

“Successful Waste Minimization Through Laboratory Mercury Thermometer Replacement”

**Stanford University
Environmental Health and Safety
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Program Summary

Stanford University developed and implemented a highly successful and innovative pollution prevention program of replacing mercury thermometers used in research laboratories with non-mercury replacement thermometers. The program protects students, faculty, staff and the environment from unnecessary exposure to mercury, a highly potent neurotoxin. Since the program’s inception, nearly 1500 mercury thermometers of all types have been replaced with non-mercury alternatives. As a result, a 40% reduction in clean up costs associated with broken mercury thermometers resulted.

Stanford University’s program is an attempt to go beyond what is required by regulation. The program aims to prevent mercury spills in the laboratory environment, sanitary sewer system, and ultimately the San Francisco Bay. Our program is unique in that we work closely with the researchers to understand their individual needs. We help ensure that they receive the appropriate thermometers for their application; researchers are given options to choose from a wide variety of thermometers.

Stanford University’s unique and innovative approach to pollution prevention through mercury thermometer replacement was recognized by Region 9 of the Environmental Protection Agency in 2002 with its’ “Environmental Leadership Award.”

Background

Five years ago, Stanford University embarked on a mercury reduction program to address the serious environmental and human health risks posed by the release of mercury into the environment. The program sought to reduce the potential health and environmental risks to the campus and the surrounding community. The program involved replacing mercury thermometers with non-mercury alternatives.

A task force was organized consisting of representatives from the Utilities Department and the Environmental, Health, and Safety (EH&S) Department to ascertain and evaluate all mercury sources on campus and identify ways to reduce the use of mercury campus-wide. The task force evaluated the various uses of mercury and determined the most efficient and effective program. A variety of uses of mercury-containing equipment were found, including fluorescent light bulbs, mercury containing switches, batteries, sphygmomanometers, lamps, and thermometers. Once this list was completed, the equipment was evaluated considering the frequency of use, the abundance of the particular process, the environmental impacts of the equipment or process, the ease and efficiency of replacement, the hazardous waste risk factors, the potential for a replacement program, and partnerships within the University.

Thermometers were determined to be the most widespread source of mercury on campus with the most readily available alternatives.

Mercury thermometers are also associated with high hazardous waste cleanup costs. Cleanup costs for broken thermometers include staff time to clean up the mercury spill and the costs for hazardous waste disposal. It takes approximately two hours of a technician's time (at \$55 per hour overtime) to complete the cleanup for a broken mercury thermometer. It is also very expensive to dispose of the broken thermometers. 30-gallon drums are used to dispose the waste from broken mercury thermometers and each drum costs \$900 to dispose of as hazardous waste. Although the buckets have the capacity to fit debris from many broken thermometers, because of the 90-day maximum accumulation limit for hazardous waste, there are rarely more than 3 or 4 broken thermometers in any one shipment. The costs to clean up spills from broken mercury thermometers average approximately \$2000 per year.

A critical influencing factor was the fact that mercury reduction is a top priority for the San Francisco Bay Region of the California Regional Water Quality Control Board (CRWQB) and the City of Palo Alto. The CRWQB reports in its April 30, 2004 "Mercury in San Francisco Bay" Staff Report that "mercury concentrations in San Francisco Bay are high enough to threaten human health... The California Office of Environmental Health Hazard Assessment has issued an interim fish consumption advisory for San Francisco Bay. In addition, mercury concentration in some bird eggs harvested from the shore of the San Francisco Bay are high enough to account for the high rates of eggs failing to hatch; therefore, mercury threatens wildlife and rare and endangered species. Because controllable water

quality factors cause detrimental mercury concentrations in sediment, aquatic organisms, and wildlife, the narrative water quality objective for bioaccumulative substances is not met in San Francisco Bay. A lengthy implementation plan for reducing mercury in San Francisco Bay is an ongoing process.

In response to the CRWQB's aggressive mandates for mercury reduction in San Francisco Bay, the City of Palo Alto of Palo Alto enforces a Sewer Use Ordinance discharge limit of 0.01 mg/L (recently lowered from 0.05 mg/L). Future plans could further reduce this limit to 0.005 mg/L. These limits could be easily exceeded should the mercury content from a single broken mercury thermometer reach the compliance sampling location. Laboratory mercury thermometers contain approximately 3 grams of mercury per thermometer. If a thermometer breaks in a sink, the 3 grams of mercury has the potential to be released to the sanitary sewer. The result could cause Stanford University to be out of compliance with the City's Sewer Use Ordinance, and cause negative environmental impacts to San Francisco Bay.

Following the initial assessment, a pilot program was started at one of Stanford University's newest and most innovative research buildings, the Center for Clinical Science Research (CCSR), in the School of Medicine. The task force identified which programs were purchasing the most thermometers and which programs had the highest incidence of spills requiring cleanups by the EH&S. This process created a prioritized list by building to replace mercury thermometers.

CCSR was chosen as the first building in the program because it was a new building and ready to be occupied by researchers. The CCSR building has approximately 50 labs with 500 researchers. The objective of the replacement program at CCSR was for a mercury thermometer free building. As the researchers moved in, information was provided introducing them to the program and offering them free non-mercury thermometers in exchange for mercury thermometers. The lab personnel were able to choose from a variety of thermometer replacements that best fit their needs. The overwhelming response and success of the pilot program provided the impetus to offer the same exchange with other buildings on campus.

The exchange program is based on a simple process. Once researchers are informed of the program and they express an interest in participating, they are provided with additional information on the types of non-mercury thermometers available through the chosen supplier

(see Appendix A). Prior to the onset of the program, the task force researched all of the various uses for thermometers and the types of thermometers suitable for each use. Researchers choose the specific thermometers that best suit the needs of their particular research, and EH&S orders the thermometers as the requests come in from the labs. EH&S provides individual consultations to the researchers whenever help is needed determining which types of replacement thermometers are needed. To exchange the thermometers, the labs turn in their mercury thermometers and receive the non-mercury replacements at the same time. In instances where non-mercury thermometers are not available in sufficiently high temperature ranges, mercury thermometers can also be Teflon coated. The Teflon coating on a mercury thermometer prevents the release of mercury should the thermometer break.

VWR was chosen as the vendor for the mercury thermometer replacement program because they were the company with the best exchange program. They sell a wide variety of thermometers to match the individual needs of each researcher. Once EH&S staff replaces the mercury thermometers, they are shipped to VWR and the vendor accepts the mercury thermometers at no cost to the University. The thermometers must be shipped back in bundles of at least 25 thermometers for them to be accepted for disposal by the vendor. The vendor then recycles the mercury recovered from the mercury thermometers.

The purchase, shipping and handling of the new non-mercury thermometers, as well as the shipping of the mercury thermometers back to VWR is all funded by the EH&S Department. Initially, the Utilities Department funded staff to research the best vendor, the various uses of thermometers and viable alternatives. Utilities Staff coordinated and documented the information about the program and thermometer alternatives, as well as the exchanges and the orders of all thermometers. It is important to note that the time put into maintaining the program has greatly decreased now that the exchange system has been put into place. EH&S now manages the entire program.

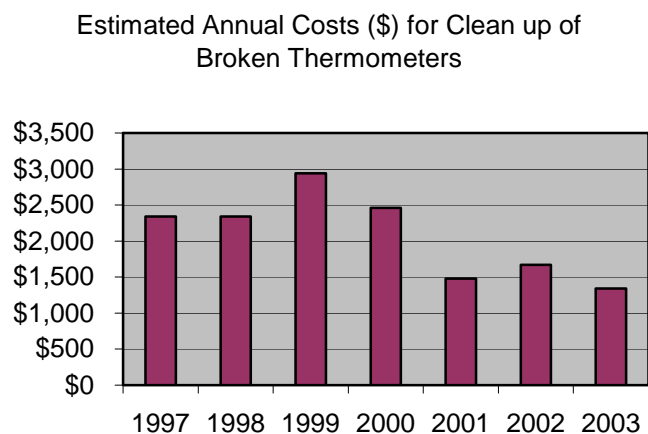
Stanford University's mercury replacement program has purchased nearly 1500 non-mercury thermometers since the implementation of the program; approximately the same number of mercury thermometers have been shipped back to VWR for reuse and recycling. The interest in the program has been overwhelming and the varieties of applications used with thermometers were much higher than anticipated. Substitute thermometers were found for

applications that require extremely high and low temperatures, thermometers that needed to be only partially submerged in a liquid and thermometers that were required to have the ability to be completely submerged as in use in freezers.

There was also the problem of the fluid column separation. The non-mercury thermometers must be stored and used vertically or the fluid column can separate. At the point of exchange, researchers are educated on this storage requirement and information is distributed on how to correct the problem should it occur (see Appendix B).

Environmental Benefits

It is difficult to quantify the amount of mercury releases prevented to the sanitary sewer system and environment from the mercury thermometer replacement program or the reduction of broken thermometers. However, the drop in the estimated costs of cleanup, indicated in the chart below, is indicative of the reduction in broken mercury thermometers. Since 1999, there has been an estimated 40% reduction in cleanup costs from broken mercury thermometers.



It is also important to note the high level of interest and participation among all Stanford University laboratory staff and researchers. There are continued requests for non-mercury thermometers. To date, nearly 1500 mercury thermometers have been collected. Many more departments still need to be included in the mercury thermometer replacement program and the ultimate goal is a mercury thermometer-free campus.

The reduction of mercury spills also greatly improves the working environment for all lab workers. Thermometers contain elemental mercury and exposure to elemental mercury can cause a variety of health effects in humans. Elemental mercury vaporizes at room temperature; therefore, most employee exposures could occur through inhalation. Elemental mercury has the ability to transport across the blood-brain barrier into the central nervous system. Early effects of exposure include: fatigue, weakness, and memory loss (1). Long-term exposure can cause renal toxicity, skeletal muscle degeneration, gastrointestinal irritation, pulmonary edema-fluid in the lungs, elevated blood pressure, low great/intermittent fevers, and the flushing of palms and soles (2).

Improper handling and accidental spills also threaten the outside environment where bioaccumulation of mercury produces relatively high concentrations of mercury in higher organisms, such as fish (3). The cycle continues as higher organisms, including humans, consume fish. Ingestion is another route for human exposure. After mercury has been ingested by fish and subsequently by humans, it changes form from elemental mercury to methyl mercury. Methyl mercury comes with a range of health effects including: neonatal brain damage, nephritis-inflammation of the kidneys, paresthesia-tingling skin sensation, muscle fasciculation-twitching muscles, abnormal heart rhythms, chromosomal aberrations, and dermatitis(4). The reduction of mercury thermometer use on campus reduces the chances of accidental exposures and releases of mercury to the environment.

Potential Model for Other Institutions

The type of program implemented at Stanford University is applicable to any facility using laboratory thermometers. Any facility working with mercury thermometers has the same potential for human exposure and environmental release. It is in the best interests of employees and employers to reduce the use of mercury whenever possible. In addition to improving workplace safety, the reduction of mercury thermometers is evidence for

- (1) DiNardi, Salvatore R., The Occupational Environment – Its Evaluation and Control. American Industrial Hygiene Association. Fairfax, VA, 1997.
- (2) Northeast Waste Management Officials' Association (<http://www.mewmoa.org>).
- (3) Regional Water Quality Control Plant, Mercury Source Identification, Aug 13, 1997
- (4) Northeast Waste Management Officials' Association (<http://www.mewmoa.org>).

employees and the community of Stanford University's commitment to pollution prevention by taking proactive measures to protect the employees of Stanford University and the environment we live in.

Stanford University's exchange program provides all of the information on the non-mercury thermometers available on the EH&S website and in handouts that provide additional educational information to potential participants in the program (see attachments). These handouts can be easily copied and adapted to other institutions' replacement programs. The vendor, VWR, has their exchange program already established and will work with any academic institution, research facility, or industrial user to set up an agreement similar to Stanford University's. Discounts are also available and can be negotiated with the distributor based on the size of the order.

Stanford University has already assisted environmental, health and safety staff from the University of Georgia and the University of Maryland by providing them with information and directing them to our website. VWR has also recommended Stanford University's mercury thermometer replacement program to other Universities as an example.

Management Support of the Program

Support by upper management for this program is evident by the funding provided to begin and continue the program to encompass the entire campus. The non-mercury thermometers are expensive with costs ranging from approximately \$8.00-\$37.00 per non-mercury thermometer. EH&S budgeted \$15,000 to start the program and to purchase the first round of replacement thermometers; to date, the program has cost approximately \$23,000 in replacement thermometer costs. Funding and resources were also provided through the Utilities Department to cover the labor costs of setting up and maintaining the program. It is important to note that labor costs diminished once the early research and program development was completed. The program includes a system for ordering, exchanging, and shipping the thermometers back to the vendor, and now that this system is established, the process takes considerably less time.

The Future of Mercury Thermometer Replacement

The mercury thermometer replacement program has a bright future. The program is currently being expanded to include the Departments of Chemistry, Engineering as well as other areas. EH&S does no advertising of the program; simple word of mouth has fueled its success. Researchers are happy with their replacement thermometers and are even happier to not bear the cost of replacement.

The mercury thermometer replacement program is also only part of a greater plan to reduce mercury use on campus. EH&S is considering expanding the program to include replacement of mercury manometers, pressure gauges that contain large amounts of mercury and have significant opportunities for spillage. Further, EH&S recently partnered with the City of Palo Alto's residential mercury thermometer replacement program. Anyone in the City's service area can drop their mercury thermometers at EH&S and receive a free digital replacement. To date, nearly 75 residential thermometers have been collected. Residential customers have expressed much gratitude in finding a safe mechanism for disposing of their mercury thermometers.

The program has been overwhelmingly popular. Requests for non-mercury thermometers continue almost daily. The ultimate goal of the program is to make Stanford University a mercury thermometer-free campus, and EH&S remains optimistic that this goal is achievable.

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Appendix A

Mercury Thermometer Replacement Alternatives

Thermometer Description Range / Division	Length		
	Non-Mercury VWR-Enviro-Safe®	Non-Mercury Fisherbrand®	Non-Mercury Brooklyn Thermometer Company Inc.
Total Immersion			
-200 to 30°C / 1°C	350mm	350mm	356mm
-100 to 100°C / 1.0°C	N/A	N/A	405mm
-100 to 50°C / 1.0 °C	305mm	305mm	305mm
-100 to 60°C / 2.0°C	N/A	N/A	152mm
-50 to 50°C / 1.0°C	305mm	305mm	152mm, 305mm
-40 to 50°C / 0.5 - 1.0°C	N/A	N/A	152mm, 305mm
-35 to 50°C / 1.0°C	N/A	305mm	N/A
-30 to 120°F / 1.0°F	N/A	305mm	N/A
-20 to 110°C / 0.5 - 1.0°C	305mm	305mm	305mm, 356mm
-20 to 150°C / 1.0°C	305mm	305mm	305mm
-15 to 60°C / 1.0°C	N/A	N/A	254mm
-10 to 110°C / 1.0°C	200mm	8in	225mm
-10 to 150°C / 1.0°C	200mm	8in	N/A
-10 to 205°C / 1.0°C	N/A	N/A	381mm
-10 to 210°C / 1.0°C	N/A	355mm	N/A
-10 to 225°C / 1.0°C	355mm	N/A	N/A
-10 to 260°C / 1.0°C	N/A	N/A	381mm
-5 to 55°C / 1.0°C	N/A	N/A	152mm
-5 to 105°C / 1.0°C	N/A	N/A	152mm
0 to 230°F / 2.0°F	200mm, 305mm	305mm	N/A
0 to 300°F / 2.0°F	200mm, 305mm	305mm	N/A
15 to 40°C / 0.5°C	N/A	N/A	152mm
20 to 435°F / 2.0°F	435mm	N/A	N/A
76 mm Immersion			
-100 to 100°C / 1.0°C	N/A	N/A	405mm
-100 to 50°C / 1.0 °C	305mm	305mm	305mm
-50 to 50°C / 1.0°C	305mm	305mm	305mm
-40 to 50°C / 0.5 - 1.0°C	N/A	305mm	152mm, 305mm
-35 to 50°C / 1.0°C	N/A	305mm	N/A
-30 to 120°C / 1.0°C	N/A	305mm	N/A
-20 to 110°C / 0.5 - 1.0°C	305mm	300, 305mm	305mm, 356mm
-20 to 150°C / 1.0°C	305mm	300,305, 325mm	305mm
-15 to 60°C / 1.0°C	N/A	N/A	254mm
-10 to 70°C / 0.5°C	297mm	N/A	N/A
-10 to 110°C / 1.0°C	N/A	N/A	225mm
-10 to 205°C / 1.0°C	N/A	N/A	356mm
-10 to 200°C / 1.0°C	305mm	305mm	N/A
-10 to 210°C / 1.0°C	N/A	380mm	N/A
-10 to 250°C / 1.0°C	N/A	375, 380mm	N/A
-10 to 260°C / 1.0°C	405mm	405mm	381mm

-1 to 51°C / 0.1°C	405mm,460mm	457mm	N/A
-1 to 101°C / 0.1°C	N/A	610mm	N/A
0 to 61 °C / 0.1°C	425mm	N/A	N/A

Thermometer Description	Length		
	Non-Mercury VWR-Enviro-Safe®	Non-Mercury Fisherbrand®	Non-Mercury Brooklyn Thermometer Company Inc.
76 mm Immersion Con't.			
0 to 230°F / 2.0°F	305mm	300, 305mm	N/A
0 to 300°F / 2.0°F	305mm	300, 305mm	N/A
20 to 400°F / 2.0°F	N/A	305mm	N/A
20 to 500°F / 2.0°F	355mm,405mm	405mm	N/A
30 to 400°F / 2.0°F	N/A	N/A	N/A
Partial Immersion Range/Immersion/Division			
-100 to 50°C /150mm - 305mm/1.0°C	N/A	380mm - 533mm	N/A
-50 to 50°C / 150mm - 305mm / 1.0°C	N/A	380mm - 533mm	N/A
-20 to 150°C / 25mm - 455mm / 1.0°C	N/A	225mm - 685mm	N/A
-10 to 110°C / 50mm / 1.0°C	200mm	8in	N/A
-10 to 150°C / 50mm / 1.0°C	200mm	8in	N/A
-10 to 250°C / 25mm - 457mm / 1.0°C	N/A	325mm - 762mm	N/A
0 to 230°F/50mm/2°F	200mm	N/A	N/A
0 to 300°F/50mm/2°F	200mm	N/A	N/A
Specialty Thermometers Range/Immersion/Division			
0 to 100°C/ 35mm/1.0°C (heat block)	225mm	N/A	N/A
-30 to 0°C /total/0.5°C (freezer)	135mm	N/A	N/A
-5 to 20°C /total/0.5°C (blood bank)	135mm	N/A	N/A
-5 to 15°C /total/0.5°C (refrigerator)	135mm	N/A	N/A
15 to 50°C /total/0.5°C (incubator)	135mm	N/A	N/A
20 to 130°C /total/1.0°C (oven)	145mm	N/A	N/A
50 to 200°C /total/2.0°C (oven)	145mm	N/A	N/A
20 to 60°C /total/2.0°C (refrigerator)	135mm	N/A	N/A
-90 to 20°C /total/1.0°C (ultra low freezer)	145mm	N/A	N/A

Notes:

If you must use a mercury thermometer, please Teflon coat the thermometer, which prevents contamination/exposure if the thermometer is broken. Please dispose of your mercury thermometer through Environmental Health and Safety, as you would other hazardous waste.

All Information was obtained from the following companies, please call to verify all information. Other mercury free thermometers may be available.

VWR - Your local campus store can order or call: 415-330-4270 x1175
 Fisher Scientific - Your local campus store can order or call: (800) 926-6060
 Brooklyn Thermometer Company Inc.: (800) 241-6316

Appendix B

Instructions for Reuniting Separated Fluid Column of Non-Mercury Thermometer

Heating Method

Heat the thermometers bulb in an upright position away from your face in warm liquid, air, or over a soft flame sufficient to allow the liquid column to rise slowly until the separated portion of the column enters the expansion chamber at the top of the thermometer. Note that over filling the expansion chamber will break the thermometer. Tap the thermometer gently on the surface of a large rubber stopper in an upright position allowing the gas separating in the column to rise above the column. Allow the thermometer to cool slowly in an upright position.

Cooling Method

Prepare a solution of shaved ice and salt or CO₂ (Dry-Ice) and alcohol. Place the thermometer bulb only in the solution. Keep the thermometer upright. Allow the liquid column to retreat into the bulb, swing the thermometer (Bulb Down) in an arc releasing the entrapped gas, permitting it to escape above the column. Allow the thermometer to warm slowly in an upright position.