATTACHMENTS

CHART 6. Total mercury (in descending quantity), by class of device or use, plotted vs. cumulative percentage. (Pareto Chart)

TABLE 6. Mercury assessment data for Facility 6.

Chart 6
Total Mercury Facility 6



Mercury Assessment WorkSheet

Facility name Facility 6

Survey Date April 6, 2000

Hg Item	grams/unit	Count or Unit Measure									subtotal (grams)	source class	class total	% of total	cumulative %
		chemistry laboratory	engineering	bicrobiology laboratory	hazardous waste	gastro-enterology	obstetrics nursery	medical surgery	ICU telemetry	old recovery					
bougies	454.0	gm/pound	26.3	pound							11,940				
												gastro-enertology	11,940	54.5%	54.5%
Baxter sphygmomanometer	83.0				5						415				
Baum sphygmomanometer	83.0				81	1		8	3	3	7,968				
Trimline sphygmomanomeer	70.0				2						140				
Tycos sphygmomanometer	77.0				2						154				
												sphygmo-manometers	8,677	39.6%	94.1%
sphyg cleanup	50.0			1							50				
sphyg service kit (dirty)	13.6		37	ml							503				
sphyg service kit (clean)	454.0		1	pound							454				
												engineering	1,007	4.6%	98.7%
bili-lights/warmers	5.5	mg/lin ft					74	lin ft			0				
general lighting	0.57	mg/sq ft	275,000	sq ft							157				
												fluorescents	157	0.7%	99.5%
calibrating thermometer	8.0	1		1							8				
water bath thermometer	6.0	2									0				
regrigerator thermometers	4.0	5		8							32				
Terice thermometers	10.0				4						40				
Weksler boiler thermometers	10.0				4						40				
												thermometers	120	0.5%	100.0%
									TOTAL Hg	(grams)	21,902		21,902		

Prepared by the California Department of Health Services Table 6

CHAPTER V
WHERE MERCURY IS FOUND AND WHY IT IS PRESENT

Bougies and other GI Devices

Bougies may be in use either in outpatient surgery or in the gastroenterology laboratory for dilatation of esophageal strictures. These are most commonly the result of ingestion of caustic substances, and the medical procedure may require multiple dilatations using several of the progressively larger-diameter devices in the set. Rubber-covered bougies are usually mercury-filled; whereas non mercury-containing bougies have a blue-green polymer-cover and are filled with a heavy tungsten gel. A set of bougies, as shown in Figures (6) and (7), weighs around ten pounds.

The Blakemore tube is used to compress bleeding esophageal varicose veins sometimes found in advanced liver disease. Because patients are often not already hospitalized but first present in the emergency room with uncontrollable bleeding, the device must be kept near the emergency room. Blakemore tubes may also be found in sterile supply Figure (8).

Sphygmomanometers

Sphygmomanometers are ubiquitous in hospitals. Some more common locations are in patient rooms and patient examination areas where dedicated wall-mount models may be found. Desktop sphygmomanometers are often found in medical offices, and as in Figure (13) in a physical therapy exercise room. The sphygmomanometer shown in the drawer Figure (14) had repeatedly been found in an examination room where an aneroid device had been installed. Sphygmomanometers on rolling stands may be found in the emergency rooms, gastroenterology labs and engineering departments (awaiting repair). Sphygmomanometers have been found stored loose in boxes in facilities where aneroids had been installed, and in hazardous waste storage, awaiting recycling, as seen in Figure (3).

Figure 13 A mercury sphygmomanometer is located next to state-of-the-art monitoring equipment. (Pollution Prevention Project Photograph)

Figure 14 This neglected storeroom drawer held 2 mercury sphygmomanometers which had been replaced by aneroid units. (Pollution Prevention Project Photograph)

Bulk Mercury

Bottles of mercury, associated with sphygmomanometer service kits, may be found either in a service kit or loose on a shelf, most often in engineering departments. The photos in Figures (4) and (5) show a kit, as well as the typical packaging for bulk mercury, in 500 gram or one pound plastic or glass bottles. Often a container of used mercury will be found in the kit as well.

Barometer

Mercury barometers may be found in pulmonary laboratories where they are used in analyzing blood gas data. A mercury thermometer is likely to be found in conjunction with the barometer. Note the thermometer attached to the mercury barometer shown in Figure (9).

Thermometers

For the most part, the use of mercury fever thermometers was found to be discontinued. However, mercury thermometers may still be found in Neonatal Nurseries. Thermometers abound in the clinical Laboratory. The ones shown in Figure (15) (e.g. heat block, water bath) assure temperature control of numerous devices.

Refrigerators in hospitals must all be equipped with thermometers as shown in Figures (10) and (11). They are nearly always placed in a bottle of buffer fluid which prevents fluctuations in indicated temperature when the door is opened. A yellow-stem thermometer with a silver bulb and column is mercury, a white-stem thermometer with a red or blue column is alcohol/spirit thermometer.

Figure 15 Laboratory thermometers monitor temperatures of various laboratory apparatus, including water bath to the right, heat blocks to the left. (Pollution Prevention Project Photograph)

Switches

Mercury switches may be found throughout the hospital. Switches are electromechanical devices, which allow electrical current to be applied or not applied to an electrical device. As a metal, mercury is one of the poorest electrical conductors, but still quite adequate to make it useful in making or breaking circuits many more times than other mechanical contacts before failure. Mechanical contact may also be made with very minimal force, making these switches quite sensitive in the barostat shown in Figure 16 (160 mercury switches control vacuum pressure.

Figure 16 This mercury barostat detects small changes in the vacuum system in the laboratory, switching the vacuum pumps on and off to maintain a constant vacuum. (Pollution Prevention Project Photograph)

Fluorescent Lighting

All fluorescent tubes contain mercury. Mercury vapor carries the electrical current, which in turn activates the phosphors on the surface of the tube to luminesce. Fluorescent lighting is found throughout facilities. In addition to the general facility lighting, “bili” (bilirubin) lights as shown in Figure (17) emit light in a spectral range that destroys bile pigments present in neonatal jaundice.

Figure 17 Extra "bili" lights in a crowded storeroom near the nursery. (Pollution Prevention Project Photograph)

Laboratory chemicals

The greatest concern in clinical laboratories is the use of "B-5" fixative in preparation of pathology specimens. "B-5" fixative also known as Zenker's solution, was formerly made with mercuric chloride. A mercury-free product, made with zinc chloride is shown in Figure (12).

CHAPTER VI
Using the Mercury Assessment "Tool Kit"

The mercury assessment tool kit was used to gather and process data for the P-2 Project. It is useful both in quantifying a facility's mercury and in demonstrating where the majority of the mercury is found in a hospital setting. The tool kit includes an example chart with the data used in its creation (linked in the electronic version). Use of this type of data plotting device makes the development of a specific facility mercury elimination strategy quite simple.

Using the tool kit is as simple as listing the facility's mercury devices and the quantity noted of each. Multipliers are then inserted, this allows for tabulation of the contribution of each device to the total quantity of mercury inventoried. By charting the quantities, a clear picture is developed as to where mercury is located. This allows for straightforward development of a mercury elimination plan.

PERFORMING THE AUDIT

During the auditing of mercury in a facility, list each unique device in the mercury item ("Hg Item") column and indicate the quantity of each in the same row in the column entitled "count." When the device is found at another location, that tally should be noted in a separate "count" column in the same row. This provides a record of the kind and number of devices to be removed, as well as where they are located. When the assessment is complete it is helpful to manually sort the device data under general category headings (e.g. Sphygmomanometers) for ease in calculating subtotals by device (or "source") class.

EXCEL CALCULATIONS

The mercury assessment tool kit is available in Excel format from the Medical Waste Management Program. Details on how to acquire this may be found on Page i.

If using DHS' spreadsheet note that the worksheet contains two formulas: "Subtotal" being the sum of all cells labeled "count" multiplied by the multiplier in that row and "Total Hg," the sum of all the subtotals. The subtotal is the total number of grams of mercury in the hospital attributable to the particular mercury-containing device being counted. The "Total Hg" is the sum of total mercury inventoried in the hospital.

Each group of similar devices should be entered into the worksheet as a specific "source class." "Class total" represents the sum of all "subtotals" in a particular source class. These and other summary data will be different for each facility, and therefore their calculation has not been built into the spreadsheet.

Cumulative percent calculation allows for visualization of the data. To calculate cumulative percent, begin with the largest class divided by the total for the mercury inventoried in the facility. Then find the next largest class, add to it the largest class. Divide the sum of these two classes by the total mercury inventoried. Next sum the largest three classes; again divide by the total mercury inventoried, and so on until the classes are exhausted.

Pareto charts provide a visual tool to demonstrate where the greatest total quantity of mercury is located. This charting is simple to develop using DHS' workbook. Before the chart may be drawn, the data source must be developed. To set up the Pareto chart data source it is necessary to sort the device classes in descending order by weight of mercury inventoried (subtotal). The data source is then used to create the chart. In Excel use the Chart Wizard. The Chart Type is found under Custom Types: "Line-Column on 2 Axes". Bar charts such as those seen in the case studies presented in this document will be created if this process is followed.

MANUAL CALCULATIONS

If using the electronic version is not desirable, the spreadsheets may be developed manually. Follow the steps outlined in the section of this Chapter entitled: PERFORMING THE AUDIT. Proceed with the calculations by sorting devices into device classes, total the count in each row, and multiply by the respective multiplier to calculate device subtotals. Sum the subtotals by class, into class totals. Calculate cumulative percent as described in the section of this Chapter entitled: EXCEL CALCULATIONS and enter next to class total. Plot as shown in the Pareto charts for the case studies.

CHAPTER VII
ANATOMY OF A MERCURY SPILL

The following information describes a mercury spill on the campus of the University of California, Los Angeles (UCLA). The UCLA Hazardous Materials (Haz Mat) Unit responds to a variety of hazardous materials incidents on campus and mercury spills account for 42 percent of the responses they undertake. This case illustrates the problems created by mercury spills and provides ample justification for instituting proactive measures to remove mercury from healthcare facilities.

The Incident

The site of the mercury spill was the Center for Health Sciences (CHS) on the UCLA campus. The incident was caused by mercury that had drained into a plumbing trap in this 40 year old facility by inappropriate disposal through laboratory sinks. The spill took place when plumbers opened the plumbing trap on a waste line that ran between floors of the facility. As the trap was opened an estimated half-liter of mercury spilled from it onto ceiling tiles of a student financial aid office on the floor below. The mercury quickly flowed through the ceiling tiles contaminating the office carpeting and a photocopying machine.

Figure 18 The office on the UCLA campus impacted by the mercury spill. (Photograph courtesy of UCLA, Office of Environment, Health & Safety)

The Response

The UCLA Haz Mat Unit responded to this mercury spill and isolated the affected office. An investigation to determine the extent of damage to the ceiling tiles was conducted. The office environment was monitored using a mercury vapor meter. Mercury indicator powder was used to pinpoint and define mercury hot spots.

Figure 19 CHS financial office isolated following mercury spill. (Photo courtesy of UCLA Office of Environment, Health & Safety)

Staff from the Haz Mat Unit wearing personal protective equipment initiated clean up activities using adsorbent, a mercury vacuum and a micro vacuum cleaner. Continual monitoring with the mercury vapor meter revealed how difficult clean up of this spill had become. The carpeting in the office was removed after repeated attempts to clean it with the mercury vacuum failed to reduce the mercury to non-detectable levels as measured by the mercury vapor meter. The mercury penetration into the photocopying machine was so extensive that the unit had to be removed from service and sent for disposal as hazardous waste.

The clean up and refurbishing of the office following the mercury spill took two months. During this time, staff from the affected office were relocated to other facilities to carryout their financial assistance duties for the medical students.

Figure 20 Investigating the extent of damage to ceiling tiles from a mercury spill. (Photograph courtesy of UCLA, Office of Environment, Health & Safety)

Figure 21 Staff using a mercury vacuum to clean up mercury from office carpet. (Photo courtesy of UCLA, Office of Environment, Health & Safety)

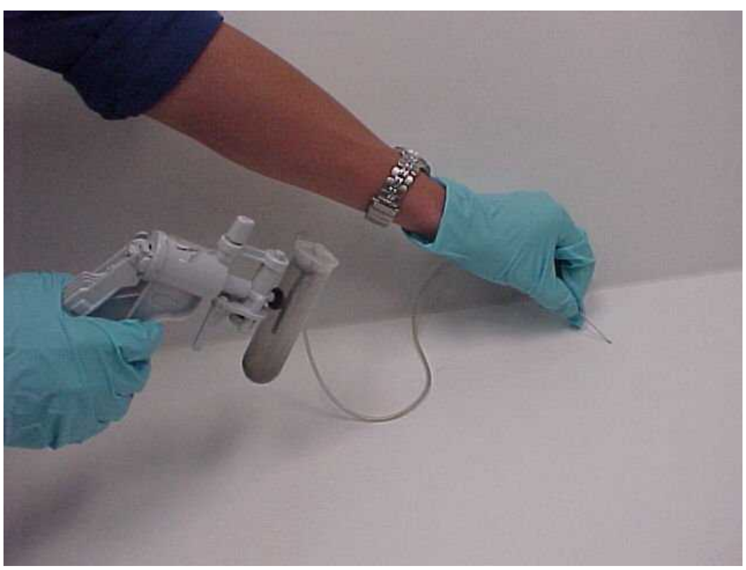


Figure 22 Micro vacuum being used to pick up spilled mercury. (Photo courtesy of UCLA, Office of Environment, Health & Safety)

Phase II of the Spill

Staff reoccupied the cleaned up office facility for approximately eight months before Phase II of this incident took place. During this time remodeling of the floor above was also being done. The remodeling required the use of a jackhammer, which caused vibrations within the facility. The vibrations caused some undetected residual mercury from the original spill to pool in a light fixture.

During the routine process of changing a light bulb a maintenance worker removed the lens covering the fixture which released the pooled mercury. This created a secondary spill into the same office impacted by the original spill. The new carpeting and photocopying machine were both impacted by the spilled mercury. Once again the office staff, highly irritated by the second spill event, had to be relocated to temporary office facilities. This time the office took three weeks to be cleaned. The mercury did not penetrate the new photocopier and it was able to be cleaned and placed back into service. UCLA had to contract for outside assistance to remove small pockets of mercury that were found in the ceiling crawl space.

Mercury Waste Disposal Costs

The CHS mercury spills in the office facility took place during 1999 and contributed to the 1,437 pounds of mercury contaminated waste generated on the UCLA campus that year. Approximately 80 percent was from Haz Mat Unit responses and the remainder from normal mercury disposal practices. The cost of disposing of the 1,149.6 pounds of mercury-contaminated wastes from the spills was $39,883 or $34.65 per pound.

Mercury Spills at UCLA

A total of 47 mercury spills were recorded on the UCLA campus from 1997 through 1999. A breakdown of the sources of these spills is presented in Figure 23. As can be seen from the data presented in Figure 23, thermometers accounted for 26 (55.3 percent) of the incidents. Sphygmomanometers were the second most frequent source of mercury spills during the 1997-99 period with eight spills representing 17.0 percent of the total events. Sink traps accounted for six mercury spills, including the CHS event, which represented 12.8 percent of the incidents. It is interesting to note that 42 percent of the hazardous materials incidents responded to by the UCLA Haz Mat Unit involve mercury. The UCLA Haz Mat Unit expended 280.59 hours responding to hazardous waste incidents during the years 1997-99. The personnel costs for the Haz Mat Unit are computed at $100 per hour resulting in a cost of $28,059 for the three year period.

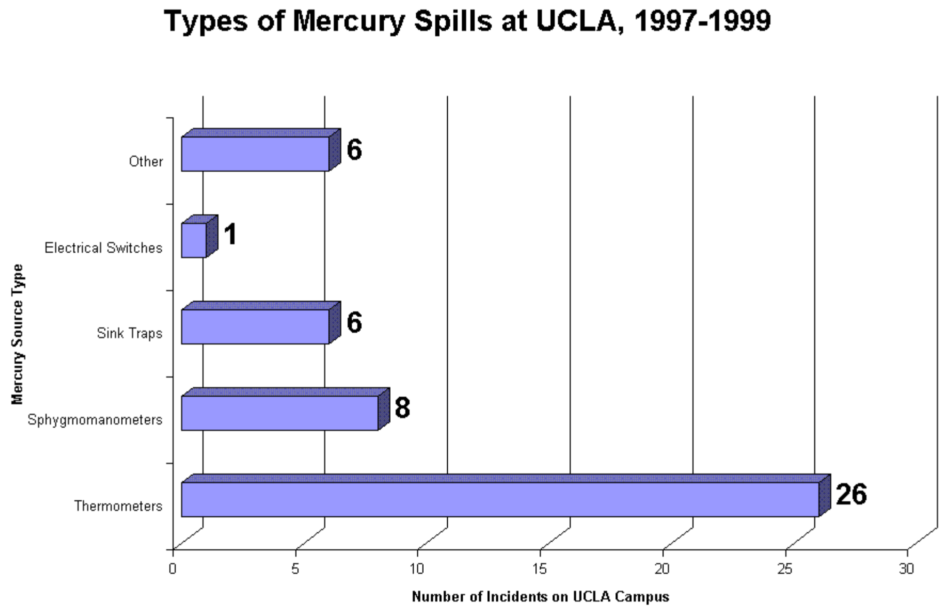


Figure 23 Mercury spills on UCLA campus 1997-99 by source type. (Graph courtesy of UCLA, Office of the Environment, Health & Safety)

Conclusions

Several conclusions can be drawn from the information about the mercury spills on the UCLA campus. The case studies from the six participating Bay Area hospitals provide insight into the costs of preventing mercury problems by proactive measures to remove mercury from their facilities. The following conclusions are not arranged in any order of importance.

Mercury spills are disruptive. They take responders away from other duties they could be performing. The spill may require that people be relocated from the affected area until the site can be remediated. Relocation can be a very disruptive process not only to those that normally occupy the site, but also to the recipients of services they provide. If a laboratory is closed because of a mercury spill, additional expenses in time and contracting to an outside laboratory for services can result. As in the case of the financial assistance services provided at the CHS facility, customers may have to be redirected to another site to receive service.

Mercury spills are expensive. The UCLA campus experience provides sound expense information for the direct costs of mercury spills. From the UCLA experience one would expect to pay $34.65 per pound for disposing of mercury-contaminated waste and $100 per hour for each responder working the spill. Costs can also accrue if staff must be relocated to temporary facilities while clean up and remediation activities take place. Additional costs for replacement of equipment or fixtures damaged by the spill must also be taken into consideration when tallying the total cost of the spill.

Mercury spills are time consuming. Mercury spills take staff from the impacted area out of their routine operations. The two months it took the UCLA Haz Mat Unit to clean up the spill in the financial assistance office demonstrates how time consuming these events can be and is reason enough to try to prevent them from happening.

Mercury spills can be avoided. Disruptive, expensive and time consuming mercury spills can be prevented through implementing steps to remove mercury-containing equipment and devices from healthcare facilities. UCLA has learned from their mercury spill experiences. UCLA is taking a leadership position by building the new hospital for their medical school as a mercury-free facility.

This document was produced in order that all hospitals and healthcare facilities can initiate actions to move their facilities to a mercury-free status. In doing so, they will improve the environment, better their communities, eliminate unnecessary costs from mishandling mercury and create a better place to work for their employees. This process should enhance the image of the healthcare institution and provide a winning scenario for all involved.