MWRA / MASCO MERCURY WORK GROUP
PHASE II MERCURY MANAGEMENT SUBCOMMITTEE
MERCURY MANAGEMENT GUIDEBOOK

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ACKNOWLEDGMENTS

The Massachusetts Water Resources Authority (MWRA) is a public agency charged with supplying water and sewerage services to municipalities in the Boston metropolitan area. The MWRA/MASCO Mercury Work Group, a public-private partnership of the MWRA and sewer dischargers (including hospitals, universities, and other industries), was established in 1994 to study and implement ways to reduce mercury discharges to the MWRA sewerage system. One institution, the Medical Academic and Scientific Community Organization, Inc. (MASCO) that represents many local Boston hospitals, has worked from the beginning of this effort to help identify the sources and methods of removing mercury from hospital waste streams. Phase II of the Work Group was initiated in 1996 to further examine mercury management techniques and promising mercury pretreatment technologies.

The MWRA/MASCO Mercury Work Group, Mercury Management Subcommittee, acknowledges the following participating institutions and representatives, who served as members of the Mercury Management Plan Subgroup, for the significant time and resource commitment they have made in support of the Work Group process and for their contributions to the development of this Guidebook.

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1.0 INTRODUCTION

1.1 Guidebook Purpose and Content

This Guidebook is a product of the Phase II MWRA/MASCO Mercury Work Group, Mercury Management Subcommittee, Mercury Management Plan Subgroup. It can be used as a reference by industrial facility owners in the development of a Mercury Management Plan to solve sewer discharge compliance problems. The plan of action may involve initiation of a source reduction program or enhancement of an existing one, and it may also involve implementation of an industrial wastewater pretreatment strategy.

This Guidebook is intended to help owners of industrial facilities to understand the process of identifying, reducing, and eliminating sources of mercury; provide information on methods for monitoring and treating mercury discharges; and present industry-specific case studies on mercury sources and successful control programs. Several subject areas and processes are highlighted that may help MWRA-permitted sewer dischargers to find solutions to mercury compliance problems.

The Mercury Management Subcommittee of the MWRA/MASCO Mercury Work Group hopes that this *Mercury Management Guidebook* will be a valuable and practical tool for many facilities, providing insight into the many variables associated with creating and successfully implementing a comprehensive Mercury Management Plan.

1.2 For More Information

Section 3.0 (References) of this document lists sources of additional information on mercury-related issues. More information, or copies of materials referenced in this Guidebook, can be obtained from:

Massachusetts Water Resources Authority
TRAC / Technical Services Section
Charlestown Navy Yard, 100 First Avenue
Boston, MA 02129

Requests for copies of the reports of the MWRA/MASCO Mercury Work Group should be sent to the MWRA at the above address. Note that the Work Group reports can also be found on the Internet at the following Web-site addresses: *http://www.mwra.state.ma.us* and *http://www.masco.org/mercury*.

The reports from Phase II of the Work Group effort provide new and updated information that generally supersede earlier reports. The Phase II reports are as follows:

Facilities Loadings Subgroup Report - estimated sewer discharge loadings of mercury from five types of facilities discharging to the MWRA sewerage system.

Pretreatment Guidance Manual - recommended steps for implementing coordinated source reduction, source segregation, and pretreatment including mercury pretreatment.

Technology Identification Subgroup Report - background and results of a bench-scale feasibility testing project involving six different mercury pretreatment technologies.

Mercury Management Guidebook - recommended steps for overall management of mercury to reduce and control the mercury concentration of sewer discharges (this document).

In addition, the Work Group has prepared a computerized database called the Mercury Products Database listing approximately 8,000 chemicals used by hospitals and institutions. For about 800 listed products, the Database includes the results of analytical testing for mercury content. The Mercury Products Database can be obtained from the MWRA at the above address and can also be found on the Internet at the following Web-site addresses: *http://www.mwra.state.ma.us* and *http://www.masco.org/mercury*.

1.3 Regulatory Background - Mercury and the MWRA Sewerage System

In areas served by municipal sewers, facilities with industrial wastewater discharges are often required to limit the discharge of toxic, corrosive, or other pollutants into the sewer system and associated sewage treatment facilities. Sewage treatment facilities owned by states and municipalities are known as Publicly Owned Treatment Works (POTW). In the Greater Boston area, the MWRA operates a POTW that serves 43 communities.

In districts served by a POTW, both general and specific discharge limits are usually applied to industrial users of the POTW system. Overall, industrial wastewater sewer discharges must be controlled to prevent:

- Harm or interference with the sewerage system or any POTW treatment process, including sludge use, management, or disposal.

- Passage (pass-through) of untreated pollutants through the POTW that could cause a violation of any federal or state law, permit, or water quality criteria or that could cause any adverse effects on the receiving waters.

- Threat of endangerment of the life, health, or welfare of any person or persons (including sewer and POTW workers) or of the public health, safety, or welfare, or the environment, or public property (including fire or explosion hazards in sewers or the POTW).[1]

As part of the EPA National Pollution Discharge Elimination System (NPDES) permit system, the operator of a POTW is required to evaluate periodically the specific discharge limits it sets for industrial wastewater relative to existing federal and state environmental quality criteria. These specific industrial discharge limits are called Local Limits. To conform with federal and state guidelines, an evaluation of Local Limits must be based upon a substantial body of analytical data including the quantity and quality of industrial and nonindustrial sewer discharges, treatment plant pollutant removal rates, and residual biosolids (sludge).

In the Boston Metropolitan Sewerage Service Area, the MWRA found in its Local Limits evaluations that specific industrial discharge limits were required for several heavy metals and organic compounds and, furthermore, that prohibitions were required for industrial discharges of pesticides, polychlorinated biphenyls, phenanthrene, and mercury. The applicable Local Limits and discharge prohibitions are included in the MWRA Sewer Use Regulations (360 CMR 10.000) and appear as requirements in MWRA sewer use permits issued to industrial dischargers.

To enforce the mercury prohibition, the MWRA developed an enforcement limit where an industrial discharge would be considered a violation if a representative sample had a mercury concentration of more than 1.0 microgram per liter (µg/L).[2] The basis for this 1.0 µg/L (ppb) enforcement limit is a recognition that the method detection limit of EPA Method 245.1 for mercury in wastewater samples was typically 0.2 µg/L (ppb). Thus, a wastewater sample measuring greater than 1.0 µg/L (ppb), which is five times the typical method detection limit, would certainly contain the prohibited mercury.

To come into compliance with MWRA Local Limits including the prohibitions, each permitted industrial facility should begin by studying its proposed or existing process wastewater discharges to find the most economical and practical approaches to meet the Limits. For some facilities, compliance with all Local Limits may be achieved by implementation of a source reduction program. For other facilities, source reduction combined with source segregation and pretreatment, or pretreatment alone, may be required. Often, the lowest capital and operating costs for a new pretreatment system can be realized when the system at each discharge point is integrated with source reduction, source segregation, and other aspects of facilities management.

In March 1997, the MWRA announced its intentions to implement a new Mercury Enforcement Plan, known as the Safe Harbor Program, effective July 1997. The Program reduces enforcement requirements for facilities that show reductions in mercury discharges. Therefore, the Program rewards facilities that continue to reduce their mercury contributions to the sewer system.

To initiate the Program, the MWRA assigned its noncompliant mercury dischargers[3] into two groups. Group 1 dischargers consisted of sewer users whose discharges contain 4 µg/L or less of mercury; Group 2 dischargers consisted of sewer users whose discharges contain more than 4 µg/L of mercury. All sewer users, regardless of assigned group, were expected to work actively toward having no greater than 1.0 µg/L (ppb) of mercury in their sewer discharges.

Each of the Group 1 and Group 2 sewer users were issued an enforcement order that outlined the applicable Safe Harbor requirements. Group 2 sewer users had more stringent requirements such as requirements to evaluate, design, install, operate, and improve (if necessary) a full-scale end-of-pipe pretreatment system for mercury. Any facility that operated outside the Safe Harbor Program would be subject to escalating enforcement including monetary penalties. Refer to **Appendix G** for a copy of the MWRA Safe Harbor Program memorandum.

The MWRA will review its mercury discharge prohibition upon its next Local Limits evaluation that will be done according to EPA requirements. The Local Limits evaluation and report will be completed and submitted to the EPA regional office early in 2000.

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2.0 MANAGEMENT OF MERCURY DISCHARGES

Successfully managing mercury discharges involves the same elements used in any effective environmental management system: commitment, goals, standards, accountability, operational controls, communication, training, and performance metrics. Most facilities have found that many individual actions are needed to achieve success. They have also found that these actions are most efficiently and effectively undertaken if they are specifically developed and coordinated under a written Mercury Management Plan.

2.1 Management Commitment

Senior management commitment and participation are essential to successful mercury management under a Mercury Management Plan. This commitment provides a framework for integration of the mercury management process into facility strategic plans and for the appropriate and necessary allocation of both human and fiscal resources.

The commitment of senior management is often demonstrated by the creation of a Mercury Management Committee. The initial task of this committee is to develop, publish, and internally distribute a written statement of the management commitment and a facility policy regarding mercury control. **Appendix A** gives an example of a brief mercury reduction policy statement used by a hospital as part of a Standard Operating Procedure. A separate, stand-alone and comprehensive facility policy statement is recommended.

2.2 Standard Operating Procedures

The Mercury Management Committee should direct the development, communication, and implementation of policies and procedures as necessary and appropriate to establish the facility Mercury Management Plan. These policies and procedures should include a statement of what is expected from each employee concerning mercury discharge control. In addition, the documents could include specific procedures for material procurement, wastewater disposal, and mercury spill response. **Appendix A** gives an example of a Standard Operating Procedure used by a hospital to implement a mercury reduction policy.

2.3 Planning and Goals

An important part of any Mercury Management Plan is the setting of goals and objectives and the development of a plan and schedule to meet them. While all facilities will have an ultimate goal of achieving and maintaining compliance with the MWRA mercury discharge limit, each facility will have its own set of priorities and directions. As explained below, the planning process to achieve compliance for mercury discharges should be a cross-functional effort.

2.4 Roles, Responsibilities, and Resources

To maximize its mercury discharge reduction effort, the Mercury Management Committee should assign specific roles and responsibilities to various individuals in developing and carrying out the overall Mercury Management Plan. It is important to include representatives from each discipline or department that could be involved. Organizational structures vary over a wide range; however, for most organizations, the process should include representatives from laboratory, manufacturing, purchasing, environmental health and safety, and maintenance departments. It can be expected that the tasks of plan development and implementation will require cooperation between the responsible departments. These tasks must be coordinated with oversight and follow-up to ensure an orderly and cost-effective mercury discharge reduction effort.

Senior management representatives must also be active participants to ensure such coordination, oversight, and follow-up. These representatives may need to enforce written policies to ensure that they are continuously put into practice. Since a comprehensive effort can involve large commitments of capital and personnel, an important part of the senior management effort will be the allocation and scheduling of those resources to address efficiently the needs of the organization and of regulatory agencies. For example, Standard Operating Procedures of the facility should include descriptions of the authority and responsibilities of each level of staff members.

The selection of, and investment in, a proper Mercury Management Committee will help to ensure a most cost-effective and resource-effective implementation of the steps listed below.

2.5 Controls and Procedures

Successful mercury management has often been organized around four major components:

- Source Identification
- Source Reduction and Segregation
- Infrastructure Control and Maintenance
- Pretreatment Systems

Many dischargers have found that actions in each of these areas are needed as part of an ongoing Mercury Management Plan. Control measures span the spectrum of administrative, procedural, and engineered controls. Source reduction, source segregation, infrastructure improvements and, in some cases, pretreatment will be needed. Frequently, more than one measure may be needed to achieve continuously the MWRA mercury discharge enforcement limit of 1.0 µg/L (ppb). While the sequence of actions carried out by different institutions may vary, it has proven helpful to go through the steps listed below when developing a plan for controlling mercury discharges:

- Inventory past and present mercury sources (uses) in the facility.

- Verify and, if possible, quantify suspected mercury sources by reviewing available data and contacting product and chemical manufacturers.

- Track pathways by which mercury enters wastewater and the sewer system.

- Conduct a targeted monitoring program to track the location of mercury sources in the facility and any changes in mercury discharges at permitted monitoring locations that result from source reduction, infrastructure improvements, or pretreatment.

- Identify substitute products and alternative processes to reduce or eliminate current mercury uses through information exchange and contact with manufacturers.

- Evaluate and test possible substitute chemicals, operating procedures, and production processes for effectiveness, and implement those that are feasible.

- For products or chemicals without available substitutes, segregate the associated waste streams for special handling and disposal.

- Establish and publicize a facility policy on the sewer disposal of individual wastewater streams.

- Develop and implement an employee training and education program.

- Conduct wastewater characterization studies to obtain specific data regarding problem sources or chemicals, monitor progress in reducing mercury concentrations, and learn of possible interferences with candidate mercury pretreatment systems from, for example, suspended solids, other heavy metals, or complexing agents. Reduce or segregate such interfering waste streams.

- If necessary, clean or replace waste piping infrastructure (traps, drains, and lines) in the facility to remove mercury accumulations from past use and mercury-contaminated bacteriological growth (biomass).

- Implement mercury pretreatment of wastewater, if needed, to achieve compliance.

- Reconsider and implement additional source reduction actions, infrastructure improvements, waste segregations, or pretreatment processes to reduce mercury levels further as needed to remain in compliance, using routine monitoring of operations and of wastewater discharges as guides for action.

For a flow diagram depicting much of this process, refer to Section 3.0, "Step-by-Step Approach to Discharge Compliance" of the MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997.

2.5.1 Identifying Sources of Mercury

The first step to manage mercury discharges is to identify how mercury enters the facilities wastewater. Several approaches to accomplish this task are summarized below:

Process characterization

Facilities should use process flow diagrams to develop a conceptual model of the facility as a series of individual processes or unit operations that produce a product or service. All steps in the processes where mercury or mercury-containing materials are either added or discharged should be emphasized in the diagrams to show where opportunities exist for source reduction and control or prevention of mercury in the wastewater before it is discharged from the process. Large, complex facilities with many separate operations can use a combination of different, connecting process flow diagrams. Examples of process flow diagrams for an overall facility and for a specific process (photodeveloping) can be seen in **Figure 1A** and **Figure 1B**, respectively. A second useful way of tracking pollutant sources is to list the production steps and locations and the specific mercury sources and quantities in each step. This approach can be used as a tracking method to ensure that all mercury sources are considered for control and to measure progress of the program at any given time.

Hidden Sources

Comprehensive process flow diagrams and lists will help identify the large, obvious mercury contributors but may not help to identify all existing sources of mercury. All paths and opportunities for the introduction of mercury from "hidden" sources must be identified. For hidden sources of mercury, consider the following possible sources:

- process feed materials, pharmaceuticals, reagents, and chemicals (such as ophthalmic and contact lens products, nasal sprays, vaccines, histological fixatives (*e.g.*, B5 and Zenker's Solution) and stains, hematoxylin, and chemicals (*e.g.*, Toxi-Dip B3) used for acidic drug analysis by thin layer chromatography)

Figure 1A
Example Process Flow Diagram
Overall Facility

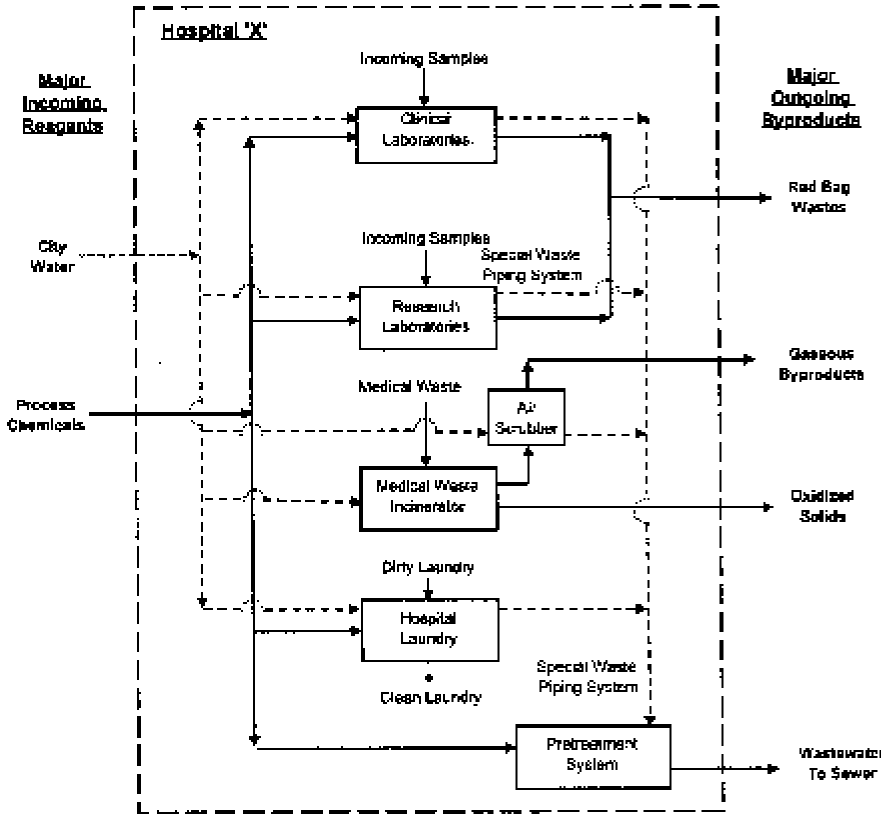
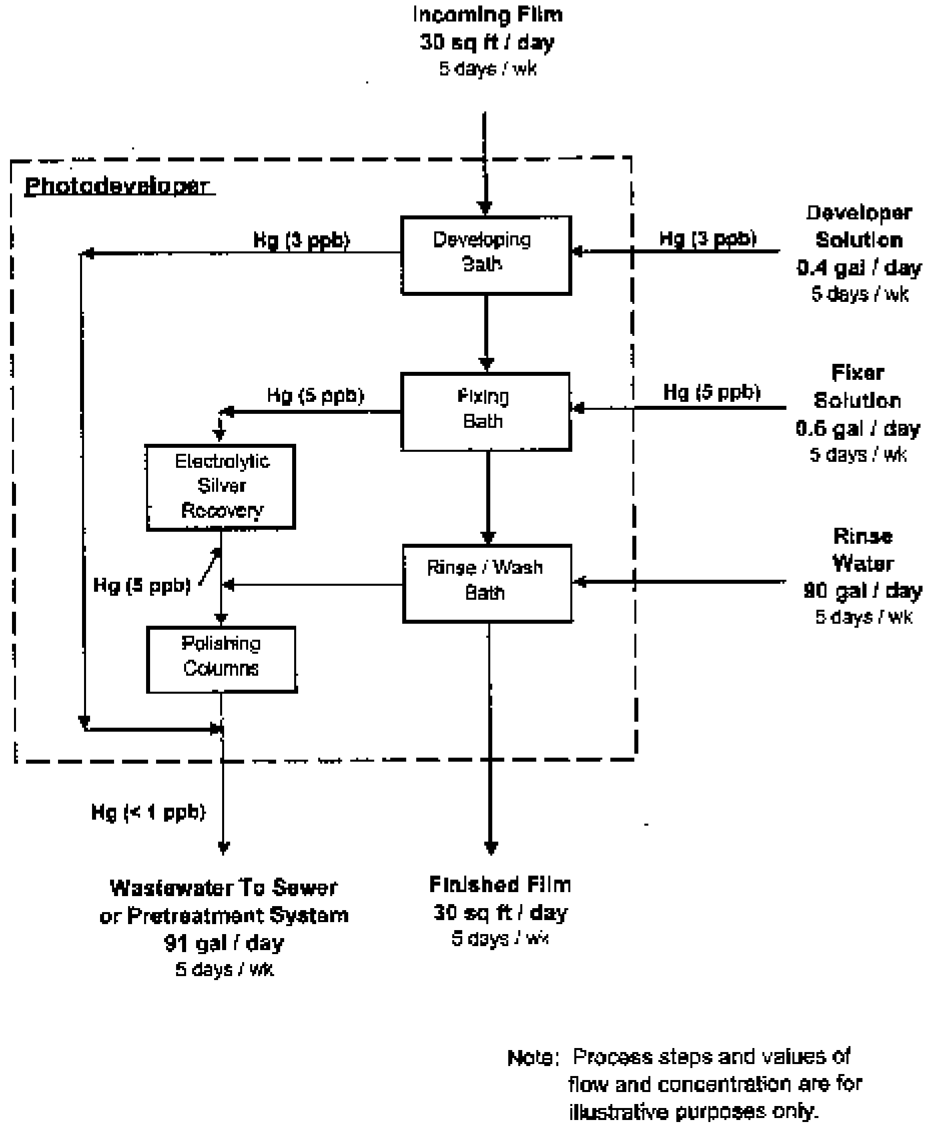


Figure 1B
Example Process Flow Diagram
Specific Process - Photodeveloping



- medical and biological wastes (blood and blood products, specimen cultures, dental amalgam, and pathological wastes including organs, tissues, and body fluids)[4]
- tissue grinders [5]
- cleaning materials, soaps and other chemicals used by janitorial services
- contaminated manufacturing or processing equipment
- inputs from an incinerator emission control process such as the fume scrubber.
- facility infrastructure (the Special Waste [6] piping system itself)[7]

Mercury sources may be distributed throughout a facility. Institutional processes and activities that occur in decentralized locations present challenges to investigations of sources of mercury-contaminated wastewater. Hospitals and other medical institutions are good examples of this problem because many different types of clinical and research laboratories may occupy adjacent areas or may be spread throughout the facility. For example, a common sink used by individuals from several different departments can be a significant source of mercury contamination.

Mercury Source Identification: Materials

The following actions can be taken to identify sources of mercury contamination in commercial, industrial, and laboratory products used at your facility:

- Research available information from chemical supply vendors including Material Safety Data Sheets (MSDS) assays and safety information on reagent containers, and if available, certificates of analysis that could suggest the presence of mercury in their products. Vendor information may be limited in usefulness because mercury-bearing substances present in concentrations less than 1 percent or considered proprietary may not be reported in MSDSs or assays.

- Refer to the MWRA/MASCO database of mercury-bearing substances, chemical reagents, and other commercial products that may be in use within a facility. Refer to **Section 1.2** and **Section 3.0** for information on the database. The database was developed with information obtained from many industries and institutions that have conducted testing of substances commonly discharged to the MWRA sewerage system.

- Request Certificates of Analysis from all suppliers. The request should specify that Certificates of Analysis list mercury contents in micrograms per liter (µg/L) or parts per billion (ppb), not as percentages. For nondetectable concentrations, the Certificates of Analysis should report the respective analytical detection limit.

- Perform mercury analyses on reagents disposed to drains in significant quantities if mercury content information is unavailable. Initial analyses could be done on products found in and around sinks in the facility. Continuous and intermittent discharges from automatic instruments or machines should also be tested. Note that many domestic cleaning agents available at retail stores, such as soaps, detergents, and bleaches, are known often to contain mercury.

Mercury Source Identification: Facility Infrastructure:

In facilities where mercury was or is being used, the infrastructure itself may be a significant source of discharge pollution. The waste plumbing system should be examined for residual mercury by conducting a sampling and testing program from the point of discharge, including any existing pretreatment systems, all the way back to points of process discharges into system. Consider the following:

- Passive pH neutralization systems, *i.e.*, limestone chip tanks, can accumulate mercury-containing deposits often in association with organic substances. Even when a chip tank is acceptable, the tank must be inspected and serviced monthly.[8] Such tanks are not allowed for recombinant DNA biomedical research or production laboratories.[9]

- Active pH neutralization systems may also accumulate metallic mercury or mercury-containing deposits and may introduce additional mercury by using low-grade mercury-containing alkaline (NaOH) or acidic (H_2S0_4 or HCl) neutralization and treatment chemicals.

- Sampling ports in the wastewater piping system should be located to segregate areas by operations and (if necessary) by discrete activities in individual units.

- Inspect sink traps for accumulations of elemental mercury from past disposal practices. A sink trap cleaning and replacement program could be conducted when suspected source areas have been isolated by other means. Contents from sink traps, both liquid and sediment, can be analyzed for mercury as a record of past and (after the initial cleaning) recent mercury-bearing material disposal to the drain. The traps should be thoroughly cleaned or replaced before reinstallation. Refer to **Section 2.5.4** and **Appendix B** for further information on infrastructure control measures.

- Inspect waste piping systems, particularly laterally running pipes, for accumulations of sediment or bacteriological growth (biomass). Refer to **Section 2.5.4** and **Appendix B** for further information on infrastructure control measures in Special Waste piping systems.

2.5.2 Source Reduction Methods

This section addresses the planning process from the point where the processes using mercury have been characterized and mercury sources have been identified and quantified. Once a better understanding of mercury sources and uses has been developed for the facility, the process of identifying and evaluating source reduction options can be started.

The information in this section is summarized in part from *"A Practical Guide to Toxics Use Reduction*" prepared by the Massachusetts Office of Technical Assistance (OTA). OTA provides free assistance to Massachusetts industries that wish to set up a source reduction program at their manufacturing facilities. Additional sources for information on source reduction are listed in **Section 3.0** of this document.

Mercury source reduction can be achieved by many methods, ranging from complete redesign of processes to simple changes in work habits and chemical handling practices. These methods can be categorized into six generic types of source reduction options as follows:

1. Input Substitution
2. Product Reformulation
3. Process Redesign/Modification
4. Process Modernization
5. Improved Operation and Maintenance
6. Recycling and Reuse

1. Input Substitution

This source reduction method or technique involves substituting materials or equipment that contain mercury with non-mercury replacements. Examples of this technique include replacement of elemental mercury with Galinstan™,[10] changing chemicals to higher grades (e.g., changing sodium hydroxide and sulfuric acid that may be used in wastewater neutralization and treatment), and replacing thimerosal containing reagents with non-thimerosal containing products. Additional examples of successful input substitution can be found in **Case Studies 1, 3,** and **7** in **Appendix F**.

2. Product Reformulation

This technique focuses on reducing or eliminating mercury in the final manufactured products. Beyond reducing mercury discharges, this method may permit companies to increase sales by appealing to growing consumer demand for "green" products. If your product formulation is specified by your customers, consider negotiating with them to change their specifications. Customers may need to be educated to realize the potential benefits of sound environmental practices. **Case Study 4** is a good example of this source reduction technique.

3. Process Redesign/Modification

When source reduction is achieved by developing and using new and different equipment or processes than those currently in use, it falls under the category of process redesign. This technique focuses on alternative ways of conducting a process (e.g., manufacturing a product, analyzing a sample) that will reduce or eliminate the use of mercury in the process and the generation of a mercury- containing discharge. One example of this technique is replacing mercury thermometers with digital units. **Case Study 6** presents another use of this option.

4. Process Modernization

This technique is similar to process redesign, but does not involve a total redesign of the equipment or processes being used. Instead, existing equipment/processes are modified or replaced with newer, more efficient approaches based upon the same technology as the old. Because fundamental changes in process technology are not made, process modernization options will often pay for themselves more quickly than process redesign options. Examples of this technique are more precise metering of chemicals and reagents into a process, and new sample analyzers that use smaller quantities of reagents. Additional examples are shown in **Case Studies 1**, **3**, and **7**.

5. Improved Operation and Maintenance

This source reduction technique applies to all industries and should be pursued by all facilities using mercury or mercury-containing materials. Improved operation and maintenance often results in significant reductions in mercury discharge, and bottom-line savings, without major up-front costs. Improved operation and maintenance has three primary categories: Inventory Controls, Materials Handling Improvements/Housekeeping and Personnel Training. Examples of the first two categories are discussed below. More detailed information on personnel training programs can be found in **Section 2.8** and **Appendix E** of this Guidebook.

Inventory Controls

- Train personnel on how to identify and order/purchase mercury-free materials
- Purchase chemicals and supplies as they are needed to reduce storage time.
- Computerize purchasing to improve inventory control.
- Install inventory management software to track supplies.
- Offer incentives to reduce rates at which stocks of chemicals and supplies expire.
- Control cleaning chemicals used by contractors.

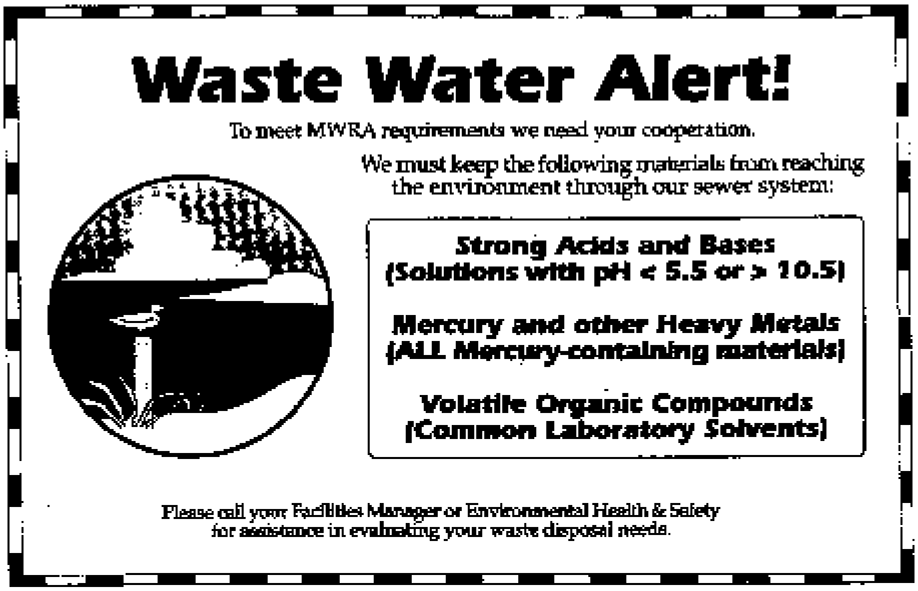
Housekeeping/Materials Handling Improvements

- Improving housekeeping procedures (e.g., prohibiting water used in floor washing in non-process areas from being poured down drains connected to the Special Waste system).
- Develop a spill control plan for mercury-containing materials, including the use of mercury cleanup kits. Make sure spills and leaks are not discharged to the sewer.
- Loading docks - repair or replace any leaking valves, pipes, pumps, containers, and fill hose or fill line connections.
- Storage areas - ensure that tank overfill alarms are working, storage containers are properly sealed and curbed, and workers are trained in proper chemical transfer procedures.
- Laboratory stockrooms - protect containers to eliminate breakage.
- Production areas/laboratories - repair or replace leaking tanks and equipment.
- Work with employees to reduce leaks and spills during material transfers or equipment operation (e.g., mixing batches of reagents.)
- Institute a program to have employees separate mercury- containing materials from the waste stream (e.g., fixatives with thimerosal, mercury thermometers, and batteries).
- Production areas/laboratories - place portable thermoplastic screens in sinks to keep medical or biological solids out of drains.

Personnel Training

Improve employee awareness of mercury discharge issues, sources of mercury in the facility, and proper handling and disposal procedures. Post signs near all sinks and drains in work areas stating that disposal of any mercury-containing compounds to the sewers is prohibited. Refer to **Figure 2** for an example "Waste Water Alert!" sticker used at some facilities. Replace the signs regularly with different background colors or revised text to maintain a high level of awareness and compliance. Develop and periodically update specific lists of mercury-containing compounds for each work area.

Figure 2
Example AWaste Water Alert! Sticker



Develop standard and improved operating and maintenance procedures. Set up personnel training and retraining programs. **Case Studies 1**, **2**, **3**, **4**, **6**, and **7** provide examples of improved operating and maintenance procedures. Refer also to the Example Standard Operating Procedure in **Appendix A**.

6. Recycling and Reuse

This type of source reduction technique has the potential to provide significant reductions in chemical purchase and disposal costs, and includes recycling both treated water and recovered mercury. An example of this technique is given in **Case Study 3**.

Source reduction programs usually include the development of formal procedures for identification of source reduction options, evaluation of the identified options, and implementation of favorably evaluated options. The following are summaries of these three steps:

Source Reduction Options: Identification

One commonly used technique for developing a list of source reduction options is a series of brainstorming sessions involving several individuals at the facility. The group should consist of facility management, engineering, maintenance, equipment operators, manufacturing and laboratory personnel as appropriate. All options generated should be initially listed, without judging feasibility. Developing an extensive list of options is beneficial since it will then be more likely that the best options for the facility will be identified. After the list is generated, the screening process can begin.

Source Reduction Options: Evaluation

The initial consideration of options need not be very detailed, but it should be documented and structured to show why a given option is considered infeasible, worthy of further study, or ready for implementation. Using an "option screening table" is often helpful in structuring the evaluation. The screening table lists the options for each part of the process, ranks them for technical and economic feasibility[11] and pollution prevention potential, and shows what action will be taken. When identifying options, the important thing is not to get the category of option correct, but to know what makes up good versus bad source reduction methods. For example, if a proposed option will increase worker exposure to safety and health hazards, it is not a viable source reduction option.

Source Reduction Options: Implementation

As in any planning process, careful scheduling and anticipation of results are needed for effective implementation. Once the mercury reduction options are identified and chosen, an implementation schedule and task list should be developed and responsibilities should be assigned.

Such a schedule is particularly important if your facility is currently in noncompliance with the MWRA mercury discharge limit. Compliance with MWRA limits is a task and schedule driven process. The MWRA enforcement staff defines and negotiates specific compliance dates based on discussions and documents from the facility and their knowledge of what is needed. If a facility does not define the actions and schedule that it wishes to follow to achieve compliance, the MWRA may define them for the facility. The MWRA approach may not be as convenient or as cost-effective as a proactive plan developed by the facility itself.

Be practical in scheduling: allow a reasonable amount of time for foreseeable and unexpected delays such as receiving results from analytical testing laboratories, receiving price quotes, or completing construction activities.

Source Reduction Summary

In cases where source reduction alone will not be sufficient to bring the facility into compliance with the current MWRA enforcement action threshold of 1.0 µg/L (ppb) for mercury, additional infrastructure, source segregation, and/or pretreatment actions may be warranted. However, when source reduction is incorporated into a Mercury Management Plan, the need for pretreatment will often be significantly reduced. This often results in a lower overall cost than if pretreatment alone is pursued. **Case Study 7** shows how a clinical testing laboratory could significantly reduce the size of a pretreatment system by including source reduction and segregation measures into its successful efforts to achieve compliance.

2.5.3 Peak Discharge Control Methods

As part of its Phase II effort, the MWRA/MASCO Mercury Work Group studied mercury loadings from five groups of facilities that had MWRA discharge permits: clinical laboratories, medical waste incinerators, hospital laundries, medical and biotech research laboratories, and other related facilities (including college laboratories, steam suppliers, pharmaceutical manufacturers, and testing laboratories). The study used discharge flow estimates and available mercury concentration data to calculate estimates of average mercury loadings (in pounds per day) for 242 of these facilities having 355 permitted discharges or sampling locations.[12]

One finding of the study was that many of these facilities had sporadic peak mercury discharges during the study period. Frequently, the peak discharges seriously affected the average mercury concentrations from the facility. For example, a hospital laundry was found to have discharged mercury at an average of about 400 µg/L (ppb) for six daily composite samples collected during a six month period. Two of the six samples were measured at about 1,000 µg/L (ppb) and 1,400 µg/L (ppb), but three samples were at or below 1.0 µg/L. The 1,400 µg/L (ppb) sample suggested that the hospital laundry discharged more than 0.1 pounds of mercury in that one day.[13] Since the overall loading to the MWRA sewerage system is estimated to be between 0.75 and 1.0 pounds per day,[14] the discharge from this one facility represented a very significant one-day loading of mercury.

To limit such sporadic peak discharges, facilities should develop and carry out a source reduction program as outlined in the previous section. For many facilities, peak discharges are likely to be associated with individual daily activities of material handling, operations, and maintenance. Therefore, continuous training and monitoring of personnel are essential activities to assure that proper material handling, processing, and disposal procedures are practiced at all times.

For facilities that continue to experience sporadic peak discharges after implementation of an intensive source reduction program, segregation of problem waste streams from the sewer discharge should be considered. Since the source reduction program should help to identify the problem waste streams, control of peak discharges could become a matter of selection of alternate disposal methods (offsite disposal) for the identified waste streams. Refer to **Section 1.3** in **Appendix C** for a discussion of procedures and permits required for offsite disposal of various waste streams. Refer also to the following section for the possible contributions of biomass accumulations to sporadic peak mercury discharges.

If a pretreatment system is to be installed, limiting the mercury concentration peaks remains an important consideration. Problem waste streams can be segregated from the influent to the pretreatment system. Also, a mixed equalization tank can be used to reduce variations in both the wastewater flow and concentration. To limit concentration peaks, the equalization tank would be operated in a partially full mode so that a volume of liquid would exist within the tank at all times. The liquid volume would serve to dilute short-term peaks in incoming mercury concentrations. A mixer would ensure that concentrations remain uniform throughout the liquid volume in the tank.[15] Refer to **Section 2.5.5** for a discussion of pretreatment systems.

2.5.4 Infrastructure Control Measures

In some cases, the following have been recognized as significant contributors to chronic mercury contamination in wastewater discharges from wastewater piping systems that carry Special Waste:

1. Quantities of elemental mercury that have collected in Special Waste piping traps that serve sinks and other fixtures.
2. Organic mercury accumulations in the bacterial biomass growth on the interior walls of the Special Waste piping infrastructure.

The presence of elemental mercury in traps and other collection points of the Special Waste piping infrastructure of a facility can result from past inappropriate disposal practices. The deposits of elemental mercury can contaminate the wastewater passing through the Special Waste system for indefinite periods.

Large quantities of bacterial biomass growth within the Special Waste piping infrastructure of a facility may be very important because mercury and mercury compounds can be converted by bacteria into very toxic methyl mercury that becomes accumulated and highly concentrated in the biomass. This phenomenon is called bacterial "bioaccumulation" and "bioconcentration" of mercury. Then, dislodged pieces of the mercury-laden biomass may be carried into the wastewater stream. In this way, large accumulations of biomass within a Special Waste piping system can lead to instances of high mercury concentrations in the discharged wastewater.

Therefore, infrastructure control measures may have to be addressed in the Mercury Management Plan developed by a facility. Specific infrastructure control measures are outlined in **Appendix B** and its subsections: *Special Waste Piping Design* (**Appendix B-1**), *Special Waste Trap Cleaning/ Replacement* (**Appendix B-2**), and *Special Waste Piping Power Washing* (**Appendix B-3**). The guidelines and procedures outlined in these appendices relate to mercury and biomass and their removal from Special Waste traps and piping systems. However, these guidelines can be followed by any facility where the discharge of mercury-containing materials to waste piping systems is suspected or has been confirmed.

It must be noted, however, that the biomass removal procedures have been found totally ineffective in reducing mercury concentrations in wastewater from metal waste piping systems such as copper,[16] high silicon cast iron and stainless steel. The reason may be that mercury cannot easily be removed from most metal surfaces because of the strong tendency of mercury to react with metals and form an amalgam (or alloy). From the amalgam, the mercury can still be released and metabolized by bacteria in the Special Waste piping system.

For all waste piping systems, depending upon the approach specified in the facility's Mercury Management Plan, infrastructure control measures may include some or all of the following steps:

- source reduction
- source segregation, waste piping modifications
- waste trap sampling, cleaning, or replacement
- waste piping replacement or cleaning (power washing)
- wastewater collection for offsite disposal[17]
- wastewater pretreatment (possibly consisting of solids sedimentation, multistage filtration, or other process steps).

While these measures are listed in a possible chronological order, some of them could be eliminated depending upon a facilities specific Mercury Management Plan.

Before any infrastructure control measures (as detailed in **Appendices B** and **B-1**, **B-2**, and **B-3**) are started, however, a facility should take all steps needed to prevent any elemental mercury or mercury-containing compounds from being disposed to the Special Waste drains of the facility. Continued disposal of any amount of mercury to the drains may mean that the waste trap and piping cleaning procedures would be totally ineffective or effective only for a short period. Then, the waste trap and piping cleaning procedures would have to be done again to reduce effluent mercury concentrations.

The MWRA is currently formulating requirements for data collection during power washing. As part of this process, a facility must notify the MWRA of its intention to do power washing and participate in a study of power washing effects according to specific conditions and protocols. The results of the study will be used to finalize a MWRA guidance on acceptable power washing procedures. Currently, the MWRA is concerned that:

- Power washing may be improperly considered by some facilities as a substitute for comprehensive mercury management that would include source reduction (including purchasing and inventory controls), source segregation (including training and supervision of waste disposal practices), and/or pretreatment.

- Power washing may lead to greater mercury violations for an indefinite period as small particles of loosened mercury-laden biomass are discharged with normal wastewater flows for several days or weeks after the power washing procedure.

Refer to **Appendix B-3** for details on the interim MWRA power washing requirements.

2.5.5 Pretreatment Systems

Facilities that experience difficulties in complying with sewer discharge limits after implementing aggressive source reduction, source segregation, and infrastructure control measures may find that "end-of-pipe" pretreatment systems may be needed to achieve compliance. Since mercury discharges to the environment have recently received considerable attention from national (EPA), regional (Great Lakes), and local (Boston, San Diego) regulatory agencies, several vendors of wastewater pretreatment technologies have conducted research, development, and marketing activities related to mercury removal systems.

The MWRA/MASCO Mercury Work Group, End-of-Pipe Subcommittee, Technology Identification Subgroup, conducted a Bench-scale Feasibility Testing Project in 1997 for which six vendors of mercury pretreatment technologies volunteered to participate. The participating vendors offered mercury removal systems in the following main process technology areas:

- Activated / Modified Carbons - Barnebey & Sutcliffe Corporation and ICET, Inc.
- Other Specialized Adsorbents - Aero-Terra-Aqua (ATA) Technologies Corporation, ICET, Inc. (a second offering), KDF Fluid Treatment, Inc., and SolmeteX, Inc.
- Electrolytic Precipitation Systems - Soils N.V. (Zwijndrecht, Belgium).

Besides these vendors and process technologies, the Subgroup found other vendors that offered enhanced filtration systems for mercury removal applications. Facilities that are considering the installation of mercury pretreatment systems are encouraged to refer to the *Technology Identification Subgroup Report*[18] that details the methods and results of the Bench-Scale Feasibility Testing Project and to its companion document, the *Pretreatment Guidance Manual*.[19]

As a follow-up to the MWRA/MASCO effort, the Massachusetts Strategic Envirotechnology Partnership (STEP), operating under the Massachusetts Executive Office of Environmental Affairs (EOEA), has been conducting a pilot-scale project of four mercury removal technologies at three wastewater generating facilities. The STEP project report is expected to be published in late 1999.

One of the most important steps in the selection of a pretreatment system is to learn the physical and chemical characteristics of the process wastewater stream in question. The study of wastewater characteristics may help identify the presence of contaminants from each contributing industrial or laboratory process. Based upon analytical testing of representative waste stream samples, the levels of contaminants can be compared with the limits of applicable sewer discharge regulations. The scope of the characterization effort will vary from simple to complex depending upon the nature and size of the facility and upon the type and extent of the discharge problem.

For wastewater containing mercury, a wastewater characterization study could include determination of the chemical species and physical forms of mercury that may be present. Mercury in wastewater may exist in three chemical species: metallic, ionic, and organic. In addition, the various species of mercury may bind to particulate matter in the wastewater to form physical agglomerates containing mercury.

In analytical testing of wastewater samples, total mercury concentrations are usually determined by analytical laboratories using EPA Method 245.1 with a method detection limit of 0.2 µg/L (ppb).[20] Besides meeting current regulatory requirements, this EPA method is usually the analytical method of choice because most applicable federal, state, and local regulations typically address total mercury concentrations.

Of the various mercury species that may be present in a wastewater stream, concentrations of particulate mercury are the easiest to quantify. Particulate mercury concentrations in wastewater samples are not directly measured, however, but are determined as mathematical differences in analytical test results of total mercury and dissolved mercury. Dissolved mercury concentrations are determined using EPA Method 245.1 on wastewater samples that have been initially filtered through a 0.45 micron (mm) filter. Additional tests on samples filtered through larger and smaller (such as 0.2 mm) filters are sometimes recommended because particulate mercury is such an important species of mercury in wastewater.

Contaminants in the wastewater (such as suspended solids; metals like copper, lead, and zinc; solvents and other organic compounds; or metal-complexing agents like ammonia and detergents) can interfere with the proper operations of certain wastewater pretreatment systems. If individual process waste streams contain these interfering contaminants, the waste streams could be either reduced, segregated from the other streams, or eliminated. If this is not possible, the pretreatment system must be designed to work effectively with the identified interfering contaminants.

A wastewater characterization study that examines these issues can help to set an overall approach to achieving compliance with regulations. Such an overall approach may involve a combination of source reduction, source segregation, and pretreatment. If the facility does not have qualified technical staff, an experienced consulting engineering firm should be employed to perform the wastewater characterization study and to help in the development and execution of the overall approach.

2.6 Managing Mercury Wastes

Guidance for managing mercury wastes according to federal and Massachusetts regulations is presented in **Appendix C**. This Appendix also deals with regulatory issues of collection and offsite disposal of industrial wastewater from a facility in an area served by a sewer system (see **Section 1.3.2**).

The information in **Appendix C** may be helpful in mercury source identification and waste reduction efforts. Wastes that exceed the current MWRA enforcement limit for mercury may be generated when activities such as waste stream segregation and infrastructure control measures are carried out.

2.7 Communication

Communication is key to the pursuit of a cost-effective reduction effort. Because many tasks will cross departmental lines, regular planning and review meetings are necessary to ensure the proper exchange of information and progression of effort. Intra-departmental communication must also take place as direction and training for the generators and managers of the waste streams. Finally, an organization must maintain good communication with the regulatory agency including a compliance schedule and routine progress reports. This reporting relationship can also become a pathway for exchange of information as new products or reduction methods are identified.

To keep personnel up-to-date on all waste management issues, the facility may want to develop newsletters and informational posters, distribute published articles, or implement other appropriate means of communication.

2.8 Training and Education

Once a facility has identified its sources of mercury and has determined what methods it will use to control those sources, it is imperative that all staff be trained in the new waste management techniques the facility has adopted. Each staff person should be made aware that the actions of each individual throughout the workday can directly affect the compliance status of the facility wastewater discharge.

The mercury management committee should play an integral role in developing the training program. While the training program should be tailored to each facility's needs, each program should include an overview of the following topics:

- regulatory requirements and responsible agencies
- sewer discharge regulations/prohibitions
- air emission regulations
- solid and hazardous waste regulations
- plumbing infrastructure information
- treatment systems information
- mercury source list
- policies and procedures for purchasing mercury-containing and mercury-free materials
- product substitution/source reduction
- proper handling techniques
- wastewater sampling protocols
- pH monitoring
- distinguishing and segregating sanitary waste from Special Waste
- waste management
- recycling opportunities
- waste minimization techniques
- waste disposal protocols and required permits

The training program should be presented to all affected facility personnel as soon as all new waste management techniques are in place. Newly hired personnel should be trained within thirty days of hire. All staff should be provided with refresher training annually, at a minimum. Refer to **Appendix E** for an example of a mercury awareness "Training Packet."

2.9 Periodic Reviews

To monitor the effectiveness of a Mercury Management Plan and maintain a continuous improvement effort, regular periodic reviews are needed. These reviews would have a dual intent:

- ensure control of mercury discharges and compliance with regulatory standards, and
- ensure continuing adherence to internal mercury management policies and procedures.

The periodic reviews should target the key areas of the Mercury Management Plan and should be scheduled accordingly for review and repetition. Annual reviews could be done for facilities that have successfully set up their Mercury Management Plan. More frequent reviews should be done during the first year, when changes are made to the system, or when deficiencies are found. Priorities should be based on the facility's assessment of its particular risks and vulnerabilities.

The periodic reviews should include assessments of source reduction and waste management practices, employee training and communication, and wastewater monitoring and pretreatment programs. Additional factors that may affect topics, complexity, and frequency of the reviews could include regulatory changes, new processes or operations, and personnel changes.

Review observations should identify deficiencies and omissions in the Mercury Management Plan and should also identify and emphasize its strengths. The reviews could include unannounced site visits to observe work practices. Reviewers may recommend actions that address ways to ensure or improve staff compliance with written mercury management procedures.

Plan review findings and recommendations should be documented and shown to senior and operations managers for their examination and action. Copies should also be distributed to operations, environmental, engineering, maintenance, and other staff as appropriate. Additionally, managers of the reviewed operations should develop and execute any needed corrective action plans that set timetables and assign responsibilities for implementation. Periodic follow-up is recommended to ensure completion of any remedial actions.

For a regulatory agency, an ongoing Plan review program at a facility may show the facility's awareness and intent to address mercury compliance issues. Thus, review results could be made available to the MWRA or other regulators as appropriate. It is recommended that a facility discuss their Plan review process with the regulating authority so that a mutual and written understanding can be reached regarding the release and use of review reports.

2.10 Continuous Improvement

Because the results of periodic reviews of a Mercury Management Plan can greatly help a facility to identify Plan accomplishments and deficiencies, periodic reviews serve as mechanisms for providing feedback into the Plan. With the support of management, the Plan can then be modified and improved to meet the goal of total success. Therefore, a successful Mercury Management Plan is usually one that includes a regular iterative process of investigation, action, measurement, review, and revision.

The Mercury Management Subcommittee of the MWRA/MASCO Mercury Work Group hopes that this Guidebook can help many facilities to properly address, successfully and efficiently achieve, and continuously improve the management of mercury.

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3.0 SOURCES OF INFORMATION

The following are sources of additional information on topics discussed in this Guidebook:

MWRA/MASCO Mercury Work Group

Reports of the Phase II effort:
Facilities Loadings Subgroup Report, December 1997.
Pretreatment Guidance Manual, December 1997.
Technology Identification Subgroup Report, December 1997
Mercury Management Guidebook, May 1999(this document)
The above reports are also available at the following Web-site addresses:
http://www.mwra.state.ma.us
http://www.masco.org/mercury

Mercury Products Database
Massachusetts Water Resources Authority
Toxic Reduction and Control Department
Technical Services Group
100 First Avenue
Boston, MA 02129
(617) 242-6000, Ext. 4900
FAX (617) 788-2301

Medical Academic Scientific Community Organization, Inc. (MASCO)
375 Longwood Avenue
Boston, MA 02215
Mr. David Eppstein
(617) 632-2860
FAX (617) 632-2759

The Mercury Products Database is also available at the following Web-site address:
http://www.masco.org/mercury

Regulations

Federal: Federal: U.S. Government Bookstore
10 Causeway Street, Room 169
Boston, MA 02222
(617) 720-4180
FAX (617) 720-5753

State: State: Commonwealth of Massachusetts Bookstore
State House, Room 116
Boston, MA 02133
(617) 727-2834
FAX (617) 973-4858

MWRA: MWRA: Massachusetts Water Resources Authority
Toxic Reduction and Control Department
Technical Services Section
100 First Avenue

Boston, MA 02129
(617) 242-6000, Ext. 4900
FAX (617) 788-2301

The MWRA *Sewer Use Regulations* (360 CMR 10.000) is available at the following Web-site address: *http://www.mwra.state.ma.us*

Pollution Prevention/Source Reduction

Massachusetts Water Resources Authority
(see above for details)
Toxic Use Reduction Institute
One University Avenue
Lowell, MA 01854-2881
(978) 934-3275
FAX (978) 934-3050
http://www.turi.org

Commonwealth of Massachusetts
Office of Technical Assistance
Room 2109
100 Cambridge Street
Boston, MA 02202
(617) 727-3260
FAX (617) 727-3827
http://www.state.ma.us/ota/ota.htm

University of Tennessee
Center for Industrial Services
Suite 105 Student Services Building
Knoxville, Tennessee 37996-0213
(423) 974-1000, Ext. 3018
FAX (423) 974-1528
http://www.cis.utk.edu/

U.S. Environmental Protection Agency
Pollution Prevention Clearinghouse
(202) 260-1023
FAX (202) 260-4659
http://www.epa.gov

Enviroene
http://es.epa.gov/index.html

Monroe County Department of Health
Water Quality Planning Bureau
P.O. Box 92832
Rochester, NY 14692
(716) 292-3935
FAX (716) 274-6098

Hospital Mercury Pollution Prevention ManualHospital Mercury Pollution Prevention Manual, 1998

Waste Management/Employee Training Programs

American Chemical Society
1155 16th West Street
Washington, D.C. 20036
(202) 872-4362

U.S. Environmental Protection Agency
RCRA/Superfund Hotline
(800) 424-9346
(800) 535-0202
http://www.epa.gov/epaOSWER/OSW/hazwaste.htm

Galinstan™ (Mercury substitute)

Geratherm™ (Non-mercury thermometers)

RG Enterprises USA, Inc.
2000 Town Center, Suite 1900
Southfield, MI 48075-1152
(800) 992-9497
FAX (248) 351-2645

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APPENDIX A

EXAMPLE STANDARD OPERATING PROCEDURE
Hospital Mercury Reduction

PURPOSE: To enable the Hospital to meet mercury level standards established by federal and state environmental protection agencies and the MWRA, and to meet requirements of the Hospital's Sewer Use Discharge Permit (Permit).

BACKGROUND: Mercury is a hazardous substance under state and federal environmental laws. The Hospital's Permit and MWRA regulations prohibit the discharge of mercury into the sanitary sewer system. Pursuant to its Permit, the Hospital must monitor its discharges into the sewer system for several parameters and substances, including mercury. Among other enforcement actions, the MWRA may assess monetary penalties for discharges that exceed permitted pollutant levels. Once mercury is introduced into a wastewater stream, removing it can be very difficult and expensive. The Hospital, therefore, must attempt to prevent mercury from entering its wastewater stream to protect the public health and avoid penalties.

POLICY STATEMENT: Mercury-containing products and processes will not be used in any manner on the Hospital campus, including within the Hospital buildings and medical office buildings, unless no reasonable alternatives, as determined by Hospital Administration, are available. When use of a mercury-containing product is permitted, measures will be taken to avoid introduction of mercury into the sanitary sewer system.

APPLICABILITY: Compliance with this policy and its procedures is a condition of employment and of clinical privileges and the use of any property on the Hospital campus. The Hospital reserves the right to take any and all actions, including to seek injunctive relief, to prevent violation of this policy by any party.

PROCEDURES

I. The Hospital's Departments of Engineering, Environmental Services, Purchasing, Pathology, Radiology, and Safety will work together to identify product(s) or process(es) containing mercury currently in use within the Hospital campus and to identify acceptable alternatives. A list of such products/processes and their alternatives will be presented to the Safety Committee that will arrange for its distribution throughout the Hospital community. The list will be reviewed, updated, and distributed at least once per year.

II. When mercury-containing products or processes are identified, the manager(s) for the department(s) using such products/processes will develop a plan to include a.) procedures for the prevention of disposal of any mercury into the sanitary sewer system, b.) a schedule for the elimination of the use of these products/processes or, in the alternative, the rationale (including information required below at IV.) for continued use of such products/processes. The manager(s) will present the plan to the Safety Committee for review and approval.

III. The Safety Committee will review all mercury use plans and may approve the plans as submitted or with modification. Upon approval, the affected departmental manager(s) will implement the plans.

IV. Managers of departments using mercury products/processes will maintain a readily retrievable log of the mercury-containing products/processes, the approved use(s), the alternatives considered, the reasons such alternatives were deemed unacceptable, and a schedule for reconsideration of available alternatives.

V. In case of a mercury spill, employees and physicians will follow the procedures of Safety Policy for Handling of Mercury Spills. Managers must report all such spills to the Safety Committee for review.

VI. All employees and physicians will prevent the disposal of mercury into the sanitary sewer system and will refrain from using mercury-containing products/processes on the Hospital campus unless such use has been approved according to this policy.

VII. All employees and physicians are encouraged to present suggestions for eliminating mercury-containing products or processes from the Hospital to the Hospital Safety Committee.

REFERENCES:

1. OTA Guide
2. UT Manual
3. EPA Pollution Prevention Guide
4. EPA Hospital Guide
5. Hospital Operations Protocol and Training

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APPENDIX B

INFRASTRUCTURE CONTROL MEASURES

As outlined in **Section 2.5** of this Guidebook, infrastructure control measures may include the following steps:

- source reduction
- source segregation, waste piping modifications
- waste trap sampling, cleaning, or replacement
- waste piping replacement or cleaning (power washing)
- wastewater collection for offsite disposal
- wastewater pretreatment (possibly consisting of equalization, solids sedimentation, multistage filtration or other process steps)

While these steps are listed in a possible chronological order, the actual number and order of steps could be different depending upon the facility and its Mercury Management Plan. Occasionally, earlier steps may be repeated before a later step is undertaken.

Infrastructure control measures have been developed and undertaken at several facilities in the MWRA sewer service area because elemental mercury waste deposits and mercury accumulations in biomass growth from past discharge practices were identified as significant contributors to chronic mercury contamination of the wastewater discharges. The accumulation of mercury within waste piping systems containing biomass growth contributes to the complexity of wastewater mercury management at a facility. In addition, because various biological nutrients may be contained in "Special Waste" (defined below), biomass growth can be promoted in facilities that discharge such waste into the building waste piping infrastructure.

The three appendices that follow are focused on mercury and biomass removal from piping systems that carry Special Waste. However, the procedures discussed in these appendices can be followed by any facility where discharge of mercury-containing materials to waste piping systems has been confirmed or is suspected. The appendices are entitled *Special Waste Piping Design* (**Appendix B-1**), *Special Waste Trap Cleaning/Replacement* (**Appendix B-2**), and *Special Waste Piping Power Washing* (**Appendix B-3**).

Before any of the guidelines and procedures presented in these three appendices are considered, however, a facility should take all steps needed to prevent any elemental mercury or mercury-containing compounds from being disposed to the Special Waste drains of the facility. Continued disposal of any amount of mercury to the drains may mean that the waste trap and piping cleaning procedures would be totally ineffective or effective only for a short period. Then, the waste trap and piping cleaning procedures might have to be done again to reduce effluent mercury concentrations.

In addition, because of a lack of consistent analytical data developed before and after power washing of waste piping systems at several facilities, the MWRA is currently developing a policy concerning power washing of Special Waste systems. Specifically, the MWRA is concerned that:

- Power washing may be improperly considered by some facilities as a substitute for comprehensive mercury management that would include source reduction (including purchasing and inventory controls), source segregation (including training and supervision of waste disposal practices), and/or pretreatment.

- Power washing may lead to greater mercury violations for an indefinite period as small particles of loosened mercury-contaminated biomass are discharged with normal wastewater flows for several days or weeks after the power washing procedure.

Refer to **Appendix B-3** for details on the current state of MWRA power washing requirements. To introduce and clarify the following three appendices, Massachusetts Special Waste is defined below and the concepts of biomass growth and mercury bioaccumulation and bioconcentration are discussed.

Special Waste

According to the Massachusetts State Plumbing Code,[1] "Special Waste" includes, but is not limited to, chemicals, nuclear, radioactive, acids, alkalis, perchloric solvents, organisms containing recombinant DNA molecules, and other similar non-domestic wastes from various laboratories and industrial activities. These types of wastes are potentially detrimental to a public sewerage system and often do not comply with discharge limitations established by a local Publicly Owned Treatment Works (POTW) such as the MWRA.

All Special Waste must be conveyed within facilities in a separate, dedicated waste and vent piping system. The Code covers piping design, types of waste neutralization systems, testing requirements, and inspection requirements for Special Waste piping systems. Allowed materials and installation methods are also specified. The Code does not specify the manner by which Special Waste piping systems are to be used after installation or what specific chemicals may be disposed into the system on a daily basis. On the other hand, the Code does prohibit the introduction of solvent-bearing waste[2] and requires the facility owner to submit a notarized letter stating what chemicals will be discharged into the Special Waste system.[3] The letter will be part of the basis of the design of the system by a Registered Professional Engineer. In addition, the Code states that wastewater treatment systems shall be part of the Engineers design when needed for compliance with regulatory limits.[4]

All proposed Special Waste piping and pretreatment system installations, modifications, revisions and additions must be detailed in engineering drawings and specifications and certified by the Engineer. The drawings and specifications must be submitted to the local Plumbing Inspector for review and approval before construction. The approved documents are then submitted to the responsible jurisdictional authority (*e.g.*, the MWRA or the MA-DEP) with the proper permitting documents and supporting engineering design data for final approval before the Special Wastes can be discharged to the sewerage system.[5]

Biomass Formation and Mercury Bioaccumulation and Bioconcentration

Bacterial biomass growth in Special Waste piping systems can be promoted by the presence of organic matter such as blood products, urea, soaps, chemical reagents, and infectious wastes discharged into the piping system. The combination of organic matter, possibly elevated temperatures, and high humidity provides a good environment for biomass growth on the interior surfaces of the waste piping. The organic matter often contains methyl and dimethyl groups that can be combined by certain bacteria with inorganic mercury in the wastewater to create very toxic organic forms of mercury (*e.g.*, methyl mercury and dimethyl mercury). In addition, the mercury accumulates in the bacterial biomass and concentrates to significant levels. Because of the phenomenon of "bioconcentration," bacterial biomass mercury concentrations 1,000 times greater than that found in the wastewater have been reported.

Within a flowing pipe, the biomass growth occurs principally below the liquid level with lesser amounts above. Within a trap at a sink or elsewhere, the growth can be more pronounced because the contained liquid creates a continuous "incubator" with effectively no oxidation or dehydration of the bacteria. A hardened skeleton of carbon, oxidized soap products containing elements such as calcium and potassium, and dried blood products can be formed that strongly adheres to the piping surface.

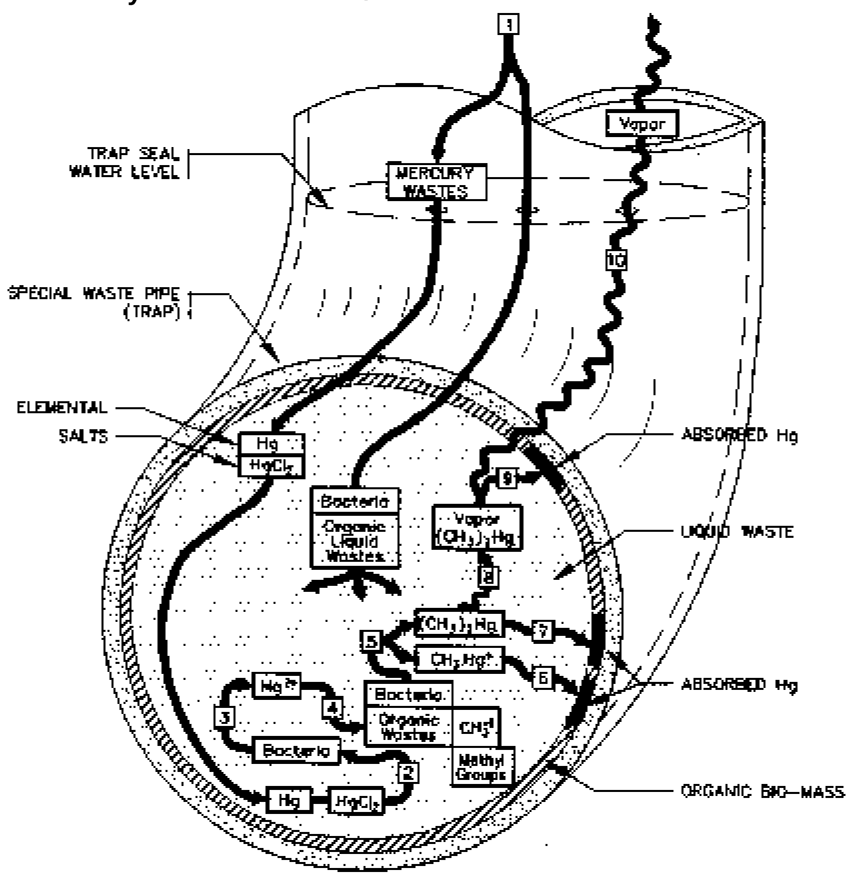
Figures B-1 and **B-2** illustrate the mercury bioaccumulation and bioconcentration process in Special Waste traps and piping, respectively. A numeric key for the figures appears in **Figure B-3** along with a general description of the bioaccumulation/bioconcentration process.

When wastewater flows through the Special Waste piping system, "slugs" of mercury-laden biomass may be carried into the wastewater stream when pieces of the accumulated growth are dislodged from the piping wall. Therefore, large amounts of bacterial biomass growth within the waste piping can lead to instances of high mercury concentrations in discharged wastewater. To move toward compliance with mercury discharge limits, therefore, this phenomenon may have to be addressed in facilities that have mercury-laden biomass growth. The following guidelines and procedures may help some facilities address the issue properly.

It should be noted that bacterial biomass formation can also occur within wastewater neutralization tanks. This formation can increase the potential for further mercury bioaccumulation/bioconcentration and wastewater contamination. According to the Plumbing Code,[6] limestone chips are often used in sumps or tanks (*i.e.*, chip tanks) for neutralization of Special Wastes containing dilute acids and alkalis. Chip tanks should not be used in facilities discharging significant quantities of organic matter, however, since bacterial biomass growth will tend to coat the limestone chips, rendering them useless for neutralization. It is recommended, therefore, that facilities check the condition and efficacy of any chip tanks and replace them with active (adjustable) neutralization systems as appropriate. For additional information, refer to **Section 2.5** of this Guidebook.

See Figure B-3 for Numeric Key Courtesy of Flow-Tech Associates, Inc.

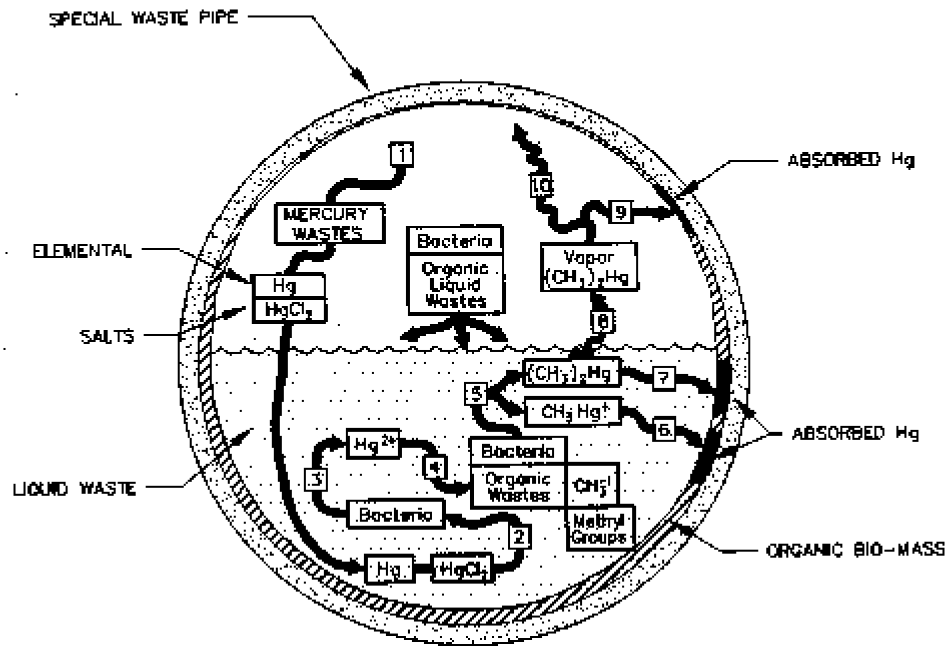
Figure B - 1
Special Waste Trap Cross-Section
Mercury Bioaccumulation/Bioconcentration in Biomass



See Figure B-3 for Numeric Key Courtesy of Flow-Tech Associates, Inc.

See Figure B-3 for Numeric Key Courtesy of Flow-Tech Associates, Inc.

Figure B - 2
Special Waste Piping Cross-Section
Mercury Bioaccumulation/Bioconcentration in Biomass



See Figure B-3 for Numeric Key

Courtesy of Flow-Tech Associates, Inc.

Figure B - 3
Numeric Key for Figures B-1 and B-2
Mercury Bioaccumulation/Bioconcentration in Biomass
NUMERIC KEY FOR FIGURES B-1 AND B-2

Liquid wastes enter the Special Waste piping system carrying organic liquid wastes, bacteria, and mercury wastes such as elemental mercury (Hg) and mercury salts (represented by $HgCl_2$).

Elemental mercury and mercury salts are slowly metabolized by certain bacteria. Chlorides are oxidized to chlorates and mercuric ions (Hg^{+2}) are released.

Elemental mercury is partly converted to mercuric ions (Hg^{++2}).

Mercuric ions (Hg^{+2}) combine with methyl ions (CH_3^{-1}) with bacteria acting as biological catalytic agents.

Toxic methyl mercury ions (CH_3Hg^+) and dimethyl mercury ($(CH_3)_2Hg$) are formed.

Methyl mercury ions (CH_3Hg^+) are absorbed and bioaccumulated/ bioconcentrated in the organic biomass growing on the Special Waste pipe wall.

Dimethyl mercury ($(CH_3)_2Hg$) molecules are absorbed and bioaccumulated/ bioconcentrated in the organic biomass growing on the Special Waste pipe wall.

Some molecules of dimethyl mercury ($(CH_3)_2Hg$) take a vapor form.

Some molecules of dimethyl mercury ($(CH_3)_2Hg$) vapor are absorbed and bio-accumulated in the organic biomass growing on the Special Waste pipe wall.

Some molecules of dimethyl mercury ($(CH_3)_2Hg$) evaporate and are potentially released into the workplace atmosphere from liquid surfaces in traps of the Special Waste piping system.

Courtesy of Flow-Tech Associates, Inc.

APPENDIX B - 1

SPECIAL WASTE PIPING DESIGN MODIFICATIONS

Introduction

This Appendix presents example design considerations for waste piping infrastructure modifications that may be needed before initiation of any cleaning or replacement activities in response to known mercury contamination. For background purposes, the discussion begins with applicable state regulations.

According to the Massachusetts State Plumbing Code,[1] "Special Waste" includes, but is not limited to, chemicals, nuclear, radioactive, acids, alkalis, perchloric solvents, organisms containing recombinant DNA molecules, and other similar non-domestic wastes from various laboratories and industrial activities. These types of wastes are potentially detrimental to a public sewerage system and often do not comply with discharge limitations established by a local Publicly Owned Treatment Works (POTW) such as the MWRA.

All Special Waste must be conveyed within facilities in a separate, dedicated waste and vent piping system. The Code covers piping design, types of waste neutralization systems, testing requirements, and inspection requirements for Special Waste piping systems. Allowed materials and installation methods are also specified. The Code does not specify the manner by which Special Waste piping systems are to be used after installation or what specific chemicals may be disposed into the system on a daily basis.

On the other hand, the Code does prohibit the introduction of solvent-bearing waste[2] and requires the facility owner to submit a notarized letter stating what chemicals will be discharged into the Special Waste system.[3] The letter will be part of the basis of the design of the system by a Registered Professional Engineer. In addition, the Code states that wastewater treatment systems shall be part of the Engineer's design when needed for compliance with regulatory limits.[4]

All proposed Special Waste piping and pretreatment system installations, modifications, revisions and additions must be detailed in engineering drawings and specifications and certified by the Engineer. The drawings and specifications must be submitted to the local Plumbing Inspector for review and approval before construction. The approved documents are then submitted to the responsible jurisdictional authority (e.g., the MWRA or the MA-DEP) with the proper permitting documents and supporting engineering design data for final approval before the Special Wastes can be discharged to the sewer system.[5]

Facility Infrastructure Inspection

The first step in dealing with known mercury contamination in the waste piping infrastructure of a facility is to conduct an audit of the existing piping systems. Drawings that reflect details of the actual waste piping, vent piping, and any associated pretreatment system installations should be prepared. Special Waste diagrams are important tools and can show regulating authorities that the facility has knowledge and control of all Special Waste discharges. These diagrams should display all piping materials and sizes, traps, isolation valves, glass inspection ports or sections, and sampling/drain valves. The diagrams should also show any current areas lacking control or isolation of Special Waste discharges.

Piping System Design and Modification

After the piping system audit, the facility may determine that modifications are necessary to allow for isolation of waste streams, cleaning, sampling, testing, and monitoring. System designs or modifications should consider the following:

- the type of wastes being discharged and the piping material compatibility.[6] Metal piping systems deserve special attention because of the potential for mercury to form an amalgam with the metal. Cleaning of metal piping systems is not expected to reduce effluent mercury concentrations. The cleaning effort may actually cause an increase in effluent mercury concentrations. Thus, redesign and replacement of the systems using nonmetal materials should be strongly considered instead of attempts at cleaning.

- the future uses of laboratory spaces (i.e., a chemical research laboratory that is to be changed to a blood testing laboratory).

- the need to isolate branch piping from waste and vent stacks to allow pipe cleaning (if needed and selected) without constricting waste flows from other areas or causing overflows to uncontaminated piping systems.

- the investigation of unidentified Special Waste sources and associated piping for bacterial biomass and mercury content before combining with previously identified Special Waste piping. Pending the results of investigation of these new sources, additional isolation valving and/or new dedicated risers discharging to the neutralization system may need to be installed.

For trap cleaning/replacement and power washing procedures as discussed in Appendices B-2 and B-3, respectively, any disinfecting or cleaning agents proposed for use must be reviewed in relation to possible interactions with the chemicals that may be contained in the waste piping system. The potential for incompatible reactions should be considered to ensure that trap cleaning and power washing procedures will not create any unsafe conditions. Reactions that may cause fuming and gas evolution into the working environment, and into the piping system, must be avoided.

Isolation Valves

The facility may determine that isolation valves need to be installed to allow for trap cleaning/ replacement, removal of noncompliant wastes, sampling of suspect branch piping, and control of potential cross-contamination. The location of isolation valves should consider accessibility and maintenance especially when co-fitted with a sampling port for testing.

The location of valves should not cause an overflow of noncompliant wastes into another area where a spill may occur. As an example, a floor drain would overflow if too much liquid used for pipe cleaning was poured into a counter top sink at a higher elevation. Additionally, the need to provide isolation valves in the venting system must not be overlooked for the same reasons.

Sampling Ports

Sampling ports should be installed in strategic locations for the periodic collection of wastewater samples for monitoring purposes. Design of the sampling ports can follow that shown in Figure 2, Recommended Sampling Port for Special Wastes, of the Pretreatment Guidance Manual.[7]

A sampling port in an isolated branch of piping may not only act as a monitoring point but also as a drain leg for any disinfecting or cleaning agents used. The sampling port nozzle may be replaced with a full-size drain leg for transfer of suspected noncompliant cleaning wastes to containers for off-site disposal.

Special Waste Risers

Vertical Special Waste and vent piping risers may need to be isolated to allow for sequential disinfection, cleaning, and testing of portions of entire systems in the same manner as has been explained for horizontal runs of piping. During these periods, special consideration must be given to the isolation of vent piping to reduce the possibility of overflow of reagents back through the piping system.

Glass Inspection Ports

Inspection ports or sections of clear borosilicate glass piping should be installed within the main horizontal runs of the Special Waste piping system fabricated of thermoplastic or other opaque piping materials so that flow conditions can be viewed and the bacterial biomass accumulation can be periodically observed. If any branch piping may contain undiluted caustic or hydrofluoric acid, however, the branch piping sections should be routed separately and connected downstream of a glass fitting and should have its individual isolation valves and sampling port assemblies.

Discussion

The above are examples of the various design considerations needed for modifications of Special Waste piping systems before cleaning or replacement activities are initiated. However, before modifying any portion of its waste piping infrastructure, a facility should determine if the system contains any metal piping or fitting materials[8] that would require replacement and not cleaning. In addition, a thorough inspection of any traps and horizontal piping runs (including analyses of biomass samples) should be done to find if modification, cleaning, or replacement efforts should be done at all. If trap and biomass contaminations are found, the decision would then be made to pursue a specific combination of source reduction, source segregation, infrastructure modification, infrastructure replacement, infrastructure cleaning, and pretreatment as a solution to noncompliance with mercury sewer discharge limitations.

APPENDIX B - 2
SPECIAL WASTE TRAP CLEANING/REPLACEMENT

In Special Waste systems, trap accumulations of elemental mercury and of bacterial biomass growth contaminated with mercury has been found a significant source of chronic elevated mercury concentrations in wastewater discharges. The trap cleaning and replacement procedures outlined below have been found of significant value in reducing the levels of mercury in affected wastewater discharges.

Trap Location / Identification

Trap locations are determined by preparing a detailed inventory of all Special Waste sources. Trap identification can be accomplished as part of the facility piping system audit discussed in Appendix B-1. After all sources are identified, a facility Special Waste piping general arrangement drawing should be generated with all traps identified by unique numbers. A master inventory of all traps should be generated to record and track all trap cleaning or replacement events. Each trap should be tagged or labeled with its unique number, the cleaning or replacement date, and the name and signature of the person doing the cleaning/replacement.

A Special Waste Trap Inventory Form such as shown in Figure B2-1 can be used to document the information and can include additional information such as the type and size of piping material.

Removal of Elemental Mercury

Elemental mercury is sometimes discharged into sinks and floor drains when mercury-containing equipment breaks. Some elemental mercury sources include mercury thermometers, thermostats, electric switches, and blood pressure manometers. When a sink or floor drain trap is removed for the first time, it may contain elemental mercury, identifiable as a pool of heavy silvery liquid separated from the trap wastewater.

Elemental mercury removed from any traps should be collected and disposed as a mercury waste. See Appendix C for disposal of mercury wastes.

Figure B2-1
Example Special Waste Trap Inventory Form
SPECIAL WASTE TRAP INVENTORY FORM

Institution Name: ______________________ Department: ______________________
Address: ______________________ Department Manager: ______________________
____
______________________ Date: ______________________
Building Name: ______________________

Trap ID No	Dept./Room	Waste Piping Material	Trap Type	Type of Waste and Hazard	Cleaning/Replacement Date	Initials
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	
					9 C 9 R	

					9 C 9 R	
					9 C 9 R	

Removal of Biomass

Almost every trap will accumulate bacterial biomass, identified as a slimy brown film on the internal surface of the plumbing material. The bulk of this growth will occur on the bottom and wetted sections but some biomass will grow along the sides and top of the non-wetted section of the plumbing materials. This capillary action of growth is the most difficult to remove. Biomass growth on non-wetted surfaces can dry out. The dried out biomass develops a strong bond to the plumbing surfaces. In addition, any elemental mercury disposed into the drain can form an amalgam with metal plumbing. The amalgam is very difficult to remove from the trap. Accordingly, some facilities have chosen to replace contaminated traps rather than attempt to clean them.

Trap Removal and Handling Precautions

Where wastewater is elevated in temperature or where chemical reactions produce heat within a piping system, greater amounts of toxic fumes including dimethyl mercury may be formed in the accumulated biomass. Both elemental mercury and dimethyl mercury may exist in vapor form within the piping systems. Since negative pressures can sometimes exist in laboratory rooms, hazardous elemental or dimethyl mercury vapors can emanate from plumbing traps back into the rooms. Therefore, proper personnel protection should be practiced at all times. In addition, the traps should be of the deep seal type and should continually be filled to afford protection against possible vapor "drawback."

Trap Cleaning or Replacement Procedures

1. Identify traps for cleaning or replacement and discuss the trap removal procedure with the affected facility occupants. Explain to them that the procedure will interrupt their operations and estimate the duration of the interruption.
2. Before any traps are removed, it is important to ask the occupants about the nature of their wastes, identifying all possible health and safety hazards. Before handling traps that are in areas that contain hazardous materials, all traps should be checked by the appropriate administrator for approval (i.e., if a radioactive isotope is being used in a room, have the Radiation Safety Department check out the trap to assure that it is safe for removal and handling).
3. After facility occupants have been made aware of the trap cleaning/replacement program and after it is determined that it is safe to handle traps, actual trap removal, replacement, and cleaning can be started.
4. It is important that personal protective equipment be worn at all times by any personnel doing trap handling. It is recommended that all these procedures be reviewed by an internal Health and Safety Officer.
5. It is recommended that all materials found inside the traps be initially handled as mercury waste and then disposed of as mercury waste unless analyzed and found otherwise. See Appendix C for information on the proper disposal of mercury waste.
6. If the removed trap is to be cleaned, either a rag or flexible brush can be used. A cleaning agent and some type of disinfectant may also be used to help ensure that complete removal of bacterial biomass and disinfection is accomplished. For metal traps, replacement is usually preferred because of the potential for mercury to form an amalgam with the metal.
7. After traps are removed, cleaned or replaced, and reinstalled, a tag or label should be wired to the trap (or an existing tag should be updated) with the unique number of the trap, the date, and the responsible individuals' initials.
8. After trap removal, cleaning, or replacement is completed and the area is returned to its original condition, all access panels and other structural materials should be reinstalled. Before leaving the area, inform the occupants that the procedure has been completed.

9. All trap cleanings or replacements should be logged on a Trap Inventory Form (See Figure B2-1 for an example inventory form).
10. If it is known that any mercury-containing materials will remain in use, the associated wastes should be segregated and collected for offsite disposal. Otherwise, it will be necessary to inspect the affected cleaned traps for recurring contamination of the biomass growth. These inspections could serve as a check on actual disposal practices and could initially be done quarterly. Once a sufficient level of experience has been obtained, inspection frequencies can either be increased or decreased depending on the levels of contamination and the rates of returning biomass. The inspections should help determine the need for repetition of the entire procedure.
11. It is highly recommended that spare traps and associated hardware be available for each type and size of trap because corroded or otherwise unusable traps are often discovered during a cleaning/replacement program.

APPENDIX B - 3
SPECIAL WASTE PIPING POWER WASHING

Background

In the past, Special Waste piping systems were sometimes used for the disposal of mercury and mercury-containing materials. Because of the phenomena of bioaccumulation and bioconcentration, the bacterial biomass within such Special Waste piping systems could contain concentrations of mercury in the part per million range. In some cases, the presence of such mercury-laden biomass was cited as the sole reason that mercury was detected in discharged wastewater at concentrations exceeding the MWRA enforcement limit of 1.0 µg/L (ppb).

A few facilities have used power washing of their Special Waste piping systems as a mercury control technique because of the scouring effect of power washing on accumulated mercury-laden biomass that effectively removes the biomass. Some of these users believe that, after all needed mercury source reduction has been carried out, power washing would be a lower cost final step in effluent mercury control than removal and replacement of the contaminated Special Waste piping system.

Special Waste piping power washing uses specialized pumping equipment to produce a high pressure/low volume stream of water. The water stream flows through a high pressure hose and a power nozzle to produce a 360^{o} high velocity spray that can remove accumulated biomass and grease from the inside surfaces of the waste piping while flushing the resulting debris down the line.

Status of MWRA Power Washing Requirements

Currently, there are uncertainties in the ability of power washing to remove all biomass residues thereby possibly exposing new surfaces from which mercury can reach the wastewater. Also, there is some evidence that power washing may lead to new and possibly higher mercury violations from the discharge of dislodged biomass particles for an indefinite period after power washing is performed.

Because of these concerns, the MWRA is currently formulating requirements for data collection during power washing. As part of this process, a facility must notify the MWRA of its intention to perform power washing and participate in a study of power washing effects according to specific conditions and protocols. The results of the study will be used to finalize a MWRA guidance on acceptable power washing procedures.

Waste Piping Power Washing Precautions

The following are some precautions, recommended techniques, and possible compliance issues that should be considered before beginning to use any waste piping power washing procedures:

- Complete waste piping accessibility is essential for successful power washing. Considerable modifications to an existing system (i.e., additions of piping isolation valves, cleanouts, access ports, and drains) may be needed to achieve the needed accessibility. Refer to Appendix B-1, Special Waste Piping Design.

- Perhaps because of the potential for mercury to form an amalgam with other metals, power washing has not been effective in Special Waste piping systems constructed of metals (e.g., high silicon cast iron or stainless steel). If a metallic waste piping system is mercury-contaminated, total replacement of the system should be seriously considered with approved non-metallic materials.[1] The MWRA will not approve a request to power wash a metal-containing Special Waste piping system.

- All associated traps should be cleaned or replaced before power washing. All substances contained within the waste piping system should be assumed hazardous until analyses prove otherwise. Before waste piping power washing, therefore, a facility Health and Safety Officer should review the proposed power washing procedure and locations to ensure that proper personal protective equipment will be used.

- Waste piping fittings and components, especially those of glass, can become cracked or broken during power washing. Inspect the entire system before power washing and identify and tag any potential obstructions and fittings, so that replacement fittings can be pre-ordered and be immediately available for installation if the original fittings were to be broken.

- If the waste piping contains large amounts of biomass, pieces may dislodge during power washing and may collect and clog downstream waste piping sections. If such clogging occurs, wastewater backups in the waste piping system may occur causing flooding at lower elevation locations.

- Dislodged biomass particles from waste piping power washing can appear in the sewer discharge for some period after power washing. To avoid compliance problems from the power washing procedure itself, the MWRA should be contacted for approval prior to power washing. Refer to Section 2.5.4 of this Guidebook and Appendix B.

- Any proposed disinfecting or cleaning agents should be reviewed to prevent possible chemical interactions with waste constituents that may exist in the piping system. The potential for incompatible reactions should be considered to ensure that trap and pipe cleaning procedures will not create unsafe conditions. Reactions that may cause fuming and result in gas evolution into the working environment and into the piping system, must be avoided.

Waste Piping Power Washing Techniques
The following techniques are easily monitored for effectiveness when performed on glass waste piping systems. The techniques may require some modification when applied to thermoplastic or other opaque waste piping materials.

1. Waste piping power washing activities usually require a minimum of two people: one serving as the power wash operator; and the other as an observer of the nozzle and hose as it moves through the waste piping.
2. The operator begins feeding the 80 to 100 feet of hose with the power washing nozzle attached, while the observer, with a two-way radio in full communication with the operator, watches the hose and nozzle for potential obstructions and other problems. Typical obstructions include: tees, reducers, p-traps, drum traps and valves.
3. Some facilities have determined that successful waste piping power washing occurs when cleaning operations begin at the collection or treatment tanks in the lower floors. The operator then works in the waste piping system toward the sources in a reverse flow direction. This technique is preferred because the nozzle is designed with a reverse flow head configuration that literally "pulls" the hose away from the power washer operator and toward the sources while flushing biomass and debris down the line and to the collection point. In addition, most plumbing fittings have smooth swings in the reverse direction and this seems to reduce obstruction interference.

4. Although reverse flow is preferred, the complexities of the waste piping infrastructure may require some experimentation. For immediate progress, select straight sections observed to contain biomass. In other locations, piping may have to be removed or modified to reach all areas of concern. Power washing on thermoplastic piping will require more experimentation and it may be necessary to remove piping sections to verify cleaning effectiveness. The installation of sight glasses may help to reduce the required amount of pipe removal.
5. At times, feeding the hose and nozzle in the preferred reverse direction may be difficult or impossible. An alternative method would then be to start at the sources (sink traps or floor drains) and work in the direction of flow. This technique, however, is less desirable because the nozzle head will not be directly flushing debris as it moves along the piping. It may be necessary, then, to apply additional water to aid the flushing process by opening faucets in an adjacent sink tied into the same waste piping line.
6. Regardless of the direction that the power wash nozzle is fed into the system, a final wash and high volume rinse in the direction of flow may help to flush residual biomass particles from the system.

Chemical Additions

Bleach

Some power washing units are designed for use with water only and do not allow for addition of chemical solutions. However, it is suggested that a bleach solution be added to the piping at the source, if possible, to accomplish disinfection of the piping system immediately before the power washing and to possibly aid in the removal of biomass.

The bleach or other disinfecting chemical should be analyzed before use to ensure that it is mercury-free or of a "low" mercury content. Unfortunately, some chemicals and reagents, including many disinfecting products that contain bleach, can contain measurable concentrations of mercury.2

Other Cleaning Solutions

The additions of surfactant, dispersant, caustic and/or wetting agents during power washing were investigated during the Phase I Mercury Work Group effort. None of these chemicals were recommended then because of performance and health and safety considerations. In addition, such chemical additions may be costly for waste piping systems at large facilities. It is unknown if any local facility has recently accomplished power washing using chemical augmentation to achieve greater levels of cleaning.

Power Washing Wastewater Disposal

All Special Waste piping power washing wastewater that contains removed biomass should be assumed to contain levels of mercury above the MWRA enforcement limit of 1.0 µg/L (ppb) and, therefore, should be collected for offsite disposal.[3] The collection of the power wash wastewater may be difficult, but since power washing will usually occur during non-operating hours, the Special Waste piping systems can virtually be drained. Once all normal wastewater flows have been stopped, existing neutralization or treatment tanks can be emptied and used as power washing wastewater collection vessels. Additional temporary collection vessels may be needed. However accomplished, it is very important that the power washing wastewater be collected and not discharged to the MWRA sewer system.

All waste disposal activities should be approved by an Environmental, Health and Safety Officer or the person(s) responsible for waste disposal at the facility. Note that the MWRA prohibits the disposal of chemicals into the sewerage system except aqueous solutions of nontoxic and non-hazardous chemicals.[4] In addition, the Massachusetts Department of Environmental Protection (MA-DEP) prohibits the improper disposal of hazardous wastes.[5] The waste disposal guidelines in Appendix C were developed to reflect both the MWRA and the MA-DEP regulations and requirements.

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APPENDIX C

DISPOSAL OF MERCURY WASTES

1.0 OVERVIEW

Although efforts have been made to reflect current regulatory requirements in this Appendix, the applicable regulations are periodically revised and updated. Therefore, the following discussions are for general information only. Anyone managing hazardous waste should definitely refer to the latest regulations. Assistance in interpreting and implementing the regulations can be obtained from a facility environmental compliance officer, hazardous waste contractors, environmental laboratories, environmental lawyers, and environmental engineering consulting firms. Some of these resources also offer seminars on complying with hazardous waste regulations.

This section presents a general review of regulations affecting the management of wastes containing mercury. Such wastes can be generated during mercury source identification and reduction and infrastructure cleaning efforts. Source reduction efforts can often generate unused (or discarded) elemental mercury, mercury-containing reagents/products, and process wastes containing mercury that must be segregated from sewer disposal. Infrastructure cleaning activities can generate mercury-containing wastes and bacterial biomass from sink traps, waste piping, solids settling tanks, and limestone chip tanks (used in passive pH neutralization systems).

1.1 Regulatory Programs Controlling Mercury Wastes

At least three regulatory programs apply to elemental mercury and mercury-containing wastes in the liquid or solid phase: Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (MA-DEP) hazardous waste regulations[1,2] and MWRA sewer use regulations.[3] The MA-DEP regulations are similar to the EPA Hazardous Waste Management Regulations. However, there are several significant differences such as differing definitions of generator status and the added MA-DEP regulations on waste oil and polychlorinated biphenyls (PCBs) equal to or greater than 50 mg/L (or parts per million - ppm). Discussions in this Appendix are based on the MA-DEP Hazardous Waste Regulations.

1.1.1 Hazardous Waste Mercury Limits

A mercury-containing waste stream would be regulated as a hazardous waste by both the EPA and the MA-DEP if an extract of a representative sample of the waste stream exhibits a mercury concentration of 0.2 mg/L (ppm) or greater when laboratory-tested using the Toxicity Characteristic Leaching Profile (TCLP).[4] Such a waste stream would be called a *characteristic hazardous waste* or, more specifically, a *Toxicity Characteristic (TC) hazardous waste*. For a liquid waste stream, the fluid itself is the extract, and the TCLP becomes essentially a "total" analysis. For a waste stream with a free liquid component, each phase is tested separately, and a weighted average concentration is determined based on the ratio of the solid and liquid phases in the sample.

A TC hazardous waste for mercury is given the hazardous waste code D009 - Mercury. By definition, elemental mercury would fail TCLP testing. In addition, unused (discarded) elemental mercury would be a *listed hazardous waste* with the hazardous waste code U151 (see **Section 2.0** below for further information).

Alternatively, if the TCLP extract of a representative sample of the waste exhibits a concentration of less than 0.2 mg/L (ppm) mercury, the waste is considered a non-hazardous waste (if mercury is the only contaminant of concern). Wastes determined to be non-hazardous are exempt from most sections of the EPA and MA-DEP hazardous waste regulations. Mixtures of non-hazardous waste and hazardous waste containing mercury are also hazardous wastes.

1.1.2 MWRA Sewer Use Limits for Mercury

The MWRA has a stringent limit for total mercury that applies for discharge of Industrial Waste to sewers, *i.e.*, prohibition. However, the MWRA currently enforces its mercury discharge prohibition for permitted wastewater discharges at a concentration level of 1.0 µg/L (ppb). For comparison, the 0.2 mg/L (ppm) TCLP limit for RCRA wastes is equivalent to 200 µg/L (ppb), *i.e.*, 200 times the MWRA enforcement limit.

1.2 Hazardous Waste Determination

Under EPA and MA-DEP hazardous waste regulations, a waste generator may use either "knowledge" or "testing" to find whether a waste or discarded reagent/product would be a listed or characteristic hazardous waste. This process is sometimes also called "identifying," "classifying," or "characterizing" a waste.

Knowledge of the waste can include the determination of mercury content from Material Safety Data Sheets (MSDS) for raw materials and from analytical testing results of others (*e.g.*, the MWRA/MASCO Mercury Products Database). However, using knowledge for classifying a waste as hazardous is usually appropriate if the waste has a contaminant concentration equal to or greater than 1.0 percent.[5] Products that contain mercury at levels equal to or greater than 1.0 percent would most likely fail TCLP testing, so it is appropriate to assume such wastes would be classified as hazardous wastes.

It is much more difficult to try to use Acknowledge to find whether a waste stream with a lower mercury concentration is a hazardous waste or a non-hazardous waste. Extreme care should be taken when determining that a waste stream is not a hazardous waste without the benefit of running a TCLP test on a representative sample. TCLP testing is considered an accurate method of waste characterization.

Although analytical testing is the preferred method for determining if a waste stream is or is not a hazardous waste, complete analytical testing can be costly if the generator has no knowledge of the waste. The lack of knowledge means that several different analytical tests (*e.g.*, volatiles, semi-volatiles, ARCRA 8" metals, and even pesticides) would be required to ensure that all potential waste constituents have been evaluated. Therefore, most waste generators use a combination of knowledge and testing to find whether a given waste stream is or is not hazardous. Knowledge of the waste enables a waste generator to eliminate analytical testing for constituents known *not* to be present.

For waste streams that are mixtures of different wastes, the generator would use knowledge and testing of each waste component for the determination. Of course, if hazardous waste constituents are known or found by testing to be present above TC limits, the appropriate waste codes would be applied when shipping and disposing of the waste.

EPA and MA-DEP hazardous waste regulations require that all facilities that transport, receive, store, treat, or ultimately dispose of hazardous wastes have a permit for such operations. Such facilities are known as licensed Treatment, Storage and Disposal Facilities (TSDF). A TSDF would typically require a waste generator to furnish a certified "profile" of each waste stream before the TSDF will accept it for treatment or disposal. The waste profile characterizes the waste based on the generator's knowledge and waste analytical testing. It is very important that each waste shipment under an established profile have all the same characteristics as initially submitted to and approved by the TSDF.

For example, if an originally approved hazardous waste profile was for Alow mercury (see **Section 2.3** below for definition) and the waste was treated by addition of a bleach solution to remove a biohazard (many TSDFs do not accept biohazardous wastes), a new waste profile could be required.[6] In this case, because bleach is known to often contain mercury, an "off-spec" waste stream could be shipped to a TSDF. Additional steps then would have to be taken (including dealing with manifest discrepancies if new waste codes have to be added), and "off-spec" charges could be incurred.

1.3 Waste Disposal Options

After the waste stream has been analyzed and a determination made regarding its status as a hazardous waste, the following are some of the waste management methods that can be considered:

- If the waste is a characteristic hazardous waste with code D009-Mercury, solely because of its mercury content (*i.e.*, greater than 200 µg/L), ship to a licensed TSDF following applicable EPA, MA-DEP, and U.S. Department of Transportation (DOT) regulations.

- If the waste is not a hazardous waste but is an industrial wastewater with a mercury content greater than 1.0 µg/L (ppb) and other constituents may or may not meet the MWRA Sewer Use Regulations (360 CMR 10.021-10.024), treat the waste stream in a pretreatment system before discharge to the MWRA sewer system according to an MWRA Sewer Use Discharge Permit and applicable federal pretreatment regulations.

- If the waste is not a hazardous waste but is an industrial wastewater with a mercury content less than 1.0 µg/L (ppb) and all other constituents meet the MWRA Sewer Use Regulations, discharge to the MWRA sewer system according to an MWRA Sewer Use Discharge Permit and applicable federal pretreatment regulations.

For example, waste piping infrastructure cleaning (*e.g.*, trap cleaning/replacement and power washing of waste piping) typically can produce wastewaters with mercury concentrations in the 1.0 to 200 µg/L (ppb) range or more. Mercury levels in sink trap water have at times been found in the low mg/L (ppm) range (*i.e.*, greater than 1,000 µg/L (ppb)). Thus, infrastructure cleaning operations will likely involve collection of wastewater and mercury-laden biomass for off-site disposal because the waste streams may violate the MWRA mercury prohibition for sewer discharge and may be hazardous wastes. Refer to **Appendix B** and **Sections 1.3.1** and **1.3.2** below for further information on these issues.

1.3.1 Offsite Disposal as Hazardous Waste

Before shipping mercury-containing hazardous waste to a TSDF for ultimate disposal, the waste generator has responsibility for preparing a manifest and Land Disposal Restriction (LDR) notifications (discussed in Section 2.3 below). In addition, the waste generator must make sure that U.S. Department of Transportation (DOT) regulations (49 CFR beginning at Part 171) are following including proper placarding of the vehicle transporting the waste. Requirements of the U.S. DOT regulations, such as training of personnel involved in shipment of hazardous waste, are beyond the scope of this Appendix.

Requirements of federal and state hazardous waste regulations regarding the handling and temporary onsite storage of hazardous wastes are also beyond the scope of this Appendix.

1.3.2 Offsite Disposal as Non-hazardous Waste

If an extract of a representative wastewater sample is TCLP tested and the results show a mercury concentration of less than 0.2 mg/L (ppm) (or 200 µg/L (ppb)), the waste would not be a hazardous waste for mercury. However, if the total mercury concentration is 1.0 mg/L (ppb) or greater, the waste would violate the MWRA sewer discharge mercury prohibition and must either be pretreated for mercury before sewer discharge or collected and sent offsite for disposal.

Before a facility installs and operates a tank to collect, hold, and discharge industrial wastewater for offsite disposal, one of the MA-DEP regional offices may require the facility to obtain an industrial wastewater holding tank permit known as BWP IW 29.[7, 8] Typically, this MA-DEP permit

is granted to facilities generating industrial wastewater in areas that are not sewered. The permitting requirements are intended to reduce overland transport of industrial wastewater from sewered areas and to prevent a facility from avoiding the discharge limits of a local POTW by hauling its wastewater to another POTW that may have less stringent discharge limits.
To obtain the MA-DEP industrial wastewater holding tank permit, a facility might have to submit the following as determined by the appropriate MA-DEP regional office:

- A two-page permit application form.
- Based upon analyses of the wastewater, documentation that a primary licensed disposal site will accept the wastewater.
- Based upon analyses of the wastewater, documentation that an alternate (backup) licensed disposal site will accept the wastewater.
- Documentation of a pending contract with a licensed waste hauler (with a minimum duration of one year).
- Four copies of an engineering report prepared by a Massachusetts Registered Professional Engineer (MRPE) having knowledge and experience in industrial wastewater.
- Four copies of design plans and specifications prepared and sealed by the MRPE. Required design elements include a wastewater holding tank size of at least five times the average daily wastewater flow. In addition, the holding tank must have level instruments with visual and audible alarms at 75 percent capacity.

  Note: The above required design elements for the holding tank are good conservative design guidelines for any proposed industrial wastewater holding tank.
- If applicable, post-installation certification by the MRPE that an in-ground holding tank was installed according to approved plans.
- Local Board of Health (BOH) approval may be required. For all in-ground holding tanks, the BOH approval would be required.

Before a non-hazardous waste is transported to a licensed waste disposal facility, the waste will require preapproval similar to that used for "profiling" a hazardous waste. The profiling typically would include generator knowledge and both total and TCLP analytical test results.
The application fee for the MA-DEP BWP IW 29 Permit is set at $350. There are no subsequent annual fees. The permit remains valid if the system served by the holding tank remained unchanged or until the MA-DEP revokes or modifies the permit. If the facility fails to maintain the holding tank properly or prevent overflows, the permit can be revoked.
Facilities that intend to collect their industrial wastewater in holding tanks for offsite disposal should remain alert to any new proposed MA-DEP regulations on this matter. For reference, the MA-DEP Web-site is: http://www.magnet.state.ma.us/dep
In addition, MA-DEP Hazardous Waste Regulations (310 CMR 30.000) allow for non-hazardous wastes to be shipped under a hazardous waste manifest using the MA-DEP waste code MA99. This approach is recommended for offsite disposal of industrial wastewater because the manifest will provide documentation of waste transport to the ultimate disposal facility.
1.3.3 Discharge to the MWRA Sewer System
The MWRA Sewer Use Regulations (360 CMR 10.000) is the primary information source about

MWRA Sewer Use Discharge Permits. The general rule is that, unless specifically exempted by the Regulations, facilities will require a MWRA Permit if they: 1) discharge Industrial Waste[9] to the MWRA Sewer System, 2) are subject to a federal Categorical Pretreatment Standard, 3) are septage haulers that discharge to the MWRA Sewer System, 4) temporarily discharge construction site dewatering drainage, or 4) are municipalities in the MWRA Sewer District.
To obtain a MWRA Sewer Use Discharge Permit, a facility must submit a Sewer Use Discharge Permit Application to the Toxic Reduction and Control Department of the MWRA. In the Application, the facility would provide:

- General information such as name, address, and responsible officials
- Product or service information
- Facility operational characteristics
- Facility water usage
- Sewer connection information
- Wastewater discharge flow characteristics
- Wastewater pretreatment processes (if any)
- Anticipated future wastewater changes
- Other waste stream quantities (such as waste oils, sludges, or hazardous wastes)
- Chemical characteristics of the wastewater discharge.

The MWRA may issue a Sewer Use Discharge Permit to a facility with a validity period generally from two to five years depending upon the applicable Category and Significant Industrial User (SIU) Classification as determined for each discharge. The Category and SIU Classification establish the value of an annual permitting charge that varies from $100 (with an initial extra charge of $50 for the first year) for Category G1 Permits to as much as $1,430 for Category 1 - SIU Permits and Category 12 Permits. There is no annual permitting charge for the General Permit for Low Flow and Low Pollutant Dischargers that carries a charge of $150 once every five years.
In addition, the Category, SIU Classification, and a Monitoring Point Score establish the value of an annual monitoring charge that varies from zero for Category G1 Permits (and for other permits in special cases) to as much as $5,550 for discharges classified as SIUs with a High Monitoring Point Score. For definitions and further information on MWRA Categories, SIU Classifications, and Monitoring Point Scores, refer to the MWRA Sewer Use Regulations 360 CMR 10.101-10.104.
If a facility determines that its wastewater contains mercury below 1.0 µg/L (ppb) and that all other pollutant concentrations are below the respective MWRA discharge limits, the wastewater can be discharged to the MWRA Sewer System after submitting a MWRA Sewer Use Discharge Permit Application and receiving the Permit. However, if the wastewater exceeds 1.0 µg/L (ppb) mercury at any time after aggressive source reduction (including purchasing and inventory controls) and source segregation (including training and supervision of individual daily waste disposal practices), the facility should study its available options to decide the most cost-effective approach to disposal of the wastewater.
Possible options could include pretreatment and sewer discharge, installation of a wastewater holding tank for offsite disposal of some or all of the wastewater according to requirements of the MA-DEP (as outlined above in **Section 1.3.2**), or even installation of an atmospheric thermal evaporator system. For certain low annual emissions rates of hazardous and miscellaneous air pollutants, the MA-DEP would not require a facility to hold an air emissions permit[10] for an evaporator system. However, the MA-DEP is opposed to the use of evaporators on mercury-bearing wastewater streams. Refer to **Appendix H** for a copy of a recent letter written by MA-DEP in response to a letter sent on behalf of MASCO regarding this issue. The original letter to MA-DEP is also included in the Appendix.
An economic analysis of these options, performed by an experienced engineer, can provide insight into the most cost-effective method of wastewater disposal. The wastewater flow and characteristics and many other permitting and site-specific factors will uniquely affect the results of the economic analysis.

2.0 HAZARDOUS WASTE REGULATIONS THAT APPLY TO MERCURY AND MERCURY-CONTAINING WASTES

2.1 Background on Hazardous Waste Regulations

The first federal hazardous waste legislation enacted by Congress was the Resource Conservation and Recovery Act (RCRA) of 1976. This Act required the Federal Environmental Protection Agency (EPA) to develop hazardous waste regulations. The resulting regulations are found in Title 40 of the Code of Federal Regulations (CFR) Parts 260-268. Parts 271 - 272 allow responsibility for operation of the EPA hazardous waste programs to be transferred to state environmental protection agencies after certain conditions have been met. Massachusetts is an EPA "authorized state" for the purposes of administering and enforcing the EPA's hazardous waste program. The Massachusetts hazardous waste legislation is found in the Massachusetts General Laws, Chapter 21C. The corresponding regulations are in Chapter 30 of the Code of Massachusetts Regulations Section 310 (310 CMR 30.00).

The Massachusetts hazardous waste regulations are similar to the federal hazardous waste regulations, but they may lag behind as described below. However, it should be noted there are sometimes differences in the way EPA and MA-DEP interpret their regulations. It is entirely possible to get differing opinions from different regulatory compliance officials from the same agency and branch on certain topics. (It is generally advisable to comply with the most restrictive interpretation). One reason that Massachusetts elected to administer its own hazardous waste disposal program was so it could regulate several additional waste streams as hazardous (e.g., waste oil and PCBs greater than 50 mg/L or parts per million - ppm).

The RCRA legislation was updated in 1984 by the Hazardous and Solid Waste Amendments (HSWA) in which Congress specified that land disposal of hazardous waste is prohibited unless the waste meets treatment standards established by EPA. HSWA required that treatment standards must substantially diminish the toxicity or mobility of hazardous waste, so that short and long term threats to human health and the environment are minimized. The treatment standards are part of the Land Disposal Restriction (LDR) requirements at 40 CFR Part 268. In developing the treatment standards, EPA sought to make the standards as uniform as possible. The results are the Universal Treatment Standards (UTS) whereby the EPA has, wherever possible, developed the same numerical limit for a hazardous constituent in all of the hazardous wastes where the constituent may be present.

Before HSWA, authorized states had one year or more to adopt new EPA hazardous waste regulations as they were promulgated. During the interim period in which state hazardous waste regulations were being updated to reflect the new federal requirements, the regulated community had to comply with the current state hazardous waste regulations. However, regulations based on HSWA go into effect **immediately**. A generator must comply with the HSWA regulations and the state hazardous waste regulations in all EPA authorized states.

Except for HSWA, complying with MA-DEP hazardous waste regulations will usually ensure compliance with RCRA hazardous waste regulations as well. However, the LDR regulations have changed several times and are presently in Phase IV of implementation. Once a waste is determined to be hazardous, the waste generator is required to use the LDR regulations to find what disposal alternatives are acceptable and to prepare the LDR certifications for the TSDF receiving the wastes.

Although efforts have been made to reflect current regulatory requirements in this Appendix, the applicable regulations are periodically revised and updated. Anyone managing hazardous waste should refer to the latest regulations. Assistance in interpreting and implementing the regulations can be obtained from a facility environmental compliance officer, hazardous waste contractors, environmental laboratories, environmental lawyers, and environmental engineering consulting firms. Some of these resources also offer seminars on complying with hazardous waste regulations.

2.2 Determining Whether a Waste Is Hazardous

A generator of hazardous waste must "identify", "classify", or "characterize" each hazardous waste stream. Both EPA and MA-DEP regulations require the generator of a waste use "knowledge" of the process generating the waste or "testing" of the waste to find whether it is hazardous within the meaning of the regulations. Earlier in this Appendix, the manner by which a waste containing only mercury was determined to be a hazardous waste was discussed. The following discussion will be helpful when dealing with mixed waste streams that have multiple hazardous waste constituents and, thus, potentially multiple hazardous waste codes.

The federal regulation 40 CFR 261.3 provides a definition of Ahazardous waste" and Subpart B provides "Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste. The corresponding MA-DEP regulation at 310 CMR 30.100 also provides for the "Identification and Listing of Hazardous Wastes. More specifically, 310 CMR 30.102 provides the following "Methods of Identification of Hazardous Wastes.

The following four-step decision tree can be used to find whether a given waste stream is a hazardous waste within the meaning of the EPA/MA-DEP hazardous waste regulations (note, however, that the MA-DEP definitions are given):

A. Is the waste an Excluded waste? If the waste is specifically described in 40 CFR Part 261.4 and 310 CMR 30.104, then it is not considered "hazardous" for the purposes of waste management, i.e., it is an "excluded" waste. Examples of excluded wastes include domestic sewage and household refuse.

B. Is the waste a "Listed" hazardous waste? 40 CFR Part 261, Subpart D and 310 CMR 30.131 through 30.136 provide "Lists of Hazardous Wastes." Rationales are given for listing each waste stream, i.e., Toxic (T), Reactive (R), Corrosive (C), Ignitable (I), Characteristic (E), or a combination thereof. If no such designation follows a listing of a hazardous waste, the waste is a listed hazardous waste solely because it is "toxic".

1. "F" - Hazardous wastes from nonspecific (i.e., general industry) sources (40 CFR 261.31 and 310 CMR 30.131). These include common halogenated and non-halogenated solvents, metal plating baths, sludges, and wastewaters. No "F" codes apply specifically to mercury or mercury-containing compounds. Wastes that are hazardous wastes only in Massachusetts (such as waste oil) would be listed here.

2. "K" - Hazardous wastes from specific sources (40 CFR 261.33 and 310 CMR 30.132). The waste codes involving mercury (K071 and K106) apply only to the mercury cell process in chlorine and caustic production.

3. "P" - Hazardous wastes that are "Acutely Hazardous Wastes" (40 CFR 261.33 and 310 CMR 30.136). These are hazardous wastes of pure chemical that have high acute toxicity or are "poisons. The following two "P"-listed waste codes apply to mercury-containing compounds:

Mercury fulminate (R, T) (P065), also described as "Fulminic acid, mercury (2+) salt. Phenylmercury acetate (P092), also described as "Mercury, (acetato-O)phenyl.

4. "U"- Hazardous wastes that are "...discarded commercial chemical products or off-specification batches of commercial chemical products or spill residues of either... " (40 CFR 261.33 and 310 CMR 30.133). The "U" can be thought of as meaning "unused." The following "U"-listed waste code applies to elemental mercury: Mercury (U151). There is controversy regarding when this waste code applies. Guidance is available from the RCRA hotline on this subject (800-424-9346).

C. Is the waste a State-listed waste? Although not applicable to mercury, it is important to point out that various states, including Massachusetts, have added additional wastes to the federal list. The state-listed hazardous wastes in Massachusetts are at 310 CMR 30.130 and 30.131.

Wastes designated as listed wastes by MA-DEP include:

1. Wastes determined to be hazardous wastes by MA-DEP on a case-by-case basis (MA00).
2. Waste oil (MA01).
3. PCBs at 50 mg/L (ppm) or greater (MA02).
4. Class A regulated recyclable material being manifested (MA97).
5. Off-spec fuel oil being manifested (MA98).
6. Non-hazardous waste being manifested (MA99).

Note that, except for the above added state-listed wastes, MA-DEP uses all of the federal hazardous waste codes.

D. Is the waste a Characteristic waste? If the waste (or its constituent(s)) does not appear on any of the above lists, it may still be a hazardous waste. If a waste exhibits one or more of the characteristics defined below, it is said to be a characteristic waste. Regulations at 40 CFR 261, Subpart C and 310 CMR 30.120 describe the "Characteristics of Hazardous Waste."

Note that 310 CMR 30.121 requires that "a representative (emphasis added) sample of the waste shall be analyzed using the tests specified in 310 CMR 30.152 - 155." Representative sampling methods are defined in 310 CMR 30.151. It is important to note that the EPA believes that grab sampling would best produce representative samples and thus requires grab sampling for hazardous waste determinations.

Since obtaining a representative waste sample is a critical element in determining whether a waste is a characteristic hazardous waste, it is suggested that guidance be obtained from a hazardous waste disposal company and an environmental testing laboratory. Also, guidance is presented in **Appendix D** on good sampling techniques (e.g., how to avoid contaminating sample containers with mercury from powdered gloves).

The four characteristics of hazardous waste are specified as:

1. Ignitability

Definition: 40 CFR 261. 21 and 310 CMR 30.122
Testing method: 310 CMR 30.152
EPA/MA-DEP waste code "D001"
Liquid: Flash point <60 ^{o}C (<140 ^{o}F)
Non-liquid: Spontaneously combustible, etc. (see 310 CMR 30.122(b))
Compressed gas: Concentration, flame length, etc. (see 310 CMR 30.152(c))
Oxidizer:

2. Corrosivity

Definition: 40 CFR 261.22 and 310 CMR 30.123
Testing: 310 CMR 30.153
EPA/MA-DEP waste code "D002"
Aqueous: pH $\leq$ 2 or pH $\geq$ 12.5
Liquid: Corrodes SAE 1020 steel at a rate given in 310 CMR 30.123.
(Interestingly, there is no corresponding definition for a solid waste, e.g., sodium hydroxide).

3. Reactivity

Definition: 40 CFR 261.23 and 310 CMR 30.124
Testing: 310 CMR 30.154
EPA/MA-DEP waste code "D003"
Unstable and readily undergoes violent changes
Reacts violently with water
Cyanide- or sulfide-bearing
Explosive
Other (see 310 CMR 30.124(1))

4. Toxicity

Definition: 40 CFR 261.24 and 310 CMR 30.125B
Testing: 310 CMR 30.155B
EPA/MA-DEP waste codes "D004 - D043"

Wastes having the hazardous characteristic of toxicity are those that leach specified constituents greater than specific limits when laboratory tested using the Toxicity Characteristic Leaching Profile (TCLP) method. The wastes are then called Toxicity Characteristic (TC) wastes. The purpose of the TCLP test is to simulate conditions in a landfill where hazardous constituents in a waste could leach out over time. The associated waste codes include certain heavy metals and organics (selected pesticides and solvents).

If mercury is present in an extract of a representative waste sample in a TCLP concentration of 0.2 mg/L (ppm) or greater, the waste is considered a TC hazardous waste for mercury and must carry a "D009" waste code. The following are all equivalents to 0.2 mg/L: 0.2 parts per million (ppm), 200 micrograms per liter (µg/L), or 200 parts per billion (ppb). Note that if "total" analytical test results for mercury are available for a liquid sample and are less than the TCLP limit of 0.2

mg/L (ppm), TCLP testing need not be run. If a TCLP-derived result for a waste that is a solid exceeds 0.2 mg/L (ppm), a total mercury analysis will need to be run to find the applicable treatment standard under the LDR regulations.

For a waste sample that is a solid, be careful to not compare a total analytical test result reported in units of mg/Kg to a TCLP Maximum Concentration limit. The TCLP Maximum Concentration Limit is given in units of mg/L (ppm) because the TCLP test is performed on an extract of the solid sample. Only the total analytical result for a liquid sample (reported in mg/L (ppm)) can be compared directly to the TCLP Maximum Concentration limit.

Testing of wastes to find whether they are hazardous wastes and, if so, the applicable treatment technology (see **Section 2.3** below) usually makes economic sense only for consistent processes that generate waste streams in sufficient quantity as to be collected in "bulk" quantities for disposal. Small quantities of mercury-bearing reagents can often be classified using "knowledge" rather than testing and then can be placed into mercury-specific "lab pack" containers.

What happens when the waste is not a hazardous waste for mercury because it is not a listed waste and because mercury is present, but at concentrations less than TCLP? The answer depends in part on the TSDF to which the waste is going. Each TSDF will have its own unique set of state and local regulatory compliance limits besides federal limits, depending on its state and local political subdivision. As discussed in **Section 1.3.2** above, the MA-DEP prefers that a facility dispose of non-hazardous wastewater to a sewerage system whenever access to the system is available. Currently, MA-DEP does not prohibit the disposal of non-hazardous mercury-containing wastewater (of greater than 1.0 µg/L (ppb)) at a TSDF but may require that a facility obtain a permit for such disposal. The best approach may be to deal with the ultimate disposal facility through your hazardous waste disposal contractor.

In summary for hazardous wastes, it is possible to have a waste stream that is:

- A listed hazardous waste but is not a characteristic hazardous waste.
- A characteristic hazardous waste but is not a listed hazardous waste.
- A listed hazardous waste that is also a characteristic hazardous waste.

2.3 Land Disposal Restriction (LDR) Regulations

It is now appropriate to address the federal LDR Regulations (40 CFR Part 268) or, in other words, how a hazardous waste may be disposed. The purpose of this section is develop a general awareness of the LDR Regulations. The information presented in this section is a very brief summary intended only as an introduction to LDR requirements. A generator of hazardous waste should learn the regulations by referring to the latest versions before making any shipment of hazardous wastes. In addition, specific guidance should be sought from the resources discussed in Section 2.1 above.

It is important to note that a generator of hazardous waste is responsible for correct classification of the hazardous waste and for preparation of hazardous waste manifests and LDR certifications. Therefore, while a generator may use hazardous waste disposal contractors to help prepare the needed documents, the generator must have enough knowledge of the regulations to be able to verify the contractor's work.

Because of the Hazardous and Solid Waste Amendments (HSWA) of 1984, hazardous wastes cannot be ultimately land disposed unless they either:

- Meet treatment standards, or are
- Treated to meet standards.

The LDR treatment standards are expressed either as a numerical concentration limit of a hazardous constituent in the waste, or a specific treatment technology. Concentration-based limits may be expressed as total or TCLP.

Theoretically, a waste could be treated before it leaves the facility. However, many facilities do not have a RCRA Part-B permit that would allow them to perform on-site treatment of hazardous wastes, so instead they must have a licensed TSDF treat the waste for them. One purpose of the LDR Regulations is to ensure that the TSDF is properly notified of waste shipments being sent by a generator. Then the waste can be ultimately land-disposed if the TSDF first treats the waste to meet the applicable standards or if the waste meets treatment standards without actual treatment. The operative word is ultimately. For example, the EPA has disallowed the incineration of inorganic metal-bearing wastes, because incineration is deemed to constitute a form of "impermissible dilution." This is because the metals are not treated (i.e., "destroyed, removed, or immobilized") during the incineration process. In fact, incineration actually concentrates metals in the incinerator ash that is ultimately land disposed. Therefore, the incinerator facility has to TCLP test its ash regularly, and determine whether the ash must be stabilized before disposal in a chemical secure landfill. Similarly, metals such as mercury may have to be recovered from wastewater treatment facilities (e.g., in sludge) before the treated waste can be disposed of on land.

The following process must be performed for each waste stream:[11]

A. Identify (classify or characterize) each wastestream.

Determine each Federal hazardous waste code for characteristic and listed wastes that applies to the waste. (Note that state waste codes do not affect the federal LDR regulations). For mercury, we will consider two cases: D009 and U151.

B. Determine if the waste is a wastewater (WW) or non-wastewater (NWW).

In general, a wastewater must contain less than 1.0 percent Total Organic Carbon (TOC) and less than 1.0 percent Total Suspended Solids (TSS). Otherwise, it is a non-wastewater. TOC is the percent by weight of the carbon content in the waste. TSS is the percent by weight of the filterable solids in the waste. (There is an exception: < 1% TOC or 1% solvent constituent for F001 - F005 solvent waste mixtures).

C. Determine applicable treatment standard.

This is accomplished by referring to the Treatment Standards in the "Consolidated Table" in Section 268.40. Use the Treatment Standard for listed waste number. Use also the Characteristic Treatment Standard if a constituent causes the waste to be a characteristic waste unless the Listed Treatment Standard applies to the constituent causing the characteristic waste property. Because Treatment Standards can be expressed as either total or TCLP concentrations, it is very important to be sure of the type of test (i.e., total versus TCLP) and units when comparing laboratory data with Treatment Standards.

Characteristic wastes cannot be land disposed until the characteristic is removed and any underlying hazardous constituents (UHCs) are below universal treatment standards (UTS). UHCs are any constituents in 40 CFR 268.48 that are reasonably expected to be present at levels above the UTS at the point of generation of the characteristic waste.

The following categories are listed for D009 involving no radioactive materials or radioactive mercury (which is beyond the scope of this discussion):

1. High Mercury-Organic Subcategory. "Non-wastewaters...containing greater than or equal to 260 mg/kg total (emphasis added) mercury that also contain organics and are not incinerator residues." The specified treatment technology code is "IMERC" (incineration) or "RMERC" (recovery or reclamation of mercury, e.g., "roast and retort").

2. High Mercury-Inorganic Subcategory. "Non-wastewaters...containing greater than or equal to 260 mg/kg total (emphasis added) mercury that are inorganic..." The specified treatment technology code is "RMERC."

3. Low Mercury Subcategory. "Non-wastewaters...(that) contain less than 260 mg/kg total mercury." The specified Treatment Standard is 0.20 mg/L (ppm) TCLP (emphasis added).

4. D009 - All others. For this subcategory of TC mercury wastewater, the specified Treatment Standard is 0.15 mg/L (ppm) total (emphasis added) mercury which is the same as the UTS for mercury wastewaters (Mercury - All Others). The Treatment Standard for TC mercury nonwastewaters in this subcategory is 0.025 mg/L TCLP (emphasis added). This is a strict standard.

The following categories apply to U151 listed wastes:

1. "U151 (mercury) non-wastewaters that contain greater than or equal to 260 mg/kg total (emphasis added) mercury." The specified treatment technology is "RMERC."

2. "U151 (mercury) non-wastewaters that contain less than 260 mg/kg total (emphasis added) mercury and are not residues from RMERC." The specified treatment standard is 0.025 mg/L (ppm) TCLP. This is a strict standard.

3. "All U151 (mercury) wastewaters." The specified treatment standard is 0.15 mg/L (ppm) total (emphasis added) mercury.
F. Prepare LDR Notification/Certifications (there is no required format but there is required certification language) to the TSDF stating that: The waste does or does not meet treatment standards, the EPA waste code(s), underlying hazardous waste constituents for F001 - F005, F039, D001, D002, and D012 - D043, WW or NWW, subcategory (if applicable), and manifest number. Note that LDRs must be prepared for excluded, recycled and treated wastes also. Refer to the Generator Paperwork Requirement Table at 40 CFR 268.7.
G. Attach each LDR notifications/certification to the applicable uniform hazardous waste manifest. Note that the LDR notification/certification is only a one-time notification, rather than with each shipment of a particular hazardous waste. No new notification would be required unless there were a change in the waste, process, or receiving facility. The one-time notification would apply to shipments of all restricted hazardous wastes, and so would include lab packs.
The EPA requires LDRs to be retained for a minimum of three years from the date the waste was last sent off-site for treatment and disposal. Massachusetts also requires hazardous waste manifests be retained for three years. Regardless, consideration should be given to retaining all documentation relating to hazardous waste activities indefinitely because of perpetual liability concerns (the RCRA "cradle to grave" concept).
Two final LDR considerations should be addressed. At the end of Section 2.2 on TCLP testing, it was noted that small containers of waste reagents are often packaged as "lab packs." Although there is a less burdensome alternative for lab packs than the full LDR procedure, it is not possible to use this alternative for mercury-containing hazardous wastes because D009 and U151 waste codes are prohibited from being included in organic lab packs by reason of the issue of concentrating metals in incinerator ash as discussed above. Therefore, the full LDR requirements apply to lab pack quantity shipments of D009 and U151 wastes.
However, the federal LDR regulations have a de minimis exemption. A generator that is generating less than 100 Kg (about 220 pounds) per month of non-acute hazardous waste or less than 1 Kg (about 2.2 pounds) per month of acute hazardous waste is not required to comply with the federal LDR regulations.
For all hazardous waste determinations, shipping manifests, LDR treatment standard determinations, and LDR Notifications/Certifications, it is important to repeat the recommendation that a generator of hazardous waste learn the regulations by referring to the latest versions before making any shipment of hazardous wastes. In addition, specific guidance should be sought from the resources discussed in **Section 2.1** above.

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APPENDIX D

SAMPLING AND ANALYTICAL TEST TECHNIQUES

MWRA Sampling and Reporting Requirements

MWRA sewer use permits often require that a sampling port be installed at the regulated discharge point for regular collection and analytical testing of representative samples of the discharged wastewater. The regulated discharge point usually means a location within the facility just prior to discharge to the sewer system after all appropriate pretreatment processes and operations but before any mixing of the industrial wastewater with other waste streams. Such a location is called the permitted sampling location.

Permit holders should be aware of MWRA sampling and reporting requirements, such as:

- Analyses submitted to comply with an MWRA sewer use permit or enforcement order must be based on samples that are both collected and analyzed by an independent analytical laboratory that is fully MA-DEP certified to analyze wastewater samples for the pollutant being reported. As an alternative to a MA-DEP certified laboratory collecting the samples at the permitted sampling location, a facility may request approval from the MWRA to use a specific sampling contractor or to sample its own waste streams.

- EPA requirements and MWRA permits also require that if a facility samples more frequently than required by its permit for any pollutant being discharged, the analytical test results from such sampling must be submitted to the MWRA following the procedures for submitting required sampling reports.

- Any analytical report being submitted must be for samples representative of the waste stream being discharged. For example, the sample must be:

  1. Collected to measure a parameter of a discharge at a permitted sampling location.
  2. Representative of the discharge over the entire process day (for most parameters).
  3. Taken as a grab sample[1] or as a flow-proportioned (preferred) or time-interval composite sample as required by the MWRA permit.
  4. Correctly preserved.
  5. Analyzed using test procedures and within allowable holding times according to 40 CFR Part 136 or other EPA approved methods.

- If a sample is analyzed using an unapproved method, the analysis should not be submitted.

- If sampling shows a violation of the provisions of 360 CMR 10.022, 10.023, or 10.024, or a violation of a limit or prohibition contained within the sewer use permit, the facility shall notify the MWRA within 24 hours of becoming aware of the violation. (The notice is required no matter who took the sample). An additional sample must be taken and the analytical results must be reported within thirty (30) days from the date the violation is discovered.

The MWRA encourages permit holders to investigate any permit compliance problems by taking additional samples (at permitted and non-permitted locations) in order to identify contaminant sources. To account for possible sampling errors and precision and accuracy limits of analytical testing, it is suggested that a facility also acquire discharge concentration data over time to establish baseline discharge concentrations for applicable pollutants at each permitted sampling location.

As indicated above, it is required that all analytical data derived from permitted sampling locations be submitted to the MWRA.[2] It is recommended that analytical data for samples taken from non-permitted locations be submitted as evidence of good faith efforts to regain compliance. Such analytical data should be clearly identified so the data is not interpreted as representing wastewater from the permitted sampling location. Ideally, the data should be submitted as part of a summary report. Even if not submitted to the MWRA, testing results from non-permitted sites should be saved as documentary evidence of investigative activities.

Sampling Considerations

For the study of environmental samples, ultra trace level analysis (UTLA) (*i.e.*, at nanogram per liter or parts per trillion levels) is sometimes used. The EPA has supported the development of a new test method (Method 1631) for ULTA of mercury.[3] Because of the very high sensitivity of ULTA, a "Clean Hands" sampling technique has been developed to reduce positive bias from mercury contamination that can occur during the sampling process. This sampling technique is recommended for the collection of water samples (e.g., surface water samples) before being analyzed for mercury because the samples are more prone to contamination with mercury than with other metals. The "Clean Hands" sampling technique, originally developed by the University of Wisconsin Trout Lake Station, employs two people, one designated as the "clean-hands person" and the other designated as the "dirty-hands person."

While Clean Hands sampling techniques are generally too rigorous and not warranted for conventional analytical testing of wastewater (including compliance sampling for mercury), an awareness of these techniques could be useful to identify possibly interfering sources of mercury that should be considered when conducting any sampling for mercury.[4]

For example, important Clean Hands or ULTA sampling considerations include:

- Sample containers should be cleaned according to EPA protocols and should be obtained from a respected commercial vendor. Field and equipment blanks using ultra-high purity water in the field can be used to identify sources of contamination during sampling activities. (Refer also to the section below on quality assurance.)

- Gloves used as personal protective equipment may have powders that contain mercury. If powders are used, it is important that they be free of mercury. Mercury free or powderless vinyl gloves are recommended.

- Airborne dust and atmospheric deposition are two examples of ambient sources of mercury. Facilities with on-site incinerators are environments prone to this type of mercury contamination.

- All sampling equipment wetted parts, including sampler pump tubing and containers, should be thoroughly decontaminated or replaced between sampling sessions.

Analytical Testing Considerations

Using the conventional EPA testing technique for mercury in wastewater by cold vapor atomic absorption (EPA Method 245.1), a typical commercial environmental testing laboratory will produce test results with a method detection limit (MDL) of 0.2 µg/L (ppb). The results are reported with a 95 percent degree of certainty (plus or minus approximately two standard deviations) with a relative standard deviation of about 20 percent.

The MWRA currently prohibits mercury in industrial sewer discharges, requires EPA Method 245.1 be used for discharge compliance monitoring, and applies an enforcement action threshold of 1.0 µg/L (ppb) for the mercury prohibition. The mercury enforcement threshold is five (5) times the typical MDL of EPA Method 245.1.

As mentioned above, the EPA has supported the development of Method 1631 for UTLA of natural waters to achieve an MDL for mercury in the low to sub-part per trillion (ppt) range. The analytical methods developed for UTLA, however, are often not applicable to wastewater samples because the actual detection limits that can be achieved using these methods are not much lower than those obtained by conventional methods. The higher detection limits are typically caused by sampling and matrix interference problems resulting from the highly variable qualities of industrial and institutional wastewater. However, good sample handling techniques derived from the ULTA studies can be important to reduce contamination problems in wastewater samples.

Beyond the potential for contamination during sampling, the measurement of mercury concentrations in wastewater samples may be subject to the following testing limitations:

Matrix interferences: Inherent sample qualities may preclude obtaining optimum test method performance by elevating the usual MDLs. For example, common laboratory reagents that may be present in the wastewater under investigation such as organic solvents, acids, bases, and surfactants may require considerable dilution of the samples to avoid damage to sensitive testing instrumentation. The dilution ratio that applies to the sample would also apply to the MDL.

Laboratory contamination: Mercury at trace levels may be present in the laboratory in the following areas:

- Inside ambient air, particularly in older facilities where spills from mercury thermometers and other sources may have occurred.
- Air supply - outside air or dust entering the laboratory through supplied-air fume hoods.
- Laboratory reagents, possibly including high-purity supply water.
- Laboratory glassware and other equipment such as disposable pipette tips, chem-wipes, and gloves.

Analytical Test Data Quality Assurance

Because the mercury content of wastewater samples may be close to or less than that detectable by EPA Method 245.1, some variations in the results from multiple analytical tests of the same sample may be considered normal. However, contamination during collection and processing of the samples can totally compromise the integrity of the analysis and subsequent interpretation of results. In fact, contamination and analytical problems in analysis of trace concentrations of mercury are well known and provide significant challenges for many laboratories. Therefore, analytical test results of the same samples by different laboratories can, in some cases, significantly vary for low concentration samples. Test result variability can sometimes even affect whether or not regulatory compliance is realized.

The following are recommendations to reduce these potential problems:

- Use extreme care in the collection and processing of samples. Typically, the collection of several hundred milliliters (ml) for analysis is required, more if replicate analysis is to be conducted or sample splits prepared. Contamination from dust and residual vapor phase mercury, improper handling (mercury-free gloves should be used at all times), improperly cleaned labware and cross-contamination from samples with very high mercury concentrations are especially prevalent sources of error.

- Labware in contact with samples should be cleaned by use of a common laboratory detergent and then acid-cleaned either in hot concentrated nitric acid or by soaking in 6M nitric acid (HNO_3) overnight followed by thorough rinsing with high purity deionized water. There must be strict adherence to safety procedures in handling of the acid. Store sample bottles filled with 10% HNO_3 prepared using high purity deionized water.

- The use of Teflon or glass labware is preferred to reduce mercury sorption losses. Sample containers (glass-stoppered 500 ml Erlenmeyer flasks or 500 ml Teflon bottles are useful) should be stored in plastic bags after cleaning and after filling with sample to reduce the possibility of contamination further. If possible, do not use sample bottles that previously contained samples with high mercury concentrations to collect samples that may have mercury at much lower levels (*e.g.*, after pretreatment). After cleaning and between uses, store sample bottles filled with 10% HNO_3 prepared using high purity deionized water.

- Because, in some cases, environmental testing laboratories may have difficulty in producing consistent high quality results at 1 µg/l (ppb) or lower, a pre-evaluation process can be used to assess the capabilities of the laboratory (and your sampling personnel's ability to prepare clean sample bottles and collect uncontaminated samples). Using your current sampling procedures, send the candidate testing laboratory approximately five samples of high purity water. If the test results for mercury concentration of the samples are erratic, you will need to evaluate whether the sampling technique or the testing laboratory is the source of error.

- If test results for mercury concentration of high purity deionized water samples are erratic, a study of split samples sent to different environmental testing laboratories can be performed to find out whether one of the laboratories generates more erratic or higher results than the other on a consistent basis. The study can also determine whether good sampling techniques were used by performing the same analytical tests on high purity deionized water samples (or even wastewater samples) collected simultaneously by different sampling personnel and equipment.

- If a testing laboratory is unable to report consistent mercury concentrations for high purity deionized water samples, and if sampling tests suggest that sampling technique was not the source of error, the testing laboratory's quality assurance and quality control procedures and data (such as matrix spikes and matrix duplicates) should be reviewed. If the review is unsatisfactory, another environmental testing laboratory should be considered for the pre-evaluation process.

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APPENDIX E

EXAMPLE MERCURY MANAGEMENT SELF-LEARNING PACKET

INTRODUCTION

We developed our Mercury Management Program to reduce the amount of mercury discharged from our facility to the sewer system to the lowest level possible. Mercury is a poison that will accumulate over time in the environment. For this reason, the MWRA has placed strict limits on how much mercury we can legally discharge in our wastewater.

Mercury is widely used in industry and is present in many products that we routinely use. Most of us know that mercury is present in equipment such as thermometers. Through hazard communication training, we have been trained to respond safely to a mercury spill resulting from the breakage of this equipment.

Mercury is also present in very small amounts in many other products we use. Even these small, seemingly insignificant sources of mercury must be safely managed. The improper disposal of this material could result in mercury entering the environment and a violation of our sewer discharge permit limits.

IT IS THE RESPONSIBILITY OF ALL EMPLOYEES OF THIS INSTITUTION TO UNDERSTAND THE CONTENT OF THIS PROGRAM AND TO FOLLOW THE PRACTICES OUTLINED IN THIS PROGRAM AT ALL TIMES.

WHAT PRODUCTS THAT I WORK WITH CONTAIN MERCURY?

Mercury is found in batteries, fluorescent lamps, laboratory reagents, cleaning products and prepackaged laboratory kits. Ask your manager BEFORE you pour any solution down a drain to be CERTAIN that doing so is safe and legal.

WHY DO WE USE PRODUCTS THAT CONTAIN MERCURY?

Unfortunately, many products that we use do not have mercury-free substitutes. When mercury-free substitutes are found, they will be used when possible.

WHAT HAPPENS TO A MERCURY SOLUTION WHEN I POUR IT DOWN A DRAIN?

The mercury will travel through the hospital plumbing system. During this voyage the mercury may become trapped in our pipes, traps, and neutralization tanks. This mercury will accumulate over time and possibly result in an expensive hazardous waste cost to the hospital. Mercury that is not trapped will pass through our plumbing system and enter the MWRA sewerage system, eventually reaching the environment. The accumulations of mercury in our plumbing or in the environment are both unacceptable. Therefore, mercury must never be disposed of into the sewer system.

HOW WILL ANYONE KNOW IF I POUR MERCURY DOWN THE DRAIN?

Both the institution and the MWRA regularly check how much mercury is leaving our hospital through the sewer system. Even a small amount of mercury discharged through the sewer system will be detected. For example, only 4 grams (0.14 ounces) of mercury can contaminate 1,000,000,000 (one billion) gallons of wastewater to a concentration slightly above the MWRA enforcement level of 1.0 µg/L.

The hospital is subject to potential fines and penalties if mercury concentrations are found greater than the MWRA enforcement level.

IF I CANNOT DISPOSE OF MERCURY DOWN THE DRAIN, WHAT DO I DO WITH IT?
First, make sure that there is not a mercury-free alternate available before you use a product that contains any mercury. If you must use the mercury-containing product, make sure you collect all waste products. Ask your manager about department-specific procedures for labeling, storing, and disposing of this material.

SUMMARY

- Mercury is present in many products used by our hospital.
- Mercury must NEVER knowingly be disposed of down a drain to the sewer system.
- Mercury-containing waste products must be collected, despite how insignificant the mercury quantity is, and disposed of according to our hazardous waste policies.
- Know which products in your work area contain mercury as a constituent.
- Know your department's procedures for collecting and managing mercury-containing waste.
- Know that if you need more information on the Mercury Management Program, you can call the Safety Department.

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APPENDIX F

CASE STUDIES

Case Study Overview Industry Reference

1. A semiconductor manufacturer investigates A, E mercury in process wastewater
2. An electronics product main component contains A mercury as a primary ingredient
3. A hospital investigation of mercury sources in a D pathology laboratory
4. A battery manufacturer investigation of mercury C in process wastewater
5. A hospital incinerator scrubber wastewater mercury B, D, E control process
6. A bulb/lamp manufacturer cleaning operation causes A mercury in wastewater A clinical testing laboratory achieves compliance through D, E source reduction and pretreatment

INDUSTRY REFERENCE CODES:
Electronics - A
Incineration/Solid Waste - B
Battery Manufacturer - C
Hospital/Medical - D
Wastewater Pretreatment - E

Disclaimer

These case studies are intended only for illustrative purposes to show by example the ways that several industries or institutions addressed specific mercury compliance issues. The case studies are not intended to be endorsements of particular courses of action or recommendations of specific effective versus ineffective practices. Similarly, any references to outside companies or vendors of either products or pretreatment technologies are not intended to be endorsements by the Work Group, the Subcommittee, the Subgroup, or any of its participating persons and institutions, including MASCO and the MWRA.

Since all facilities and situations are unique, individual courses of action should always be developed as pertinent and needed to achieve compliance.

CASE STUDY 1 - Semiconductor Manufacturer

Introduction

A manufacturer conducts research and development of advanced electronic materials and semiconductors where mercury in wastewater was traced to a chemical vapor deposition process on a mercury-cadmium-tellurium substrate and to the "wet" operations of a laboratory in the facility. A program for identifying mercury sources, evaluating process substitution, cleaning infrastructure systems, and examining various pretreatment technologies was carried out at the site. While the deposition process itself had been discontinued for some time, infrastructure residuals continued to affect compliance with the MWRA industrial wastewater discharge prohibition for mercury.

Laboratory wastewater flowed to a central industrial wastewater pretreatment system that originally included only neutralization. The system was modified to include metals removal and filtration of suspended solids. The facility now uses off-site disposal for the wastewater from one process that remained a problem. Overall, daily sewer discharges were reduced from 3,000 to 2,000 gallons per day.

Description of the Problem

Before installation of a mercury pretreatment system, the levels of mercury were measured between 50-100 µg/L (ppb). The facility was issued a cease-and-desist order by MWRA. In response, an investigation of the sources of mercury that were affecting wastewater discharge was conducted. Once the sources were identified, options were evaluated for reducing the mercury discharged to the wastewater pretreatment plant, removing residual mercury within the plant piping infrastructure, and pretreating mercury-bearing wastewater before discharge to the MWRA sewer system.

Methods Investigated/Implemented

The program to obtain compliance with the MWRA mercury prohibition was organized into the following areas: problem confirmation and data collection; awareness and management of the issue; reduction of mercury-containing wastewater; substitution for mercury-containing process chemicals; assessment of mercury introduction via equipment; decontamination of piping system infrastructure; and assessing wastewater pretreatment technologies.

As a first step, the wastewater discharge was resampled several times to confirm that the measured elevated level of mercury was not due to some one-time abnormal event. Occasionally, analytical test result variability exceeded 40 percent, affecting whether or not compliance was achieved. An inter-laboratory study of split samples sent to different DEP-certified laboratories suggested that some labs generated higher results than others. Once, the cleanliness of the vendor's automatic sampling device was called into question when analytical test results for samples collected by the vendor were higher those for samples collected by the facility that had cleaned its automatic sampling device before use.

Employee awareness played a critical role in controlling the discharge of certain sources of mercury into the sewer system. A meeting of all employees was held by the plant manager to emphasize the serious nature of the cease-and-desist order and to stress the need for adherence to the mercury reduction program. To reinforce the message, signs were posted above laboratory sinks noting that chemicals were not to be discharged down sink drains. In addition, training given to new employees was revised to address the issue of mercury in wastewater.

Once the problem was confirmed, the discharge was rerouted for several months from the sewer to a holding tank for off-site disposal until an engineering solution could be installed. Roughly 100,000 gallons of wastewater were collected and disposed of at a cost of $ 75,000. All "wet" processes were examined to reduce water usage and discharge to absolute minimum amounts. This was accomplished largely by the following:

- C adding flow restrictors on each lab sink water supply,
- C installing still/dragout rinses after the acid clean step and before the running rinse that went to the collection tank, and
- C using still/dragout rinses as makeup to the process chemical baths.

Water supply, various process chemicals, and "wet" process equipment were investigated to see if they could be sources of mercury. Several test results on the incoming water between 1991 and 1994 showed that this was not a contributing source. Few mercury sources were found in process chemicals since the laboratories only used "ultrapure" semiconductor grade chemicals. However, the wastewater treatment chemicals (sodium hydroxide and bleach) were found to have up to 1.0 ppm of mercury. These mercury sources were addressed by switching from standard grade to "membrane" grade chemicals, which have mercury below 50 µg/L (ppb), at an added cost of less than $10 a drum.

The examination of equipment as potential mercury sources focused on the exhaust ventilation and fume scrubber system. The small volumes of condensate from drip collection lines in ventilation systems were found to be high concentration sources of mercury. Inside surfaces of the exhaust fan were cleaned after they were found to have residues with very high levels of mercury. Open top wastewater treatment tanks were covered to prevent dust and other solids from the sludge filter press operation from entering the system.

A key aspect of the mercury issue was removal of residual mercury from the facility waste piping infrastructure. Sink traps in known mercury-containing areas were removed and replaced, whereas all other sink traps in "wet" areas were dismantled and cleaned. The entire industrial waste piping system was flushed and cleaned in two separate events. The piping system was first flushed with water. Wastewater generated from the flushing activities was directed to a collection tank for offsite disposal.

After the water flushing, an emergency response contractor familiar with handling acid chemicals was retained to flush and clean the piping by filling the piping system with 20-30 percent nitric acid for 12 hours. The cost of this activity was roughly $10,000. However, the high unit weight of the acid solution caused leaks in some gravity piping. (*Note: The use of acid is <u>not</u> recommended* *for waste piping cleaning because of handling hazards, corrosion potential, waste disposal issues, and cost. Refer to **Appendix B** for information on recommended waste pipe cleaning procedures and associated cautions.*)

Since there was a general perception that source reduction alone would not reduce mercury levels to the MWRA prohibition of less than 1.0 µg/L (ppb), an engineering firm was hired to evaluate pretreatment options. The technologies evaluated were ion exchange, sulfide precipitation, evaporation, and microfiltration. One technology alone would apparently not consistently meet the MWRA mercury prohibition. The engineering evaluation recommended modification of the pretreatment system with the addition of sulfide precipitation followed by an ultrafilter (to remove small suspended particulate) and activated carbon (to reduce remaining levels of dissolved mercury). Capital cost of the system for 3,000 gallons per day was roughly $150,000.

Initially, the ultrafilter achieved excellent results but, as the unit became clogged and required cleaning, subsequent performance levels decreased. Waste liquid (concentrate) from the ultrafilter was collected with filter press sludge for off-site disposal. Influent and effluent samples from the activated carbon unit did not show any appreciable removal of mercury.[1]

Although it did achieve compliance a significant portion of the time, the pretreatment system could not consistently meet the MWRA limit of 1.0 µg/L (ppb). Repeated efforts at minor adjustment of system control set points and routine maintenance were unsuccessful in bringing the system to a point of continuous compliance. Finally, the waste stream from the mercury deposition process was segregated for alternate disposal to eliminate that stream from the discharge to the sewer.

Conclusion

The problem of removing mercury from wastewater to a level of 1.0 µg/L (ppb) was a difficult one and required that the problem be approached from several angles. Although wastewater pretreatment and fume scrubber chemicals were contributing mercury to the discharge, the main source of mercury was the water rinse after acid cleaning of equipment from the known mercury-containing process. The waste acid from the cleaning process was collected and managed for off-site disposal.

Several rounds of analytical data confirmed that mercury was present above the regulated limit and that the existing wastewater pretreatment system alone could not remove the mercury. Because consistent results could not be obtained with one technology, a combination of technologies was needed. Between 1991 - 1994, overall expenditures to achieve compliance was between $400,000 and $600,000. Since 1995, mercury concentrations in the sewer discharge from the facility have been between nondetectable (less than 0.2 µg/L) and 3 µg/L (ppb). Recent performance information has not been examined.

A key aspect of managing the issue was employee awareness, so that the staff members could know the consequences of their actions. Attempts at reducing the mercury in materials and chemicals used also yielded significant improvement. Additionally, cleaning of the waste piping infrastructure (subject to the recommendations and cautions in **Appendix B**) was a critical action because residual mercury within the waste piping system had caused additional violations.

CASE STUDY 2 - Electronics Manufacturer

Introduction

This case study documents the activities performed by an electronics manufacturer in its attempt to reduce/eliminate its mercury discharge to the MWRA sewer system. This facility is engaged in the development, design and low volume production of Electro-Optical Systems for Infrared Sensors and Seekers. A main component of the product is a mercury-cadmium-tellurium wafer.

Mercury Reduction/Elimination Activities

Sampling

Various sample points showed mercury levels from 0.2 to 75 µg/L (ppb). Mercury-contaminated debris consisted of Chem-wipes, Q-tips, cotton swabs, protective gloves and glassware. The sodium hydroxide (NaOH) used in the manufacturing process was found to have a mercury content of 0.005 mg/l (5 µg/L or 5 ppb). Although this mercury content was fairly low, the facility eliminated the use of this product to help reduce the mercury found in the facility discharge.

Sampling was done at the discharge point of potential sources, rather than at the end-of-pipe, to identify actual mercury sources throughout the facility. In addition, a baseline of sample data was developed (at the end-of-pipe) to characterize the discharge accurately.

<u>Formation of Environmental Health and Safety Team</u>

An environmental health and safety compliance team was assembled to meet biweekly to discuss and actively address applicable issues. The team serves as the platform for internal training and awareness to lab operations. The team simplified the exchange of information needed for process change and modification to achieve compliance with discharge standards.

<u>Collection of Wastes</u>

All lab procedures require that all spent chemicals, such as organics and acids, be collected. All process containers and beakers are rinsed with DI water and have the first and second rinses collected and stored for hazardous waste disposal. Mercury-contaminated debris is separated in the labs satellite accumulation area and later compacted with a specific hazardous waste compactor. Quartz tube cleaning and the photo array process in the Research and Development area have been disconnected from the drain. Currently all water from these operations is collected for off-site disposal.

<u>Water Use Reduction</u>

Water use was reduced in several ways. Filter saw wastewater is recirculated back to mercury wafer dicing equipment. The water in the quartz dicing and sawing research and development operation is also recirculated, using a closed loop filter system. All nonessential process sinks in the research and development area have been eliminated. The facility is currently seeking a water recycling filter media. DI water will be used for makeup.

<u>Consolidation of Discharge Points</u>

All wastewater discharges were piped to two 3,200 gallon wastewater holding tanks. Following MA-DEP permitting requirements for offsite disposal of the wastewater, both are equipped with alarms that sound when the tanks reach 75 percent of capacity. In addition, both tanks are plumbed in series to the MWRA system. The pH of the tank contents is monitored by the facility. Before discharging to the sewer system, the facility analyzes the wastewater for all pollutants required to be analyzed by its Sewer Use Discharge Permit. If the waste stream meets all MWRA limits, the contents of the tank are released to the sewer system. If it is found that any MWRA limits are not met, the waste stream is hauled offsite according to the MA-DEP permit.

<u>Pretreatment</u>

Currently no pretreatment is done at this facility. The facility is currently doing bench tests on a pretreatment system that will treat for Hg, Cd and Te in the following waste streams, which are currently collected: a) quartz glassware etch rinse, and b) lapping, polishing and dicing.

The pretreatment system under investigation includes: pH neutralization, carbon treatment for organics and a 3-stage ion-exchange resin canister for the removal of Hg, Cd and Te.

Summary

There is now a better understanding of the sources of mercury in the facility. The wastewater discharged to the sewer system has been reduced to a manageable level. The facility now has "control" of what pollutants it allows to discharge to the sewer system. The last analysis of wastewater showed that the facility was in compliance.

CASE STUDY 3 - Hospital Pathology Laboratory

First all chemicals used in the Pathology Department were identified and a database was established using MSDS information. In the database, each chemical was listed along with the following information:

- quantity discharged, and
- mercury content (provided by manufacturer or by analytical testing).

Levels of compliance with hazardous waste disposal policies and regulations were tightened through employee education and posted disposal listings at laboratory benches for all waste reagents.

It was decided that in all areas where chemical reagents were used, analytical evaluations were necessary. (For example, a grab sample of one reagent showed mercury at 42 µg/L (ppb) or

0.042 mg/L (ppm) - a "noncompliant" level). In retrospect, sampling and analysis should have been performed for all benches and waste streams in the laboratory - not just in "chemical reagent areas."
To account for wastes as sources, all waste materials were segregated by department and screened for "hidden" mercury:

- Large drums were deployed for collection of all waste in all departments. Even if the waste sample was initially considered free of mercury, aliquots were tested for mercury.
- The drums were used to eliminate the waste piping as a possible source of mercury contamination.
- In retrospect, an ideal situation would have been a laboratory plumbed to allow segregation of individual department waste streams.

(Winter 1993 to Spring 1994)
After the analytical results were in, all positive bulk streams were segregated by bench within each department. Collection stations were placed at every bench and representative samples were taken and submitted for analysis. The bench areas where mercury was found were identified and a thorough evaluation was done to find its sources. MSDSs were examined, manufacturers were questioned, and all suspect reagents were analytically tested.
The goal was to work with all the pathologists to eliminate mercury compounds in the laboratory where possible. The results of initial testing are shown in the following table.

Laboratory	**Bench**	**Measured Hg Concentration (µg/L or ppb)**
Chemistry	TDX Benches	< 5
Chemistry	IMX Benches	< 1
Chemistry	Array	< 2
Chemistry	Flex Benches	< 5
Chemistry	E4A Bench	< 2
Chemistry	Specials Bench (Electrophoresis)	8,800 [2]
Chemistry	Plating Solution (leads)	600
Cytology	EOSIN Stain	< 2
Cytology	OG-6 Stain	< 5
Bacteriology	CSpor	10,000
Bacteriology	Hepatitis (Abbott)	150
Bacteriology	Probes	2

Bacteriology	Methylene Blue	2
Bacteriology	Basic Fuchsin	2
Bacteriology	Iodine	BQL [3]
Bacteriology	Crystal Violet	BQL
Bacteriology	Auramine-Rhodamine	BQL
Bacteriology	Parasitology	25,000

Hematology	Coagulation (MLA + Dade Reagents)	BQL
Hematology	IRIS	BQL
Hematology	Technicon H1	BQL
Hematology	Hematoxylin	BQL
Hematology	Coulter T890	BQL
Hematology	Semen Analysis (Hematoxylin)	40
Hematology	Naphthol and NAP AS-D	BQL

(January 1995)

The histology department eliminated mercury-containing fixatives for tissue processing (some brands of hematoxylin are mercury-free), and a process was established to screen incoming products carefully for the presence of mercury. Results of testing all benches in the histology department showed that all wastes collected and tested were below the quantitation limit (BQL) with the detection limit at 0.5 µg/L. Results from follow-up testing of the 8,800 µg/L mercury level found in the electrophoresis waste were as follows:

Electrophoresis Reagents	
Reagent	**Measured Hg Concentration (µg/L or ppb)**
HGBA1C Buffer	28
IFE Buffer	200
Electrophoresis Stain	1,800

These results could not explain the 8,800 µg/L mercury level found in electrophoresis waste. Further evaluation led to the blood bank saline and blood bank reagents. Results from testing of blood bank saline and reagents and candidate alternative products were as follows:

Blood Bank Reagents	
Reagent	**Measured Hg Concentration (µg/L or ppb)**
Reagent Mix	14,300
Waste from Drain System	5,800
Dade Immusal (saline)	44,200
Dade Certified Blood Bank Saline	29
0.9% Sterile Saline Bags	BQL
Immu Add (LISS)	206

Candidate Alternative Reagents	
Reagent	**Measured Hg Concentration (µg/L or ppb)**
Ortho Antibody Enhancement	70
Gamma N-Hance	< 0.5
BCA EM-X	138

As a result of the analytical testing effort, the blood bank switched to the saline with the lowest amount of mercury, continued to seek an alternative, and replaced the Liss reagent with Gamma N-Hance.

(March 1995)

Although not in compliance with the MWRA discharge enforcement limit of 1.0 µg/L (ppb) at all times, significant strides were made in reducing discharge mercury concentrations.

- All laboratory waste was still being collected for offsite disposal.
- All new reagents and waste streams were tested for mercury, even for reagents whose MSDSs stated no mercury was present.
- Alternative reagents were sought for the blood bank and microbiology.
- The hospital established a hospital-wide mercury policy.
- Elimination and reduction of sources were highly successful means of bringing processes under control.

Source reduction techniques used were:

Input Substitution - Several sections of the Pathology Laboratory converted to mercury-free reagents after lengthy clinical trials.

Operating and Maintenance Procedures - A Standard Operating Procedure was developed and implemented for reducing mercury use and discharge at the facility.

(1997)
Goals for the year in the Pathology Department included continued work toward elimination of mercury and a reduction in the use of toxic chemicals. Toxic use reduction was accomplished by:

1. Reduction in chemical purchases and improved inventory control using the Meditech Chemical Database.
2. Purchase of equipment that used small reagent volumes and generated less hazardous waste.
3. Elimination of Hg PVA in Microbiology by replacement with a low Zn PVA system.
4. Replacement of manual staining procedures in Histology with kits and elimination of dry chemicals and toxic concentrated stains.
5. Increased levels of employee training in hazardous materials management and mercury source reduction.

At the end of the year, the amount of chemicals nearing expiration dates were cut in half from 1996 levels. Safety inspection reports showed that staff members had increased knowledge of chemical handling and spill procedures.

Notes on the Histology Laboratory:

It was not possible to replace all manual staining procedures in the Histology Laboratory with kits because of the unavailability of kits for certain staining procedures. As kits become available, the manual staining procedures will be eliminated.

Contamination of equipment in the Histology Laboratory also became an issue. Although the Laboratory had eliminated the use of Hg-containing reagents, measurable amounts were still being discharged from the area. It was discovered that the water from the flotation water baths (microtome stations) and VIP processor was contaminated with mercury. Therefore, all flotation baths, VIP filters, baskets and tubing in the processor were replaced to rectify this problem.

(1998)
Non-hazardous liquid laboratory waste volumes decreased this year by about 11 percent although the workload increased by as much as 21 percent. Hazardous waste drums shipments showed no change from 1997 though the workload in Histology alone showed an increase of 23 percent. Currently, formaldehyde and xylene recycling systems are being evaluated under criteria that include minimal employee exposures and waste generation.

CASE STUDY 4 - Battery Manufacturer

Mercury was a common constituent in some types of dry cell batteries. A manufacturer in New England eliminated mercury from in their batteries in 1988 because of growing concern over its hazardous nature. The mercury content of the batteries was steadily reduced over several years. After the use of mercury was ended, the facility went on to conduct a thorough clean-out to become truly "mercury-free."

Manufacturing activities included chemical mixing, battery assembly, storage, and shipping, and wastewater pretreatment. Mercury was used in the chemical mix area as a component of the battery slurry. In July 1988, the facility conducted a cleanup effort using an outside contractor to remove all residual mercury from the chemical mix area. Cleanup involved thorough cleaning out of all wastewater pretreatment system sumps and trenches, repiping of all pretreatment system sources, treatment and cleaning of grossly contaminated surfaces and equipment, and a final steam cleaning.

In detail, steps were:

- Pretreatment sumps and trenches were acid washed (hydrochloric)
- All piping to the pretreatment facility replaced
- Noticeable gross elemental mercury: vacuumed using mercury vacuum
- Residual elemental mercury: residual elemental mercury was converted to metal/mercury amalgam using a mercury absorbent powder that was vacuumed using mercury vacuum
- All areas: final high pressure water wash

All areas were tested for mercury contamination after cleaning. If mercury was detected, the area was recleaned. Equipment used in processing and distributing mercury-containing battery slurry was also thoroughly cleaned. If mercury was detected in equipment after cleaning, it was recleaned. Larger and unnecessary equipment was cut out of the processing system but not necessarily removed from the area. The battery assembly machines, production areas, loading dock, storage areas, and trades shops were not cleaned.

The mercury source was also found in the facility infrastructure. Although mercury has been removed from the process, it was still found occasionally in equipment and material samples. The thorough cleaning and removal of contaminated piping, vessels, floors, and walls removed the source and, therefore, essentially eliminated the potential for mercury discharges.

CASE STUDY 5 - Hospital Incinerator

Introduction

Some hospitals operate onsite incinerators for disposal of infectious (or Ared bag) wastes. These wastes frequently contain mercury (from various tissues and diagnostic reagents). Some mercury can be transferred to wastewater generated by air pollution control systems (wet scrubbers) on the incinerator fume discharge.

In a medical waste incinerator, typically operating at temperatures of 1800-2200 ^{0}F, any organic material containing mercury in any form will be oxidized and most of the mercury will be released in gaseous metallic (ionic) form. For mercury in an amalgam or other inorganic compound (*e.g.*, as a chloride or oxide), it is possible that either the compound or the metallic form will be released. As a vapor, mercury may pass through pollution control equipment when gas temperatures are elevated (perhaps at about 300 ^{0}F or more).

Wet scrubbers, however, can remove much of the mercury vapor from the gas stream. The removal rate varies with the partial pressure of mercury at the effective scrubber temperature. The mercury is removed from the gas stream by the recirculating water stream in the scrubber and appears in the wastewater (*i.e.*, the blowdown) discharged from the scrubber. Typically, the blowdown stream from a medical waste incinerator scrubber cannot meet the current MWRA prohibition of mercury.

Source Reduction Measures

Identification and removal of all mercury-bearing substances before incineration could potentially eliminate the need for pretreatment of the wastewater discharge from the wet scrubbers that serve these medical waste incinerators. For example, one hospital set up a policy banning mercury thermometers. However, a full year after the ban was in place and a Acomplete roundup of all mercury thermometers had been conducted, some mercury thermometers could still be found in use.

The hospital integrated other mercury control measures into routine daily operations including a program of spent battery collection. Satellite collection containers for used batteries were placed at nursing stations throughout the hospital. Two 55 gallon drums of used batteries were accumulated annually from beepers, flashlights, calculators, and medical equipment. The collected batteries were sent offsite for proper disposal. Other potential mercury sources eliminated from the incinerator were vacuum cleaner bags and used fluorescent light bulbs.

Even after these source reduction measures were fully carried out, however, the incinerator scrubber wastewater stream could not meet the MWRA prohibition of mercury.

Description of the System

The hospital medical waste incinerator was equipped with a scrubber having a blowdown rate of six gallons per minute or about 5,000 gallons per day (gpd). The blowdown was being sent to the sewer system. Mercury concentrations in samples of the blowdown varied from nondetect to nearly 900 µg/L (ppb) as a function of quantity of mercury contained in the materials being incinerated. The hospital retained an incinerator pollution control company to help achieve compliance with the MWRA prohibition for mercury.

Pretreatment Methods Investigated/Implemented

<u>Activated Carbon Adsorption</u>

An activated carbon unit was considered for installation in the blowdown line from the water recirculating section of the incinerator scrubber. However, over the long term, the mercury removed from the blowdown stream by the activated carbon could be re-released with variations in the blowdown pH and temperature. After trying various activated carbon materials, the use of an activated carbon was rejected as a solution to the problem.

Sulfur-impregnated Activated Carbon

Many mercury spill control kits rely upon elemental sulfur to react with the free mercury to produce a solid product, mercuric sulfide, that is easy to recover and remove. Mercuric sulfide is a very stable form of mercury. Therefore, an activated carbon material impregnated with elemental sulfur was seen as a possible solution to the problems of activated carbon alone. The pollution control company decided, therefore, to test a sulfur-impregnated activated carbon in place of standard activated carbon.

The impregnated carbon is manufactured by a process that impregnates the pore structure of an activated carbon with elemental sulfur. Where activated carbon itself physically adsorbs the mercury from a wastewater stream, sulfur-impregnated activated carbon first physically adsorbs the mercury and then the adsorbed mercury chemically bonds with the sulfur. The chemical bond between the adsorbed mercury and the impregnated sulfur provides good stability in wastewater environments of varying pH and temperature.

At the medical waste incinerator, substitution of a sulfur-impregnated activated carbon for activated carbon resulted in blowdown samples with mercury levels frequently below detection limits. A pilot wastewater pretreatment system using a sulfur-impregnated activated carbon achieved an average mercury removal efficiency of 99.92%.

Because of the strong chemical bond within the medium, regeneration of the sulfur-impregnated activated carbon is not a possibility. Depending upon the ultimate mercury loading of the medium, however, recovery and recycling of the adsorbed mercury may be possible.

Conclusion

Hospital incinerators equipped with wet scrubbers often have compliance problems with the MWRA prohibition of mercury in permitted wastewater discharges. Sulfur-impregnated activated carbon is being used at one hospital facility to reduce mercury concentrations in the incinerator scrubber blowdown. To reduce initial and operating costs of the blowdown treatment system, source reduction measures should be carried out and aggressively monitored.

CASE STUDY 6 - Bulb/Lamp Manufacturer

Introduction

The facility is involved in the manufacture of bulb/lamp lighting components. One stage of the manufacturing process, known as the alumina reclaim process, uses acid (hydrochloric acid, HCl) to remove internal metal components from alumina arc tubes. Mercury is one metal removed during this cleaning process. Spent acid is collected for disposal as a hazardous waste. Rinsewater flows to an on-site wastewater treatment system (pH adjust only) before discharge to the local sewer. Monitoring data from the rinsewater showed that mercury was present above the regulated limits. In 1994, work practice and technical measures aimed at reducing the carryover of acid into the rinsewater were set up. The facility is not on the MWRA system and has a local limit of 0.1 ppm or 100 µg/L (ppb).

Description of Problem

The acid cleaning process consists of the following two steps: (1) removing frit left over from the process of sealing the arc tube electrodes to each end of the tube; and (2) final dissolution of remaining internal metallic components/deposits, one of which is mercury. The first key step in addressing the problem of controlling mercury levels in wastewater was to reduce the carryover of acid from the cleaning process into the rinse. The problem involved the need to evaluate both work practice and technical measures.

Methods Investigated/Implemented

In 1994, sampling data showed exceedances of the facility's mercury permit limit. A more detailed sampling program from the end-of-pipe back up into the process was conducted to identify areas where mercury loading to the system was highest. Values ranged from below 1.0 ppm in treated effluent wastewater to 1,500 ppm in spent process acids collected for off-site disposal as a hazardous waste. An issue that arose during review of the sources discharging to the sewer was that the dilution effect from combining liquids both regulated and unregulated by the local sewer authority called into the question the end-of-pipe compliance of the combined flow. Adjustment of the end-of-pipe data to reflect this inadvertent dilution was recommended. The Acombined wastestream formula was used to adjust the end-of-pipe data to reflect the inadvertent dilution.

A Quality Assurance/Quality Control review of the laboratory work was done to identify if laboratory procedures had the potential to affect the mercury being reported. Independent review of the laboratory confirmed that reported values were not affected by laboratory procedures. Examination of the processes contributing mercury to the wastewater linked the probability of the facility exceeding its mercury limit to the timing of sample collection relative to the acid baths life cycle. An opportunity became available to analyze raw aliquots of unused and used acids to identify a point at which the accumulation of mercury in the process acid approached a level that would affect compliance with the sewer limits.

The facility did not expect mercury to exist in the HCl acid because chemical handbooks said that mercury was A insoluble in weak HCl acid solutions. The term A insoluble means that only relatively A small concentrations of a material will dissolve. However, A small concentrations may be high enough to result in a wastewater discharge compliance problem. Here, mercury may be more soluble in the concentrated acid used.

Observation of the process steps identified that under the current work practices, acid solutions were not being completely drained before removal of the tube and immersion in the rinse step. Work practice modifications to increase drainage rates were reviewed. Also, small quantities of elemental mercury particles were settling out on the rinse tank trough. The trough was sloped toward the drain, and it was recommended that the trough be sloped away from the drain to retain the settled mercury particles.

In an additional attempt to control the mercury transferred to the wastewater, a recommendation was made that a stagnant rinse tank be added as a process step between the acid clean and running rinse operations. This tank will rinse off most of the acid carried out of the process bath and result in a clean part being immersed into the running rinse that ultimately flows to the sewer. The periodic need to change the stagnant rinse could be addressed by treatment, collection, and off-site disposal, or by reuse of the stagnant rinse as makeup to the process cleaner. The option of using the stagnant rinse as makeup to the process cleaner was not advised because of accumulation of mercury in the stagnant rinse.

Mercury was found in a component of the wastewater treatment system where supposedly no alumina reclaim processing wastewater was discharged. One possible explanation is that elemental mercury was present in the tank and was dissolving into the wastewater. Since the facility discharged on a batch basis, a recommendation was made to consider a larger tank for flow equalization that could attenuate the discharge of mercury over a longer period.

Conclusion

Current work practices required modification to increase the amount of acid solution drained before the rinse step. This modification and the installation of a stagnant rinse tank between the acid clean and running rinse operations will help reduce the mercury transferred to the wastewater. A mathematical model showed that these measures alone may be sufficient to bring the facility into compliance with the local mercury standard of 0.1 ppm.

CASE STUDY 7 - Clinical Testing Laboratory

Introduction

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

1. Source reduction techniques were used to reduce the mercury entering the facility's wastewater treatment system by approximately 90 percent; and
2. A sophisticated treatment system was then installed to remove the residual mercury.

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

Background

After the laboratory received an MWRA compliance order to eliminate mercury from its wastewater discharge, it was found that the source of the mercury was thimerosal, a mercury salicylate salt used as a bacteriostat/fungistat in many clinical tests and could not readily be replaced. Clinical test equipment and test kit manufacturers, aware of the problem and under pressure from their customers, are working to develop reagents with alternative preservatives.

However, the removal of mercury from a test kit involves revalidation of the test kit with subsequent approval by the US Food and Drug Administration. This is a time-consuming process that can require several years to complete.

Source Reduction Efforts

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

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

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

Because of the investigations, about five gallons per day of wastewater is now sequestered at the sources, collected in containers, and transported off-site as hazardous waste. This sequestered wastewater consists of all equipment discharges containing mercury that can be easily collected at the sources in small containers. While the sequestered wastewater is not a large volume of water, it does include many instrument discharges containing high concentrations of mercury. From these source reduction efforts, the mercury level in the wastewater discharge was reduced to about 0.03 mg/L (ppm) or 30 µg/L (ppb). Although this represented a significant reduction in mercury concentration, it was not sufficient to comply with the MWRA enforcement limit. Consequently, the facility investigated additional wastewater sequestering and offsite disposal (up to and including the entire facility discharge) and wastewater pretreatment. The pretreatment options explored included evaporation, ion exchange, precipitation, and carbon adsorption. Based on an economic analysis of the various approaches, carbon adsorption was chosen as the most cost-effective technique.

Wastewater Pretreatment

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

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

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

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

- Install bag filters upstream of the carbon beds to avoid plugging with solids that decrease the adsorptive capacity of the carbon.

- Investigate the use of an ultraviolet (UV) light sterilization unit or silver-impregnated carbon to control bacterial growth in the carbon adsorption system. (Silver is a bacteriostatic material, *i.e.*, it inhibits bacterial growth).

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

Results

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

While toxics use reduction (TUR) efforts were not themselves sufficient to achieve compliance, they did lead to a 90 percent reduction in the mercury that had to be removed in the pretreatment system. This reduction translated into lower pretreatment system capital and operating costs. Capital expenditures to achieve compliance were more than $60,000. This figure includes the costs of both the pilot and full-scale carbon adsorption systems and of replumbing the facility. According to facility calculations, the operating costs of the new system are more than $7,500 per month. However, the facility would have faced higher costs for offsite disposal of the wastewater and could have been liable for fines of $10,000 per *day* if it had not met the MWRA deadline for elimination of the mercury from the wastewater.

For further information about this case study, other OTA case studies, or OTA's technical services, contact:

Office of Technical Assistance
100 Cambridge Street, Room 2109
Boston, MA 02202
Telephone (617) 727-3260
Facsimile (617) 727-3827

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APPENDIX G

MWRA MERCURY ENFORCEMENT
SAFE HARBOR MEMORANDUM
MARCH 6, 1997

MASSACHUSETTS WATER RESOURCES AUTHORITY
Charlestown Navy Yard
100 First Avenue
Boston, Massachusetts 02129

M E M O R A N D U M

TO: Sewer Users with an MWRA Sewer Use Discharge Permit

FROM: Kevin McManus, Director, Toxic Reduction and Control Department

DATE: March 6, 1997

RE: MWRA Enforcement of Mercury Discharge Prohibition (the safe harbor from escalated enforcement for mercury violations)

This memorandum sets forth how the Massachusetts Water Resources Authority (MWRA) will exercise its enforcement discretion regarding mercury discharges, effective July 1, 1997.

The MWRA will create an enforcement "safe harbor" in which it will not take escalated enforcement action, such as the imposition of financial penalties, for sewer users with mercury discharge violations who take the steps required by this memorandum to reduce and eliminate their discharges of mercury.

The enforcement safe harbor will be as follows:

! Mercury prohibition. Mercury is prohibited from being discharged to the MWRA sewer system (360 C.M.R. ' 10.024(1)). To take into account the method detection limit for mercury and test method variability, the MWRA uses an enforceable limit of 0.001 mg/l for mercury. Discharges at or below 0.001 mg/l for mercury are not considered violations of the mercury prohibition.

! Enforcement for mercury violations. The MWRA may issue a Notice of Violation for a first time mercury discharge above 0.001 mg/l and an escalated enforcement document, such as a Notice of Noncompliance (NON), for repeat or serious mercury discharge violations.

! Escalated enforcement safe harbor. For sewer users who are actively attempting to correct their mercury discharge problems as required by this memorandum, the MWRA will not escalate enforcement beyond the NON and enforcement order level for mercury violations and will grant extensions of mercury compliance dates in NONs, other enforcement documents, and settlement agreements for sewer users in Groups 1 and 2, as follows:

! Group 1 defined. Group 1 consists of sewer users with mercury discharge results consistently at 0.004 mg/l or less at all their sample locations, except for a rare excursion above 0.004 mg/l.

! Group 2 defined. Group 2 consists of sewer users with mercury discharge results above 0.004 mg/l at a sample location, unless those results are a rare excursion.

! Initial placement in a group. In July 1997, the MWRA will inform each mercury discharger of which group it is in, based on sample data from July 1996 through June 1997, on a sample location by sample location basis.

A sewer user that has its first mercury violation after January 1, 1997, at a sample location will be placed in Group 1 for up to six months to give it an opportunity to reduce and eliminate its mercury discharge without pretreatment. If the first three months of data show that the sewer user is making progress in reducing its discharge of mercury but still has discharge results above 0.004 mg/l, the MWRA may elect to keep the discharger in Group 1 for an additional three months.

! More than one sample location. Group placement is on a sample location basis. A sewer user with more than one sample location may be in Group 1 for some of its sample locations and Group 2 for other sample locations, based on the discharge history of each sample location.

! Change in group placement. A sewer user placed in Group 1 that then discharges mercury above 0.004 mg/l at a sample location, except for a rare excursion, will be moved to Group 2 for that sample location.

! Rare excursion. For purposes of this memorandum, a rare excursion is one mercury result above 0.004 mg/l in a six month period. Three mercury results above 0.004 mg/l in a six month period is not a rare excursion. If two mercury results in a six month period are above 0.004 mg/l, the MWRA will review the discharger's mercury results over a longer period of time and the magnitude of the results above 0.004 mg/l. It is not a rare excursion if there is an emerging pattern of more than one mercury result above 0.004 mg/l in successive six month periods, or there are two results above 0.006 mg/l in a six month period.

! Mercury compliance. Each sewer user, regardless of group, will be required to work actively toward having no greater than 0.001 mg/l of mercury in its discharges.

! Specific requirements for Group 1 sewer users. Each Group 1 sewer user must have a written agreement with the MWRA or be under an MWRA enforcement order that includes: a description of the sewer user's approach to correct its mercury discharge problems; a timetable for actions to be taken; the requirement to implement and operate mercury source control and reduction strategies (including product substitution and wastestream segregation) and facility maintenance plans; and the requirement to evaluate the feasibility of mercury treatment options. A sewer user in Group 1 may install mercury pretreatment if it chooses.

! Specific requirements for Group 2 sewer users. Each Group 2 sewer user must have a written agreement with the MWRA or be under an MWRA enforcement order that, in addition to the requirements of Group 1, includes the requirement to evaluate, design, install, and operate a full-scale end-of-pipe pretreatment system for mercury within six months of notice from the MWRA that it is in Group 2 unless the MWRA and the sewer user agree upon a different schedule or a modification of the schedule. The MWRA will provide an extension of the six month time limit to evaluate and install pretreatment if the sewer user's initial evaluation of a promising pretreatment technology shows that the technology would have little mercury removal efficiency. If a sewer user has achieved a consistent mercury discharge of 0.004 mg/l. or less, except for a rare excursion, when it has completed pilot testing, it will not be required to install pretreatment unless it again exceeds 0.004 mg/l. for mercury, taking into account the allowance for a rare excursion as defined in this memorandum.

! Mercury pretreatment. To implement the pretreatment requirement, a sewer user shall, at a minimum, perform a wastestream characterization study, do side-stream and full-scale pilot testing, and modify and upgrade system components to achieve optimum performance. If the results of pilot testing show that the system can most likely reduce mercury concentrations to 0.001 mg/l. or less, the sewer user shall install and run the system on a full-scale basis, unless it has achieved compliance without use of the system. If the results of pilot testing show that the system can reduce mercury concentrations, but most likely not to 0.001 mg/l. or less, the sewer user will be required to install the system, operate the system, and then refine the system to achieve 0.001 mg/l. or less in its discharge, unless at the time of installation the sewer user demonstrates that it can achieve equal or more effective mercury removal results with another pretreatment system, which it then must implement and refine.

! Interim mercury limit. The MWRA cannot provide a system-wide or industry type interim limit for mercury as part of an enforcement safe harbor. The mercury discharge prohibition is a regulation that may be changed only through the local limit review, MEPA, and regulations revision processes. The MWRA anticipates undertaking a review of its local limits within the next eighteen months. A facility that enters into a settlement agreement with the MWRA in which it agrees to install an end-of-pipe pretreatment system will be given an interim mercury discharge limit for nine months at the sample location where pretreatment will be installed. The MWRA will base the interim limit on an average concentration of the sampling data at the location over the previous twelve months (or longer if there are fewer than twelve sample results), removing high results that appear to be atypical for the location from the calculation of the average. If the sewer user does not install pretreatment, the interim limit will be considered forfeited by the sewer user and never in effect.

! Sampling requirements. All mercury dischargers will be required take at least one representative sample per month at each designated sample location where mercury may be present, have the sample analyzed for mercury, and report the result to the MWRA each month. The MWRA may require more frequent sampling as it deems appropriate. As required by EPA, 40 C.F.R. 403.8(f)(2)(vii), the MWRA will use all sampling data from representative sample locations to determine compliance status and whether a sewer user is in Significant Noncompliance.

The results of sampling for mercury at permit sampling locations, done by a Group 1 or 2 sewer user or the MWRA during the duration of the safe harbor, will not be used by the MWRA to assess monetary penalties, unless the violations are not within the safe harbor because they resulted from intentional or grossly negligent actions or were in contravention of an MWRA agreement or enforcement order. See the section below on mercury violations not within the safe harbor.

! Compliance reports. Sewer users in Group 1 will be required to submit quarterly compliance reports to the MWRA, discussing the actions they took each quarter to reduce and eliminate the mercury in their discharges. Sewer users in Group 2 will be required to submit monthly compliance reports to the MWRA, showing their progress toward implementation of pretreatment and discussing the other actions they took to reduce and eliminate mercury in their discharges.

! Removal from the safe harbor. A sewer user who fails to do the required work, take the required samples, or submit the required reports, will be considered outside the safe harbor and will be subject to further enforcement, including the imposition of monetary penalties for noncompliance with the mercury prohibition.

! Other violations. If a sewer user has compliance issues in addition to mercury, the MWRA will treat those issues separately and require the sewer user to resolve those issues as soon as possible, given the nature of the problems.

! Other sampling and reporting. In addition to the sampling and reporting required under this mercury enforcement discretion memorandum, sewer users must sample and report according to their MWRA permits, orders, and agreements, subject to the sewer user's right to appeal a permit or order and the MWRA's right to amend the requirements. All results of samples taken at representative sample locations following EPA protocol are required to be sent to the MWRA, even if the sample results are in addition to those required by a permit or order. Results of samples taken at non-representative sample locations need not be submitted to the MWRA.

! Mercury violations not within the safe harbor. The MWRA recognizes that time, resources, and strong commitment are necessary to attain mercury compliance and that an escalated enforcement safe harbor is appropriate for sewer users who are doing the necessary work with the necessary commitment to achieve mercury compliance. There are, however, mercury violations that are not within the safe harbor because they result from intentional or grossly negligent actions that could have been prevented or were done in contravention of an MWRA enforcement order, agreement, or regulations. Those violations include new processes or discharges not covered by an existing permit, intentional bypasses of pretreatment systems, mercury dumping, and dilution to meet the mercury limit. Violations of 360 C.M.R. ' 10.021 are also not covered by the safe harbor. The MWRA may take enforcement action, including the imposition of monetary penalties, for violations not within the safe harbor.

This memorandum is not intended to create any legal rights for any sewer user. The MWRA may change or end the safe harbor if it experiences an increase in the amount or concentration of mercury in the influent to, or effluent from, its treatment plants or in the fertilizer pellets it produces from its treatment plant residuals. The MWRA may change or end the mercury safe harbor as other circumstances require, in the sole discretion of the MWRA. The MWRA does not anticipate extending the safe harbor or any specific provisions of this memorandum beyond its next local limits study, when it will review whether it should change its mercury discharge prohibition. TO:

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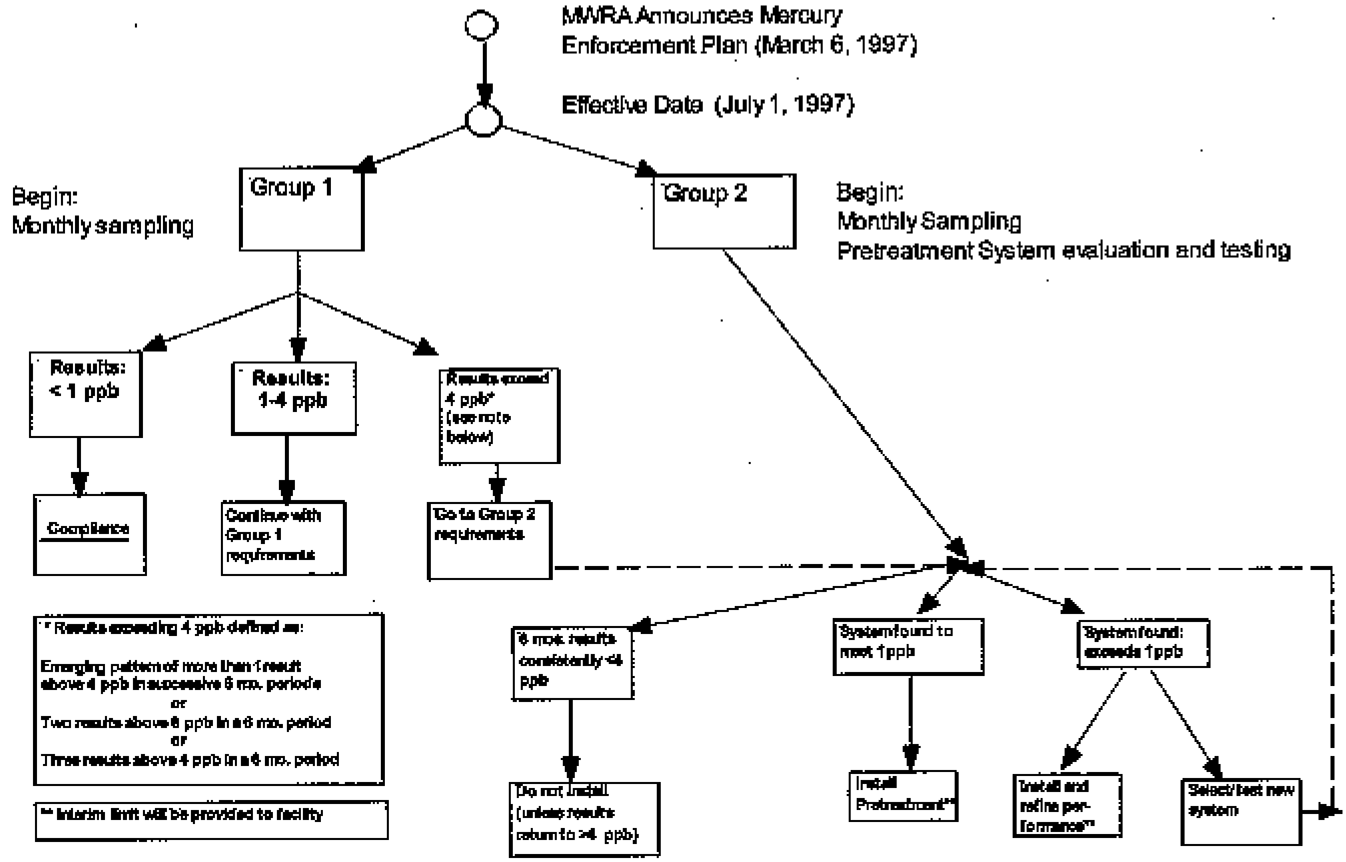
This memorandum is not intended to create any legal rights for any sewer user. The MWRA may change or end the safe harbor if it experiences an increase in the amount or concentration of mercury in the influent to, or effluent from, its treatment plants or in the fertilizer pellets it produces from its treatment plant residuals. The MWRA may change or end the mercury safe harbor as other circumstances require, in the sole discretion of the MWRA. The MWRA does not anticipate extending the safe harbor or any specific provisions of this memorandum beyond its next local limits study, when it will review whether it should change its mercury discharge prohibition.



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APPENDIX H

EARTH TECH LETTER (for MASCO) TO MA-DEP ON THE USE OF EVAPORATORS FOR PROCESSING HOSPITAL WASTEWATER JUNE 26, 1998

196 Baker Avenue, Concord, Massachusetts 01742-2167
Tel: 978-371-4297, Fax: 978-371-2468

June 26, 1998

Mr. Thomas Parks
Environmental Engineer
Air Quality Control Division
Massachusetts Department of Environmental Protection
Northeast Regional Office
205 Lowell Street
Wilmington, MA 01887

Subject: **Use of Evaporators for Processing Hospital Wastewater**
MASCO
Project Number 24127-55-01

Dear Mr. Parks:

As you may know, the discharge of mercury to the Massachusetts Water Resources Authority (MWRA) sewerage system is prohibited {360 CMR 10.024: (1)(a)}. Under present policy, the MWRA interprets the discharge of wastewater containing mercury at a concentration in excess of 1.0 ppb as being in violation of this standard. As part of an ongoing search for economically and technically available alternatives for approaching compliance with this standard, Earth Tech, on behalf of the Medical, Academic and Scientific Community Organization (MASCO) and their constituents, has been asked to more fully explore the possible use of evaporative technology for processing wastewater produced within Hospitals and Institutions with the Department.

Description of the Issue

As stated, MASCO is very interested in identifying alternatives to the installation of a pretreatment system designed to remove mercury from the wastestream, as such systems have, in most cases, been determined to be inordinately expensive to both install and to operate. Bulk hauling of institutional wastewaters has also been judged unfeasible due to cost and difficulty in obtaining the necessary permits to authorize the storage of wastewater in tanks prior to having it hauled from the site by a licensed wastewater disposal company. The Hospitals, Universities and Institutions within the MWRA Service Area, which are represented by MASCO in this petition would, therefore, be interested in clarifying the use of evaporation for the processing of mercury-bearing wastewaters to determine if this technology is appropriate and judged acceptable by the DEP Air Quality Control Division (Department). Earth Tech wants to emphasize that, in conducting its analysis, the Department should consider the use of evaporative technology using a 'holistic' approach.

Hospital and Institutional laboratory wastewater contains trace amounts of mercury along with other contaminants. The type and nature of these other contaminants can vary significantly according to the work being performed by the connected sources but typically includes conventional pollutants such as suspended solids, heavy metals, dilute acids and bases, organic material, nutrients and traces of solvents. Body fluids, such as blood and urine, that are discharged in conformance with the provisions of the Massachusetts State Plumbing Code (248 CMR 2.18) and MWRA Regulations {360 CMR 10.023 (18)}, bacteria, viruses or pathogens, such as those that can cause AIDS, hepatitis, herpes, tuberculosis and other illnesses, may also be present in the wastestream despite the diligent application of biokill measures, as stipulated by the National Institute of Health (NIH), and the regulations appearing at 105 CMR 480. Finally, the wastestreams may also contain concentrations of low level radionuclides that are correctly disposed in accordance with Nuclear Regulatory Commission (NRC) protocols appearing at 10 CFR 20.301 which have been recognized by the MWRA at 360 CMR 10.023: (12). Though the issue at hand may be mercury, we must be ever mindful of the potential for these other pollutant parameters to be present in the wastestream and how the application of one technology for the control of one pollutant may affect or encourage the transference of other pollutants to other media.

Understanding DEP's Requirements for Mercury

It is our present understanding that the DEP does not require permitting of sources emitting less than one ton per year of any single listed hazardous air pollutant (HAP) or less than one ton of the sum of all other miscellaneous air pollutants. Calculations, subject to the review of the DEP, man be used to determine whether a source will be less than or greater than these thresholds. If a source is operated without a permit based upon such calculations, records must be kept following start-up in order to confirm that the source does, in fact, emit less than the threshold quantities of regulated pollutants.

In addition, the emission source may not cause the ambient concentrations of emitted pollutants to rise above allowable ambient levels (AALs). In the case of mercury, two separate AALs - the 24 hour average and the annual - average must be met to avoid having to permit the source, as follows:

Pollutant	**24-Hour Average AAL (micrograms per cubic meter)**	**Annual Average AAL (micrograms per cubic meter)**
Elemental Mercury	0.14	0.07
Inorganic Mercury	0.14	0.01
Methylated Mercury	0.003	0.0014

Calculations

Assuming that a MASCO member institution has a wastewater stream that averages approximately 500 gallons per day (gpd) in total volume with an average mercury concentration of approximately 2 micrograms per liter (µg/L), it may be calculated that this constitutes a total of approximately 0.003 grams of mercury per day, or 1.4 grams of mercury per year.

A thermal evaporator having a capacity appropriate for this wastewater stream was used as the basis for the attached calculations. The evaporator is equipped with an 800 cubic feet per minute (scfm) blower to remove steam and off-gasses. Assuming total volatilization of mercury, the calculations predict what the average mercury concentration would be at the tip of the stack prior to any dilution as the stack off-gas is assimilated into the ambient environment. Modeling of declining mercury vapor concentration in the drift has not been conducted at this time, as choosing a specific location for an evaporator would be premature. Accordingly, the estimated ambient mercury concentrations were reduced by multiplying the stack tip off-gas concentration by a conservative factor to anticipate the decrease in concentration that would results following the discharge of the stack off-gas into the ambient environment.

These calculations, which are admittedly conservative, show that the mercury concentrations that might be emitted by a thermal evaporator should be much less than the required regulatory thresholds. In addition, the total quantity of mercury present in the wastewater is orders of magnitude less than the one ton per year limit for a miscellaneous HAP. By this measure, Earth Tech might conclude that the DEP could authorize the installation of such an evaporator for this scenario without requiring the Hospital to obtain an air pollution control permit.

Commercially-available evaporators do not evaporate the wastewater to dry solids, but, rather, to a concentrated brine solution which would contain the particulate and dissolved solids originally present in wastewater. Mercury, as a relatively volatile solid, however, would be completely emitted in the evaporator off-gas. Though not exceeding a DEP AAL, we expect that none of the mercury would actually be controlled, only converted to another media.

Conclusion

Under the assumed, though simplified, conditions presented, Earth Tech could conclude that no permits or plan approvals would apparently be required from the Department in order for a Hospital to install an evaporator as a technically viable alternate to continued sewer discharge using mercury as the sole criteria. However, we remain very concerned that the likely presence of other organic and inorganic pollutants in the wastestream entering the evaporator might create a serious potential for the evolution of and distribution of airborne pathogens which would render the application of evaporative technology inappropriate in this type of hospital setting.

We would appreciate the opportunity to meet with you and representatives of the Department to more fully discuss our concerns and to seek clarification of this issue. In the interim, please contact me if you have any questions or comments on the information presented. Thank you, in advance, for your time and cooperation.

Very Truly Yours,
Earth Tech, Inc.

Robert K. Gingras, P.E., DEE
Senior Program Director

cc: Mr. David S. Eppstein, MASCO

enclosure

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

Calculation Sheet

Computed by KRC Subject DAQC - EVAPORATION Sheet 1 of 1
Checked by RKG Client MASCO Job No. ______ Date 6/11/98

CALCULATION OF MERCURY POTENTIALLY EMITTED BY AN EVAPORATOR PROCESSING 500 gpd of WASTEWATER CONTAINING 2 μg/L OF MERCURY

ASSUME ALL Hg EMITTED OUT STACK — NONE IN RESIDUAL BRINE.

$$500 \frac{gal}{day} \times 2 \frac{\mu g}{L} \times \frac{3.78 L}{gal} \Rightarrow 3{,}780\ \mu g/day \text{ of mercury}$$

NEED A 33 gph EVAPORATOR TO TREAT THE 500 gpd (21 gph)

33 gph EVAPORATOR OPERATES WITH A VAPOR DISCHARGE RATE OF 800 cfm

$$800 \frac{ft^3}{min} \times 60 \frac{min}{hr} \times 24 \frac{hr}{day} \Rightarrow 1.15 \times 10^6 \frac{ft^3}{day} \times 0.028 \frac{m^3}{ft^3}$$

$$= 32{,}600\ m^3/day$$

$$\Rightarrow 0.116\ \mu g/m^3 \text{ at the stack}$$

ASSUMING A CONSERVATIVE 1:10 DILUTION AS THE STACK GAS DISSIPATES INTO THE AMBIENT ATMOSPHERE ⇒ 0.012 μg/m³ in ambient air

ASSUMING A MINIMAL AMOUNT OF METHYLATED MERCURY, THIS INDICATES THAT, USING CONSERVATIVE (I.E., WORST CASE) ESTIMATES, THE EMISSION WILL NOT EXCEED 24-hr AALs. THE ANNUAL AMBIENT CONCENTRATION IS EXPECTED TO BE MUCH LESS.

MA-DEP RESPONSE LETTER
ON EVAPORATORS
FOR MERCURY-BEARING WASTEWATER
DECEMBER 30, 1998

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

ARGEO PAUL CELLUCCI
Governor

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

Robert K. Gingras, P.E., DEE
Senior Program Director
Earth Tech
196 Baker Avenue,
Concord, MA. 01742-2167

December 30, 1998

Subject: Use of Evaporators for Processing Hospital Wastewater

Dear Mr. Gingras:

In a letter to the Department, dated June 26, 1998, you had asked for clarification concerning the acceptability and permitting procedures for using evaporative technology to treat wastewater from hospitals to remove mercury prior to discharge to the MWRA sewer system. The discharge of mercury to the MWRA system is prohibited and under present policy the MWRA interprets the discharge of wastewater containing mercury at a concentration in excess of 1.0 ppb to be in violation of this prohibition. Earth Tech has been conducting research into economic and technically feasible options for treating wastewater to meet this standard on behalf of the Medical, Academic and Scientific Community (MASCO) and has been asked to examine the possible use of evaporative technology for processing the wastewater.

The Department has carefully considered your letter of June 26, 1998 regarding the use of evaporative technology to process wastewater from hospitals to remove mercury. Please note that the Department's comments are limited to the issue of mercury removal. The Department suggests that you discuss the possible release of pathogens to the air with Howard Wensley of the Department of Public Health. He may be reached at 617-983-6761.

While the emissions of mercury from the evaporator are projected to be below the Department's Ambient Air Limits (AALs), and the emissions do not trigger review by the Department under the Air Quality Regulations, 310 CMR 7.00, the Department considers your proposal to be extremely ill-advised. Emissions of mercury in Massachusetts is a very serious problem which the Department, along with the other Northeast states and the Eastern Canadian provinces, are addressing through a mercury strategy which calls for reducing emissions of mercury from all sources. The ultimate goal of the strategy is zero mercury emissions. The New England Governors/Eastern Canadian Premiers 1998 Mercury Action Plan specifically calls for maximum achievable reductions in mercury emissions from area sources. Use of an evaporator would add an area source of mercury, rather than result in a reduction. Furthermore, one of the guiding principles of the Action Plan is that "efforts to eliminate mercury contamination in one environmental media should not result in significant contamination of another media". DEP will not support use of technology which results in a cross-media transfer of contaminants as a means to meet discharge limits. Use of an evaporator is simply a means to transfer mercury from wastewater to air in order to meet a wastewater discharge limit. Furthermore, as you acknowledge, it is possible that organics and pathogens could also be emitted.

The Department is therefore of the opinion that release of any mercury, where technology exists to eliminate that release, as is the case here, is unacceptable and should not be pursued. The Department would suggest that the best solution to the discharge of mercury into wastewater is to develop pollution prevention approaches to identify sources of mercury and eliminate those sources from the hospitals. The next best solution is for Earth Tech and MASCO to investigate other technologies which will remove mercury from the wastewater, but in a manner which does not release the mercury to the air and will allow for the recycling of the captured mercury. Technologies have been presented to the Department through the Innovative Technology (IT) program which may effectively remove metals such as mercury from wastewater and allow recovery of the heavy metals for recycling. For more information on technologies that have been reviewed through the IT program, please contact Claire Barker, the Department's Innovative Technology coordinator at 617-556-1128.

If you have further questions regarding this issue, please contact James Doucett at 617-292-5868.

Sincerely,

James C. Colman
Assistant Commissioner

cc: BWP Permit Chiefs
James Doucett, BCD
Heidi O'Brien, DRD, NERO
Howard Wensley, DPH
Kevin McManus, MWRA

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FOOTNOTES

Guidebook Text:

1. Refer to the MWRA Sewer Use Regulations, 360 CMR 10.021.
2. The concentration unit of µg/L is often referred to as "parts per billion" (ppb).
3. Noncompliant mercury dischargers are sewer users with discharges containing more than 1.0 µg/L of mercury.
4. The Massachusetts State Sanitary Code, Section VIII (105 CMR 480.200(A)(1) and (E)) states that free-draining blood, blood products, and liquid pathological wastes (body fluids) can be disposed of directly to a municipal sewer system if they meet requirements of the responsible regulatory agency. For MWRA purposes, such wastes are considered Industrial Waste (360 CMR 10.004) because they would be discharged to the sewer because of an action taken by a medical facility. For example, blood waste is Industrial Waste because it would be discharged after extraction by the medical facility. Common human waste, such as urine, would not be Industrial Waste unless the facility had chemically processed it in any way. Because of the potential for intrinsically high mercury levels in these types of waste, an effective Mercury Management Plan might specify pretreatment or segregation and alternate disposal of such waste that would be considered Industrial Waste.
5. The Massachusetts State Sanitary Code, Section VIII (105 CMR 480.100(F)) allows the use of compactors or grinders for processing medical and biological wastes (including tissues) <u>after</u> the wastes are rendered noninfectious by sterilization or disinfection. While the Code does not specifically authorize or prohibit their use prior to discharge to a municipal sewerage system, the processed wastes would apparently have to be considered liquid pathological wastes for discharge to the sewerage system to be allowed (by 105 CMR 480.200 (E)). Even if taken as liquid pathological wastes, such wastes may be chemically disinfected and would therefore qualify as Industrial Waste according to the MWRA Sewer Use Regulations (360 CMR 10.004). They would also tend to have intrinsically high mercury levels. Therefore, an effective Mercury Management Plan might specify an alternate method of disposal of such wastes.
6. Special Waste is generally defined in the Massachusetts State Plumbing Code, 248 CMR 2.13, as wastes from other than standard plumbing fixtures. In Section (1)(e), Special Waste is more specifically defined as including, but not limited to:

   > organisms containing recombinant DNA molecules, chemical, nuclear, radioactive, deionized, acids, perchloric, solvents and alkalines from laboratories and industrial activities.

7. Possible facility infrastructure mercury sources in Special Waste piping include residual accumulations from past mercury disposal and biomass accumulations. Refer to the following page, Section 2.5.4, and Appendix B of this Guidebook for further information.
8. Massachusetts Regulations 248 CMR 2.13 (6) (d).
9. Massachusetts Regulations 248 CMR 2.13 (9) (f).
10. Galinstan™, developed in Germany, is a liquid eutectic mixture of gallium, indium, and tin that is being promoted as a replacement for mercury in laboratory and clinical thermometers, blood pressure devices, dental fillings, switches, fluorescent lamps, and other applications. The thermometers are available in the US under the trade name Geratherm™. Mention of these products is not an endorsement or recommendation. Refer to Section 3.0 for supplier information.

11. For guidance on source reduction concepts and economic evaluations, refer to the MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997, Sections 5.0 and 11.0.
12. MWRA/MASCO Mercury Work Group, Phase II, Mercury Management Subcommittee, *Facilities Loading Subgroup Report*, December 1997.
13. Many hospital laundries have found that high mercury discharges are usually caused by singular events such as mercury thermometers that have been left in the pockets of lab coats.
14. MWRA/MASCO Mercury Work Group, Phase II, Mercury Management Subcommittee, *Facilities Loading Subgroup Report*, December 1997, page 27.
15. For a block process flow diagram depicting source segregation and a schematic diagram depicting an equalization tank intended for both flow and concentration equalization, refer to Figure 3 and Figure 4 of the MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997, pages 26 and 27, respectively.
16. While often used in waste piping systems, copper is not an approved material for Special Waste piping systems in Massachusetts. Refer to 248 CMR 2.13 (2).
17. For the collection and offsite disposal of industrial wastewater in an area served by a sewer system, refer to **Appendix C, Section 1.3.2,** for MA-DEP permitting requirements.
18. MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Technology Identification Subgroup Report*, December 1997.
19. MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997.
20. In May 1998, the EPA proposed that Method 1631 be approved for mercury measurement with a detection limit as low as 0.5 nanograms per liter, *i.e.*, 0.5 parts per trillion.

Appendix B:

1. The Massachusetts State Plumbing Code is found in 248 CMR 2.00, and Special Waste is covered in Subsection 2.13.
2. 248 CMR 2.13 (8)(e).
3. 248 CMR 2.13 (4).
4. 248 CMR 2.13 (10).
5. For further information, refer to the MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997.
6. Massachusetts Regulations 248 CMR 2.13.

Appendix B-1:

1. The Massachusetts State Plumbing Code is found in 248 CMR 2.00, and Special Waste is covered in Subsection 2.13.
2. 248 CMR 2.13 (8)(e).
3. 248 CMR 2.13 (4).
4. 248 CMR 2.12 (10).
5. For further information, refer to the MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997.

6. Massachusetts State Plumbing Code, 248 CMR 2.13 (2), limits fixture and piping materials in Special Waste systems to high silicon (14.5%) cast iron, polypropylene, polyethylene, glass, chemical stoneware, lead, stainless steel (Type 316, 18-8), and chemical resistant monolith epoxy resins.
7. MWRA/MASCO Mercury Work Group, Phase II, End-of-Pipe Subcommittee, *Pretreatment Guidance Manual*, December 1997. Refer to Sections 1.2 and 3.0 for information on obtaining a copy of the *Pretreatment Guidance Manual* and other Phase II reports.
8. As part of a special project investigating sources of copper in its sewer system, the MWRA began in September 1998 to collect samples of discharges from various permitted facilities to analyze them for copper content. Several medical and biotech facilities were sampled and found to have elevated copper levels in their discharges. It is not yet known if the copper originated from copper compounds in waste medical reagents or from corrosive reagents contacting copper piping materials in the facility Special Waste systems. Regardless, as shown in a previous footnote, copper is not an allowed piping material in Massachusetts Special Waste systems.

Appendix B-3:

1. Refer to **Appendix B-1, footnote 6,** for a listing of approved fixture and piping materials in Massachusetts Special Waste systems.
2. For example, some brands of bleach have the active ingredient, sodium hypochlorite, derived from chlorine that is manufactured in a mercury cell process. Preferred brands would instead have their chlorine manufactured in a diaphragm cell or membrane cell.
3. For the collection and offsite disposal of wastewater, refer to **Appendix C, Section 1.3.2,** for MA-DEP permitting and collection tank design requirements.
4. For general and specific prohibitions and discharge limits, refer to MWRA Sewer Use Regulations at 360 CMR 10.021, 10.023, and 10.024.
5. MA-DEP Hazardous Waste Regulations: 310 CMR 30.000.

Appendix C:

1. EPA Hazardous Waste Management Regulations: 40 CFR Parts 260 to 2XX.
2. MA-DEP Hazardous Waste Regulations: 310 CMR 30.000.
3. MWRA Sewer Use Regulations: 360 CMR 10.000.
4. 40 CFR 261.24 (b).
5. Because mercury is not considered a carcinogen, OSHA does not require mercury in concentrations below 1.0 percent to be listed in a MSDS.
6. This example is for illustration only. Caution is strongly advised here because a TSDF license is generally required before a facility can engage in any treatment of a hazardous waste.
7. Currently, the MA-DEP BWP IW 29 Permit Application and general requirements can be downloaded from the MA-DEP Web site: http://www.state.ma.us/dep.
8. Currently, new rules are under review as part of the MA-DEP Environmental Results Program and the revised Industrial Wastewater Sewer Connection Program. It is possible, therefore, that submittal of the BWP IW 29 industrial wastewater holding tank permit application would not be required by one or all of the MA-DEP regional offices.
9. The regulation (in 360 CMR 10.004) defines Industrial Waste as:

any solid, liquid, or gaseous Wastes or Wastewater, resulting from an industrial or manufacturing process, or from a commercial, governmental, or institutional activity, or from the development, recovery, or processing of natural resources.

10. Refer to Massachusetts Regulations 310 CMR 7.00.
11. Note that other requirements apply to contaminated soils.

Appendix D:

1. Note that for hazardous waste sampling, the EPA allows only grab sampling.
2. In addition, if a discharge needs but does not have a sewer use permit or if a sampled location is the equivalent of a permitted location, the data must be submitted to the MWRA if the data meets the other requirements for submission as listed above.
3. In May 1998, the EPA proposed that Method 1631 be approved for mercury measurement of samples of wastewater streams that are directly discharged to surface waters. The full impact on POTW's, sewer-discharging industries, and directly-discharging industries from the potentially required use of this proposed method is not yet known.
4. Refer to the previous footnote about proposed Method 1631. If Method 1631 becomes EPA-approved and required for mercury measurement of samples of wastewater streams that are directly discharged to surface waters, awareness of and compliance with all the Clean Hands techniques will become crucial.

Appendix F:

1. The volume or wastewater superficial residence time of the activated carbon adsorbers is not known. Typically, large volume adsorbers having long superficial residence times are required for the very low effluent mercury concentrations as required for compliance.
2. Refer to the following page for results of follow-up analyses on the electrophoresis waste.
3. BQL = Below Quantitation Limit with an unknown numerical value.

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