MWRA/MASCO Hospital Mercury Work Group
Infrastructure Subcommittee Maintenance Guidebook

This Manual is Intended As a Guideline for the Cleaning of "Special Waste" Piping and Pretreatment Systems for Control of Mercury and is Presented to the MWRA/MASCO Work Groups by Beth Israel Hospital, 330 Brookline Avenue, Boston, Massachusetts, 02115.

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For further information on appendices that are not currently linked here, please contact David Eppstein by email at deppstein@masco.harvard.edu or by phone at 617-632-2860. Thank you.

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- **Appendix B DEP Certified Independent Laboratories, February, 1995**
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Acknowledgments

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- Beth Israel Hospital - Mr. Daniel C. Murphy, Chair
- Beth Israel Hospital - Mr. Edward Cummings
- Beth Israel Hospital - Mr. Vinny Massone
- Newton-Wellesley Hospital - Mr. Bill Sullivan
- South Shore Hospital - Mr. Al Busa
- Lahey Clinic - Mr. Terry Cannon
- St. Elizabeth's Medical Center - Mr. Alvan Fletcher
- Flow-Tech Associates, Inc. - Mr. Kenneth J. Southwick, (St. Elizabeth's Staff Support)
- MWRA, TRAC - Mr. Dennis Capraro, (Subcommittee Delegate)
- EARTH TECH - Mr. Robert K. Gingras, (MASCO Staff Support)
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- Mount Auburn Hospital - Mr. David Hathaway
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1.0 PROBLEM OVERVIEW

1.1 Purpose

Mercury is a prohibited substance within the Massachusetts Water Resources Authority (MWRA) district, with an enforceable wastewater discharge limit, at the present time, of one (1) part per billion (ppb). The MWRA has issued Notices of Violation (NOV) for first time mercury discharge results above one (1) ppb and Notices of Noncompliance (NON) to all sewer users with repeat mercury discharge violations. NOVs and NONs were issued to a number of hospitals and institutions during the time period of 1993 - 1995. A number of these institutions joined in a collaborative effort with the Medical, Academic and Scientific Community Organization (MASCO) and the MWRA to identify the sources and methods of removing the contaminate from the wastewater effluent. The MWRA/MASCO Hospital Mercury Work Group was divided into three subcommittees: Operations, Infrastructure and End-of-Pipe.

The Infrastructure Subcommittee focused on developing a "Special Waste" conveyance plumbing maintenance Guidebook intended to help those institutions experiencing problems with mercury contaminated biomass within their systems. Research from several institutions provided information indicating that the organic materials entering these systems act as a food source for biological growth. This "biomass" was found to readily absorb or accumulate mercury within these "Special Waste" plumbing systems. Beth Israel Hospital, for example, determined that the biomass inside their conveyance system contained as much as 1,000 parts per million (ppm) of mercury. As bits of these biosolids would periodically break off and be flushed out of the systems, they would carry the concentrated mercury with them. This would result in a display of elevated concentrations of mercury, once the solids were digested and the sample analyzed. Some of the maintenance procedures that are discussed in this Guidebook for the control or elimination of biomass growth are: trap cleaning, powerwashing, chemical cleaning and associated procedures.

1.2 General Findings

As previously explained, mercury accumulation within "Special Waste" conveyance piping systems containing biomass growth with mercury creates a complicated wastewater compliance issue. But, through institutional efforts, two techniques, trap cleaning and conveyance pipe powerwashing, have been identified, tested and proven to be very successful with biomass removal and mercury sources identification.

The trap cleaning procedures simply require that a trap be removed, the contents be collected for off-site disposal, and the trap cleaned with a rag or brush prior to being placed back into operation. The powerwashing procedure provides a physical scouring effect on the accumulated biomass adhered to plumbing and piping infrastructure. Powerwashing is an effective, but not permanent, method for removing biomass and preventing biosolids from appearing in the effluent discharges. Powerwashing techniques are most efficient when performed on glass piping. With thermoplastic piping, some technique modification is required. Powerwashing activities usually require a minimum of two people: One serving as the powerwash operator; and the other as an observer of the nozzle and hose as it moves through the conveyance piping.

Since trap cleaning and conveyance pipe powerwashing will not permanently remove biomass, periodic cleanings will be necessary to help ensure recurring growth is removed. In an effort to augment or perhaps even eliminate the need for trap cleaning and powerwashing activities, several means of chemical cleaning were also tested and evaluated. Some of the chemicals succeeded in softening or loosening the biomass, and others actually facilitated the removal of bulky segments of biomass. But not one of the methods tested was capable of completely removing biomass from the piping systems. In addition, some of the chemicals had significant health and safety issues associated with them, making their use in the field impractical. Consequently, not one of the chemical cleaning means tested is recommended for use.

The Infrastructure Subcommittee also found that neutralization sumps or tanks (chip tanks) that are often used for the pretreatment of wastewaters containing dilute acids and alkalis from laboratory sinks cannot be used in facilities discharging significant quantities of organic materials due to the fact that the biomass present will coat the marble chips, rendering the media useless. It is, therefore, recommended that institutions review the efficacy of these systems, and replace them with active (adjustable) neutralization systems when and where appropriate.

Adjustment tanks for pH can be used to treat all "Special Wastes" including dilute acids and alkalis, and wastewater containing organic materials. The anticipated flows through the waste piping system may dictate the use of a two tank system; the first tank being a mix tank for rough neutralizing and a trim tank for final adjustment prior to discharge to the sewer system. As required by the Massachusetts State Plumbing Code, 248 CMR 2.13 (12/1/93), all plans and specifications for "Special Waste" piping and pretreatment systems shall be prepared by a Registered Professional Engineer and shall be submitted to the local Plumbing Inspector for approval *prior* to installation. Systems adjusting pH are to be accessible for maintenance, repair, operation, and sampling procedures. The operation and maintenance requirements of these pH adjustment systems are detailed in 314 CMR 12.00, Division of Water Pollution Control regulations. In addition, these wastewater pretreatment systems are required to be operated by certified operators. Certification requirements for wastewater pretreatment system operators are detailed in 257 CMR 2.00, Board of Certification of Wastewater Treatment Facilities regulations.

The installation of flow monitoring devices at several facilities (carried out as part of the Infrastructure Subcommittee's analysis of wastewater characteristics) also provided documentation of the tendency to over estimate institutional flow rates. Since the MWRA bases permitting and sampling fees, in part, on flow, additional sampling and permitting fees may be avoided if actual flow rates are obtained via the installation of flow monitoring devices. In most cases, these devices can pay for themselves in a short period of time from savings derived from reduced sampling and reporting requirements.

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2.0 SPECIAL WASTE PIPING AND PRETREATMENT SYSTEMS

2.1 Definition of Special Waste

In Massachusetts, "Special Waste" includes, but is not limited to, organisms containing recombinant DNA molecules, chemicals, nuclear, radioactive, acids, alkalis, perchloric solvents and other such wastes that could be considered detrimental to the public sewer system and which do not comply with limitations established by the Publicly Owned Treatment Works such as the MWRA.

2.2 Special Waste Piping Design

The design, methods, materials, type of neutralization, testing, and inspections required for "Special Waste" piping systems serving laboratories and industrial activities are governed under 248 CMR 2.13 of the Massachusetts State Plumbing Code (12/1/93).
The code establishes the guidelines for the proper installation methods and materials selection for "Special Waste" piping systems but not for the way it may be used after it is installed or what "chemicals" may be disposed into it on a daily basis.
Constant changes in chemical technology, the rearranging of existing laboratory spaces, and the lack of versatility in piping systems have created concerns relative to the safety and operations of "Special Waste" piping systems. Most recently, the greatest concern centers on the impact created by historical discharges of elevated amounts of mercury into these systems. Although the reduction of the mercury point source from existing waste streams will address most, if not all, of the non-compliance concerns, there is still the ongoing issue of biomass absorption of mercury within the piping system itself.
In particular, the following design guidelines are meant to focus on the biomass removal from piping systems. However, it must be noted that these guidelines should be followed when any type of "Special Waste" is introduced into a dedicated piping system designed specifically for the conveyance of special wastes.

2.3 Special Waste Regulatory Guidelines

The following regulatory guidelines have used 248 CMR 2.13 - Piping and Treatment of Special Wastes (12/1/93), as the primary basis for the design protocol considerations:

2.3.1 General

248 CMR 2.13 (12/1/93) governs "Special Waste" systems other than from standard plumbing fixtures.
All plans and specifications for "Special Waste" piping and pretreatment systems shall be prepared by a Registered Professional Engineer for submission to the local Plumbing Inspector, MWRA, DEP or other authorities for their review and approval. Permits are applied for on the basis of the design and the inspections of the installed "Special Waste" piping and pretreatment systems must be made by the engineer during construction.
All "Special Wastes" must be conveyed in a separate waste and vent piping system. These systems are to be constructed of approved code materials. A list of these materials and installation requirements are located in 248 CMR 2.13 (12/1/93).

2.3.2 Design and Installation of Special Waste Systems

The Owner shall provide a notarized letter stating what materials are to be disposed of into the piping system.

All designs must conform with the intent of the regulations. Alternate design of a system, materials and/or "Special Waste" termination point shall be considered ONLY where evidence is presented that certain standards cannot be reasonably complied with. The plan for such a proposed alternate system shall specifically be submitted to the local Plumbing Inspector for review and approval.

Piping materials and equipment such as pumps, pits, etc., shall be constructed of materials chemically resistant and thermally compatible with the liquids being disposed or pumped.

Great care must be taken in the selection of system materials in order to be compliant, technically compatible and safe to use without the danger of leakage and spills. Non-compatible applications such as hydrofluoric acid with glass piping, high-temperature waste streams with thermo-plastic piping and non-pressure rated pipe and fittings on special waste pump discharge lines must be addressed. Conversely, "Special Waste" piping systems cannot be used for the conveyance of sanitary type wastes.

2.3.3 Neutralizing Sumps (Chip Tanks)

Neutralizing sumps or tanks shall be used for the pretreatment of wastewaters containing dilute acids and alkalis from laboratory sinks. These sumps are **not** allowed to adjust the pH for wastewater generated by biomedical laboratories. These sumps similarly cannot be used in facilities discharging significant quantities of organic materials into the "Special Waste" System or the biomass which is found will coat the marble chips rendering the media useless. The different types of neutralizing materials, and approved materials of construction and sizing are described in 248 CMR 2.13 (12/1/93).

2.3.4 pH Adjustment Tanks

Adjustment tanks for pH are used to treat all "Special Wastes" including dilute acids and alkalis. The sizing of the pH adjustment tank (reactor vessel) shall initially be based upon 248 CMR 2.13, Table 1 (12/1/93), in order to determine hourly flows and relative retention times. However, diversity factors for estimated flows, type of wastes (acid and caustic), waste stream temperature, high flow surges from pumped discharges or equipment dump cycles, future capacity, etc., all have a bearing on correctly sizing an automatic pH adjustment system. The anticipated flows through the waste piping system may dictate the use of a two tank system; the first tank being a mix tank for rough neutralizing and a trim tank for final adjustment prior to discharge to the sewer system. As required by the Massachusetts State Plumbing Code, 248 CMR 2.13 (12/1/93), all plans and specifications for "Special Waste" piping and pretreatment systems shall be prepared by a Registered Professional Engineer and shall be submitted to the local Plumbing Inspector for approval. Figures 2.1 and 2.2 display typical "Special Waste" pH adjustment system, and special waste battery system and vent piping.

Each reactor vessel is to be fitted with an agitator capable of operating at all times when waste flows occur, a pH monitoring system for operation of acid/alkali neutralizing media to maintain a tank pH level of between 5.5 and 10.5, as required by the MWRA's Sewer Use Rules and Regulation 360 CMR 10.023 (7/2/93) and related controls. Prior to using any neutralizing media it should be analyzed for mercury content. Several institutions found that lower grade neutralizing media contained high concentrations of mercury. This finding forced the institutions to use a higher quality reagent grade chemical.

The discharge piping from the reactor vessels shall be fitted with a trap, pH monitor and recording device, a sampling port for Regulatory Agency testing, and a flow meter and recording device, as required.

The MWRA requires that all facilities with industrial wastewater discharges of 25,000 gallons per day or greater, or subject to EPA categorical limits with wastewater discharges of 1,000 gallons per day or greater, monitor flow during compliance sampling. The recent installation of flow monitoring devices in several institutions has documented that these institutions had been significantly over estimating their flow rates. Since the MWRA bases permitting and sampling fees on flow, an institution may be doing unnecessary sampling and reporting if flow estimates are not accurate. The additional sampling and permitting fees may be avoided if actual flow rates are obtained via flow monitoring devices. In most cases these devices can pay for themselves from the reduced MWRA sampling and reporting fees alone.

Systems adjusting pH are to be accessible for maintenance, repair, operation, and sampling procedures.

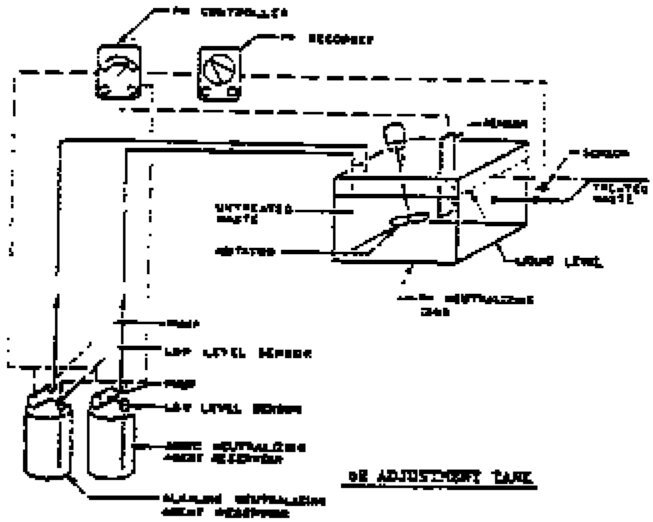

Figure 2.1 pH Adjustment System
Source: Commonwealth of Massachusetts Fuel Gas and Plumbing Codes, 248 CMR 1.00 - 7.00, pg. 84

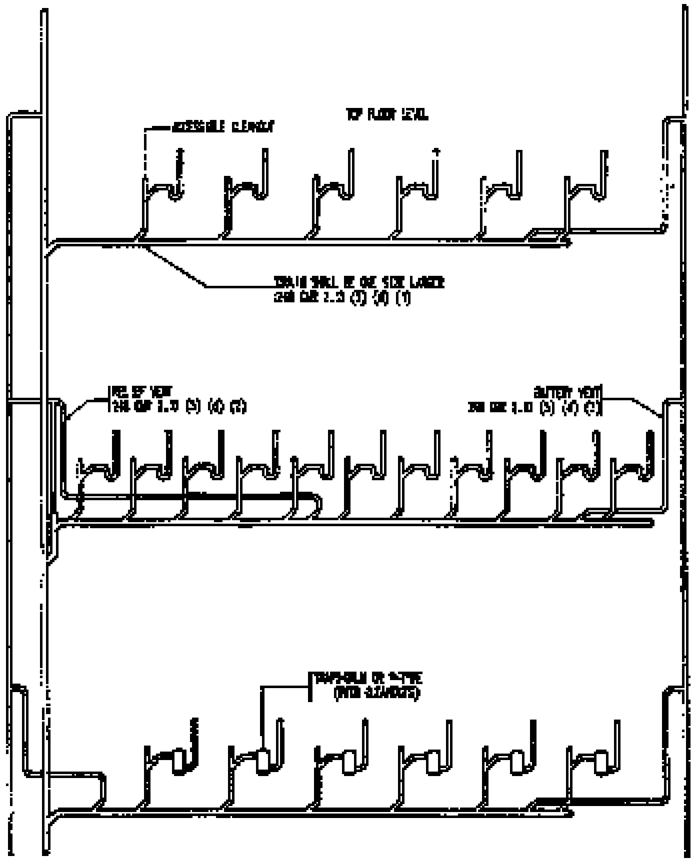

Figure 2.2 Special Waste Battery System and Vent Piping

Source: Commonwealth of Massachusetts Fuel Gas
and Plumbing Codes, 248 CMR 1.00 - 7.00, pg. 140

The operation and maintenance requirements of these pH adjustment systems are detailed in 314 CMR 12.00, Division of Water Pollution Control regulations. In addition, these wastewater pretreatment systems are required to be operated by certified wastewater pretreatment operators. Certification requirements for wastewater pretreatment operators are detailed in 257 CMR 2.00, Board of Certification of Wastewater Treatment Facilities regulations.

The MWRA prefers that institutions use open channel type flow devices whenever possible and that these devices be compatible with their samplers for flow monitoring connections. The recommended open channel flow device for high flow conditions is the Parshall flume and, for low flow conditions, the Palmer-Bowlus flume is preferred.

It is not always possible to install open channel flow devices because of space limitations. In this situation, the use of an in-line velocity meter to monitor flow is acceptable.

Whichever device is selected, it is very important that these devices be compatible with the MWRA's sampling equipment. The MWRA's samplers are capable of receiving direct and indirect signals from flow monitoring devices. The specific signal requirements are presented in communication from the MWRA to Beth Israel which is located in Appendix E.

3.0 FORMS OF MERCURY

3.1 Purpose

The following section provides an explanation and general overview of the forms of ***Mercury.*** Mercury refers to any of the different chemical forms that it can take including elemental mercury (Hg 0), methyl mercury (CH3Hg+), dimethyl mercury ((CH3)2Hg) and divalent mercury (Hg 2+).

3.2 Types of Mercury

3.2.1 Mercury the Element

Mercury as per the periodic chart takes the symbol **"Hg"**. which comes from the Latin - hydrargyrum which translated, means, liquid silver. Mercury, together with gold and silver make up only approximately 0.00001 percent of the earth's crust. Mercury is obtained from cinnabar, also known as mercuric sulfide by heating it in air. The atomic weight of the element is 80 and it's atomic weight is 200.59.

3.2.2 Elemental Mercury (Hg 0)

Elemental mercury is the form of mercury which is nonionized; familiar to most as the silvery liquid. It can volatilize to the atmosphere at normal temperatures. Over 90 percent of mercury in the atmosphere is mercury zero, although other forms may be considerably higher than 10 percent near sources. Because it does not adsorb to particulates and is not very water soluble, it is removed from the atmosphere very slowly with a half life in the atmosphere of about a year. The liquid or amalgam form is not adsorbed during digestion, but the vapor is readily absorbed by the lungs.

3.2.3 Methyl Mercury (CH3Hg+)

Mercury will not bioaccumulate unless it is converted to this simple organic compound, CH3Hg+. Methyl mercury is water soluble. Virtually all of the mercury in fish is methyl mercury, and it is readily absorbed during digestion.

3.2.4 Dimethyl Mercury (CH3)2Hg

Dimethyl mercury is a volatile substance that boils in normal circumstances at 96ºC (205ºF), is readily absorbed by the biomass or skin and may be inhaled as vapor.

3.2.5 Divalent Mercury (Hg 2+)

Mercury two is the mercuric ion. Because it is water soluble and associates with particulates, atmospheric deposition of mercury two is relatively fast, either as dry deposition or precipitation. Combustion sources can emit both mercury zero and mercury two. Mercury two can also be produced in the atmosphere by the oxidation of mercury zero by ozone or other oxidants.

3.3 Uses of Mercury

3.3.1 Mercury Products

There are many common products that contain mercury such as the thermometer. In addition, mercury is widely used in or as part of metal amalgams, lab equipment, lab instrumentation, many forms of electrical apparatus components, pesticides, chlorine production, anti-fouling paint, batteries and various catalysts. The most common salt form of mercury is mercuric chloride ($HgCl_2$).

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4.0 MERCURY ACCUMULATION IN BIOMASS

4.1 General

Preventing mercury from entering the waste stream will not ensure the elimination of mercury being accumulated within the special waste piping system. The combination of organic waste products being discharged, bacteria, temperature and humidity within a piping system provides a natural environment for biomass growth and a vessel for the accumulation of mercury onto the walls of the waste pipe.

4.2 Biomass Formation

Biomass evolves from organic matter such as blood products, urea, soaps, chemical reagents, bacteria, virus, infectious wastes, etc., that have been discharged into the piping system. The combination of these organic substances forms a growth on the side of the piping system.
Within a trap, the growth can be more pronounced due to the lower flows of wastes over the sides of the pipe thus creating a continuous liquid "incubator" where oxidation or dehydration of bacteria will not occur.
Within a flowing pipe, the biomass growth occurs principally below the liquid level with lesser biomass present above that line. A hardened skeleton of carbon, oxidized soap products containing elements such as potassium and dried blood products is formed and strongly adheres to the wall of the piping material.
The presence of organic material allows for the formation of methyl and dimethyl groups which, when combined with mercury, increases the solubility of the now formed methyl and dimethyl mercury compounds into organic substances such as the biomass.

4.3 Biomass Absorption of Mercury

The two species of methyl mercury groups accumulate in the biomass and can concentrate to significant levels. As larger biomass materials are eventually dislodged and carried away in the waste stream, a non-compliance issue will most likely occur due to "slugs" of mercury laden biomass being discharged. It should be noted that biomass formation also occurs within neutralization reactor vessels thereby increasing the potential for further mercury accumulation.
Concentration levels of mercury 1,000 times that found in wastewater have been reported as absorbed into organic masses. The presence of large amounts of biomass could lead to a higher mercury concentration potential.
Deaconess-Glover, a New England Deaconess Hospital affiliate institution, performed a small pilot test to determine if biomass solids were contributing to its mercury effluent violations. The pilot study was performed on an area of plumbing during non-operating hours: city water was poured down a laboratory sink at a 1 minute, 3 minute and 5 minute interval and allowed to travel through the piping where samples were then collected at three corresponding time intervals. After the rinsing pilot test was completed, a biomass sample was removed from the conveyance piping and analyzed for mercury. The results are as follows:

Influent City water at interval	1 minute = < 0.0002 ppm
	3 minute = < 0.0002 ppm
	5 minute = < 0.0002 ppm
Effluent samples at interval	1+ minutes = 0.037 ppm

3+ minutes = 0.0064 ppm

5+ minutes = 0.015 ppm

Biomass at 28.6 % solids contained 9700 ppm

This was one of the first pilot tests which provided evidence that mercury laden biomass was being dislodged by wastewater flows and eventually becoming a part of the effluent.

4.4 Mercury Accumulation Process

Figure 4.1 and 4.2 illustrate how mercury wastes combined with organic material is, in turn, absorbed by the biomass where it accumulates within the piping system. A numeric key and general description of the accumulation process, for figures 4.1 and 4.2, is presented in Figure 4.3.

4.5 Dimethyl Mercury Precautions

There is a tendency for greater amounts of dimethyl mercury to form within piping systems where the waste water is elevated in temperature and where heats of formation of chemical reactions may occur within the piping systems. Additionally, dimethyl mercury may vaporize at lower temperatures due to the interaction with more unstable chemical compounds within the piping system or due to negative pressures within the laboratory room where the point of discharge occurs.
Since vaporized dimethyl mercury is water soluble, it can emanate from the trap back into the room. Traps should be of the deep seal type and be always sealed to help ensure complete protection against possible vapor "drawback."

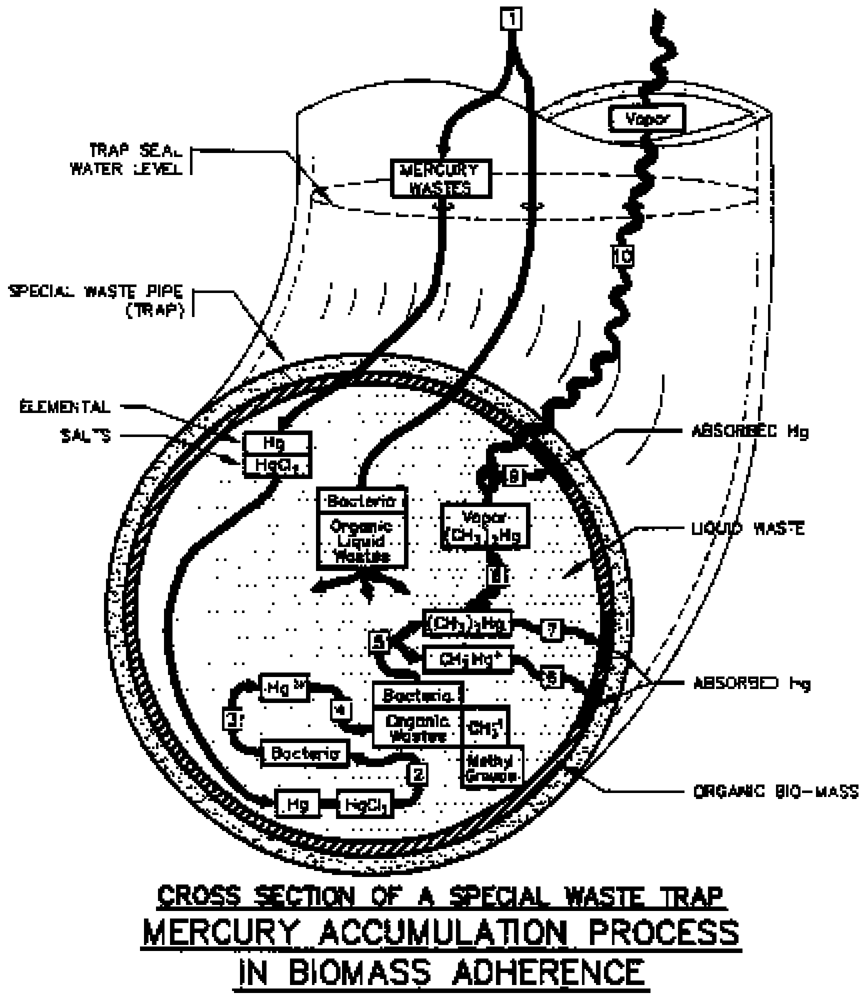

FIGURE 4-1: Mercury Accumulation Process in a Special Waste Trap
Source: Flow Tech Associates, Inc., Detail 1

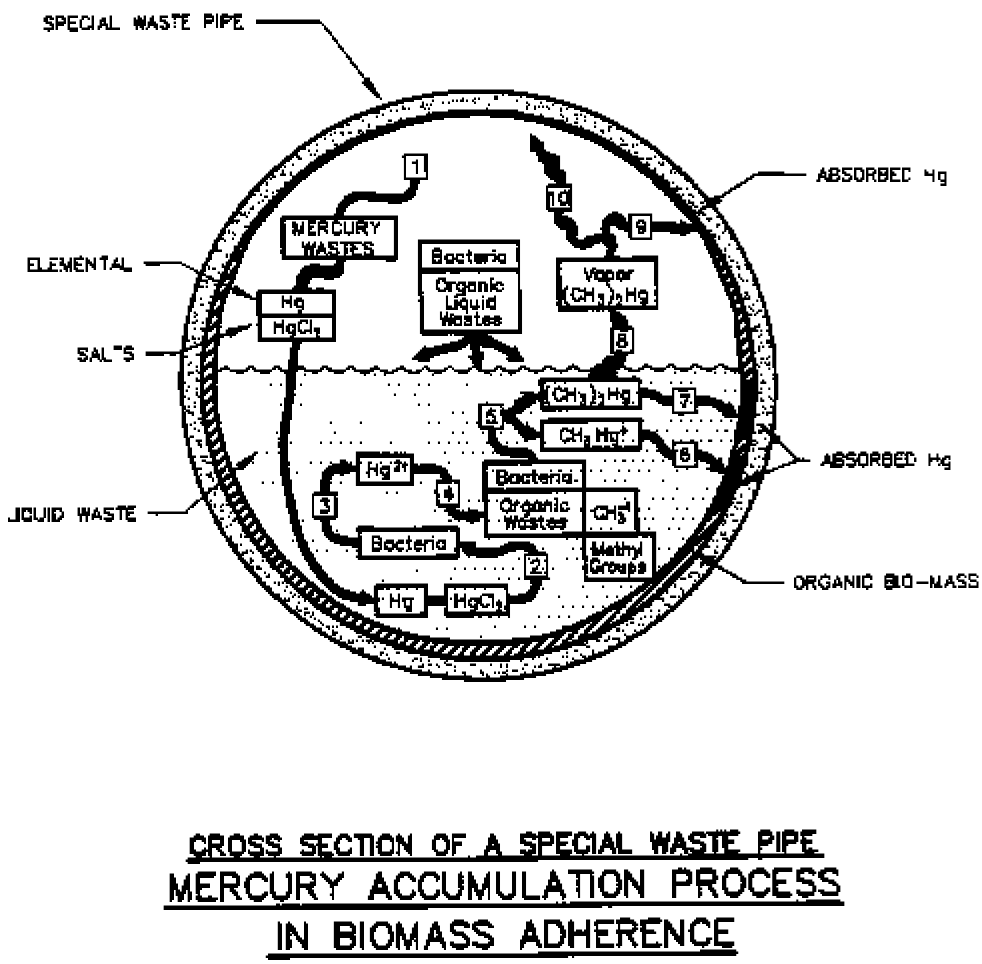

FIGURE 4-2: Mercury Accumulation Process in a Special Waste Pipe
Source: Flow Tech Associates, Inc., Detail 2

1. MERCURY WASTES, BACTERIA AND ORGANIC LIQUID WASTES ENTER INTO THE PIPING SYSTEM.
2. ELEMENTAL MERCURY AND MERCURY SALTS ARE REACTED ON BY BACTERIA. CHLORIDE IS OXIDIZED TO CHLORATE AND Hg^{2+} IS RELEASED.
3. ELEMENTAL MERCURY IS PARTLY CONVERTED INTO THE MERCURIC ION Hg^{2+}.
4. MERCURIC ION REACTS WITH ORGANIC WASTES METHYL GROUP (CH_3^+) AND IS CATALYZED BY BACTERIA.
5. METHYL MERCURY ION CH_3Hg^+ AND DIMETHYL MERCURY ION $(CH_3)_2Hg$ ARE FORMED.
6. METHYL MERCURY ION IS ABSORBED INTO THE ORGANIC BIOMASS ADHERENCE AND ACCUMULATED ON PIPE WALL.
7. DIMETHYL MERCURY ION IS PARTIALLY ABSORBED INTO THE ORGANIC BIOMASS ADHERENCE AND ACCUMULATED.
8. DIMETHYL MERCURY ION IS PARTIALLY VAPORIZED.
9. DIMETHYL MERCURY ION IS CONDENSED AND ABSORBED INTO THE ORGANIC BIOMASS ADHERENCE AND ACCUMULATED.
10. DIMETHYL MERCURY ION IS VAPORIZED AND POTENTIALLY RELEASED BACK INTO ROOM THROUGH THE TRAP.

KEY FOR TRAP AND PIPE CROSS SECTION

MERCURY ACCUMULATION PROCESS IN BIOMASS ADHERENCE

FIGURE 4-3: Numeric Key and General Description of Mercury Accumulation Process

Source: Flow Tech Associates, Inc., Detail 3

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5.0 SPECIAL WASTE RISER

5.1 Purpose

The "Special Waste" riser diagrams are an important tool in approaching wastewater compliance for mercury. The riser diagram illustrates to regulating authorities (MWRA) that an institution has extensive knowledge and control of all special waste discharges. The diagram will indicate areas of inability to control and isolate special waste discharges for all "Special Waste" sources. As required by the Massachusetts State Plumbing Code, 248 CMR 2.13 (12/1/93), all plans and specifications for "Special Waste" piping and pretreatment systems shall be prepared by a Registered Professional Engineer.
The inability to contain and isolate the discharge of mercury or other non-compliant wastes into the public sewer system is, in large part, due to the indiscriminate routing of "Special Waste" piping systems, their interconnections with each other, lack of future planning and restrictive economic considerations.

5.2 Riser Diagram

The proposed use of isolation valves in "Special Waste" and vent piping systems under 248 CMR 2.05 (12/1/93), is allowable when the valve would not cause a normal frictional obstruction to flow in the piping system or when the valve has "a desirable and acceptable function and as of the ultimate benefit to the proper and continuing function of the plumbing system." The ability of the isolation valves to allow for trap cleaning, removal of non-compliant wastes, sampling or suspect branch piping and control of waste flow from cross-contaminating the entire special waste piping system would be allowable. However, each proposed installation must have the approval of the local plumbing inspector and each location, when installed with a sampling port, must be approved by the MWRA or the DEP.
The Infrastructure Committee recommends that the following guidelines be followed when planning to install or modify an existing piping system capable of having isolated trap and pipe cleaning procedures:

5.2.1 Facility Audit

An on-site audit of existing piping systems should be conducted and drawings prepared to reflect the actual waste, vent, and associated pretreatment system installations. Figure 5.1 is an example of a "Special Waste" riser diagram prepared by Beth Israel Hospital. This diagram illustrates individual floors and sinks, with each individual sink identification number, and stack color code and numbering system. An exploded view of a typical "Special Waste" and vent riser diagram is shown in figure 5.2. This diagram displays strategically located isolation ball valves, glass inspection pieces, and sampling/drain valves.

5.2.2 System Designs and Modifications

System designs or modifications to an existing system in order to allow isolation of wastes for cleaning, testing, etc., must take into account:

1. The type of wastes being discharged and the piping material compatibility.
2. The future use of laboratory spaces (i.e., chemical changing to blood lab).
3. The need to isolate branch piping from waste and vent stacks to allow piping cleaning without the potential of constricting waste flows from other areas or causing overflows to other uncontaminated piping systems.

4. Caution should be taken when combining any unidentified "Special Waste" piping to previously identified "Special Waste" systems. All waste sources and piping should be investigated for biomass and mercury content prior to combining with previously identified piping. Pending the results of investigation of these new sources, additional isolation valving and/or new dedicated risers to the neutralization system may need to be installed.

5.2.3 Isolation Valves

The location of isolation valves for cleaning or flow control must be placed with consideration for accessibility and maintenance especially when co-fitted with a sampling port for testing. An example of suggested isolation valve locations is shown in figure 5.2. The location of valves cannot cause an overflow of non-compliant wastes into another area where a spill may occur. As an example, a floor drain would overflow if too much sanitizing liquid used for the pipe cleaning procedure was poured into a countertop sink situated at a higher elevation. Additionally, the need to provide isolation valves in the venting system must not be overlooked for the same reasons.

5.2.4 Sampling Port / Drain Leg

The sampling port may act as not only a testing point, but also a drain leg for the isolated sanitizing and cleaning agents used in the affected branch of piping. The serrated nozzle may be replaced with a full-size drain leg for the transfer of suspected non-compliant wastes to a container for off-site disposal. See Figure 5.2 for typical locations of sampling/drain valves.

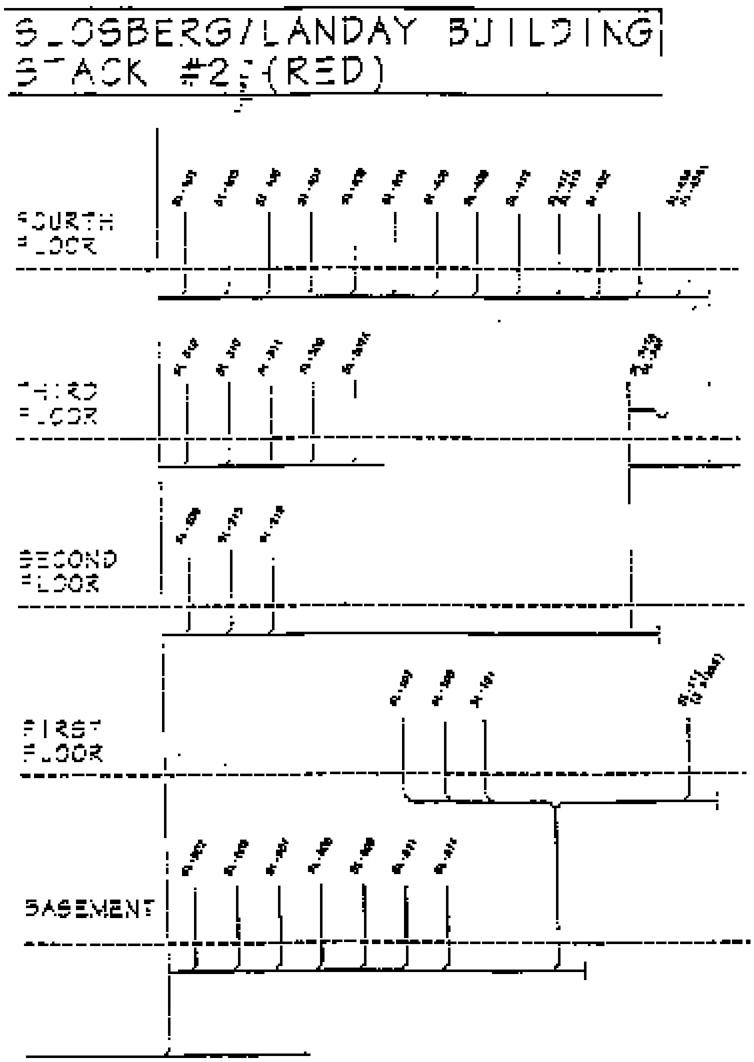

Figure 5.1 Typical "Special Waste" Riser Diagram of Beth Israel Hospital

Source: Beth Israel Hospital, Boston, Facility Engineering Department

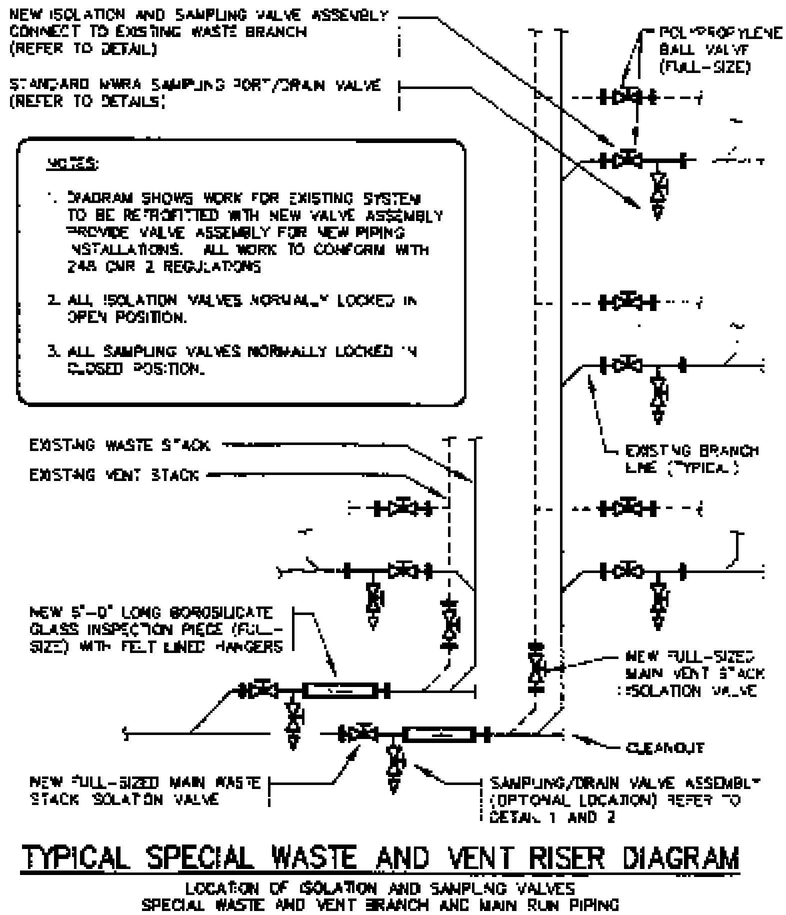

Figure 5.2 Typical "Special Waste" and Venting Riser Diagram
Source: Flow Tech Associates, Inc., Detail 1B

5.2.5 Riser Venting

Vertical "Special Waste" and vent piping risers may need to be isolated in order to allow for sequential cleaning, sanitizing 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 due to the potential for overflow of reagents back through the piping system.

5.2.6 Glass Inspection Segment

A section of clear borosilicate glass piping should be installed within the main horizontal run of the "Special Waste" conveyance system employing thermo-plastic piping so that flow conditions can be viewed and the formation of biomass accumulation can be periodically observed. Figure 5.2 presents a suggested location for this glass inspection piece. If branch piping containing undiluted hydrofluoric acids is being used, however, this piping should be routed separately and connected downstream of the glass piping and fitted with its own isolation valve and sampling port assembly.

5.2.7 Chemical Reactions of Incompatible Materials

The type of sanitant and cleaning agent being used must be analyzed in conjunction with what may be contained in the piping system from a chemical interaction perspective.

The potential for incompatible reactions should be considered to ensure that trap and pipe cleaning procedures will not create an unsafe condition. Reactions that may cause fuming and result in gas generation into the working environment, as well as into the piping system, must be avoided.

5.2.8 Support Engineering Drawings

All proposed special waste piping and pretreatment installations, modifications, revisions and additions must be detailed in engineering drawings and specifications certified for 248 CMR 2.0 (12/3/93) compliance (unless otherwise noted as an alternate design) and must be submitted to the local Plumbing Inspector for review and approval prior to construction. These approved documents are then submitted to the jurisdictional authority having control (either the MWRA or the DEP) with the proper permitting documents and supporting engineering design data for final approval prior to discharging wastes to the sewer system.

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6.0 TRAP CLEANING

6.1 Purpose

As explained in the problem overview, mercury accumulation within "Special Waste" conveyance piping systems containing biomass growth creates a complicated wastewater compliance issue. The following procedures have been developed for use during trap removal and cleaning maintenance. Trap cleaning and removal procedures, in section 6.5, will accomplish the following objectives: trap location / identification, removal of elemental mercury (Hg0) and removal of biomass growth.

6.2 Trap Location / Identification

Trap location is accomplished by preparing a complete and detailed inventory of all "Special Waste" sources. After all sources are identified, a facility "Special Waste" conveyance pipe drawing should be generated with all traps to be identified by a unique number. A master inventory of all traps should be generated to record and track all trap cleaning events. Each individual trap should be tagged or labeled with its unique number, cleaning date, name and signature of the person performing the cleaning.
Trap identification can be accomplished as a part of locating the necessary information to generate the conveyance pipe drawings. An additional piece of information would include the type of piping material and associated trap. Figure 6.1 contains an example of a trap inventory spreadsheet.

6.3 Removal of Elemental Mercury (Hg0)

When a trap is removed for the first time, it may contain elemental mercury. This can usually be identified as a pool of silvery liquid which is separated from the trap wastewater. Elemental mercury usually and accidentally gets disposed down laboratory sinks and floor drains as a result of broken laboratory equipment. Some elemental mercury sources include old mercury thermometers, thermostats and blood pressure manometers. If a trap contains elemental mercury, it should be collected and disposed as a mercury waste. Section 10.0 of this manual explains the procedures for disposal of mercury wastes.

6.4 Removal of Biomass

Typically a trap will not contain elemental mercury, but almost every trap and conveyance pipe will eventually accumulate biomass. The biomass is identified as a slimy light or dark brown film on the internal surface of the plumbing material. It has been determined that the biomass, over several years, will accumulate dissolved mercury from various chemical reagents and other laboratory chemicals.

TRAP INVENTORY FORM

Institution Name: ____________________

Address ____________________
____
____

Building Name. ____________________

Trap Identification	Room / Dept Name	Plumbing Material	Trap Type	Type of Waste & Hazard	Cleaning Date

Figure 6.1 Example Trap Inventory Spreadsheet

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. When the biomass grows on the non-wetted surfaces it eventually dries out. This dried out biomass develops a strong adhesion to the plumbing surfaces as it becomes encrusted.

6.5 Cleaning Procedures

1. Identify necessary traps for cleaning and discuss the trap cleaning operation with the building's occupants. Explain to them how the effect of the cleaning will interrupt their

operations and indicate for how long.

2. Before any traps are removed, it is important to ask the occupants about the nature of their laboratories' wastes, identifying health and safety hazards. Before handling and cleaning traps that are located 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 cleaning).

3. After the building occupants have been made aware of the trap cleaning program and it is determined that it is safe to handle traps, actual trap cleaning can be started.

4. It is important that personal protective equipment (PPE) be worn by all personnel doing this trap cleaning at all times. It is recommend that all of these procedures be reviewed by an internal Health and Safety Officer.

5. All materials found inside the traps must be handled and disposed as mercury waste. Section 10.0 of this manual explains the procedures for the disposal of mercury waste.

6. The removed trap can be cleaned with either a rag or flexible brush. The use of a cleaning agent and some type of disinfectant may also be used to help ensure that complete removal and disinfection is accomplished

7. After traps are removed, cleaned and replaced, a tag or label should be put on or updated with the unique number, date of cleaning and the cleaner's initials.

8. After cleaning 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 building occupant that the cleaning is complete.

9. All trap cleanings should be logged on the Trap Inventory Form.

10. It will be necessary, in the future, to inspect these traps for reoccurring biomass growth. These inspections should initially be performed on a quarterly basis. Once a sufficient level of experience has been obtained, inspection frequencies can either be increased or decreased, depending on the rate of returning biomass.

11. NOTE: Have spare traps available for replacement.

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7.0 INFRASTRUCTURE POWERWASHING

7.1 Purpose

The powerwashing procedure is a recommended way to provide a scouring effect on the accumulated biomass that has adhered to plumbing and piping infrastructure. Powerwashing is an effective, but not permanent, method for removing biomass and preventing biosolids from appearing in the effluent discharges. Figures 7.1 through 7.3 display powerwash pipe cleaning events with associated compliance sampling results from Beth Israel Hospital's discharges from December 1993 to December 1994. The figures show that, in late 1993, effluent mercury concentrations were persistently high but, in 1995, effluent mercury concentrations appear to stabilize after pipe cleaning events. As mentioned in the Problem Overview, the biomass within an institution's conveyance piping may contain concentrations of mercury in the 1,000 part per million range. Several institutions have verified the presence of mercury in the biomass through pilot testing and pipe cleaning protocols. Figure 7.4 is a spreadsheet with some of the initial data determining the presents of mercury in the biomass. This data was generated from pilot testing performed by Beth Israel Hospital showing the relationship between particulate and dissolved mercury after powerwashing.

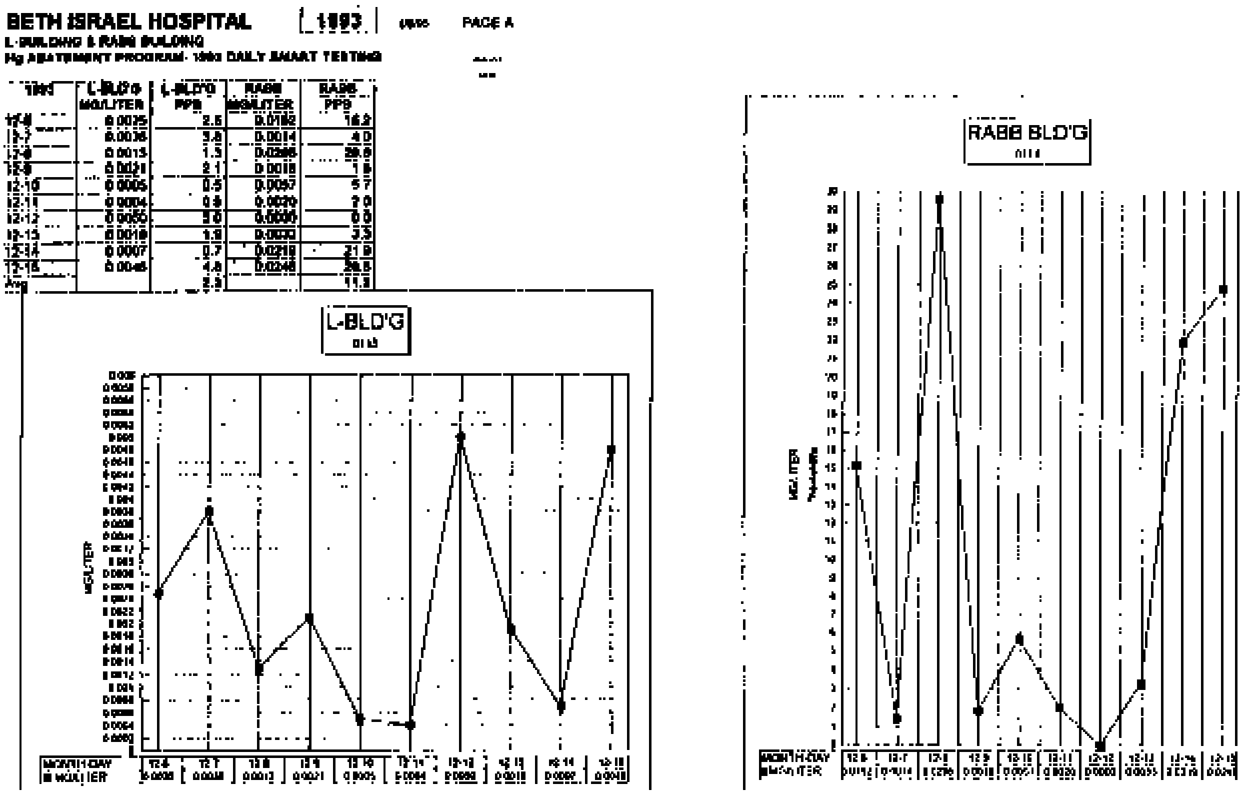
A typical high pressure/low volume powerwasher pushes water through a nozzle that is designed to remove biomass and grease buildup with a strong scouring action while flushing the debris down the line as the hose and nozzle are fed along the conveyance piping. The more accessible the piping structure is (via cleanouts and access ports), the more successful the power washing effort will be.

7.2 Powerwashing Operations

7.2.1 Cleaning Operations

Conveyance piping accessibility is essential for successful powerwashing. The following techniques are most efficient when performed on glass piping. The techniques mentioned, hereinafter, will require some modification when cleaning thermo-plastics piping. Powerwashing activities are usually, at a minimum, a two (2) person operation; an operator of the powerwasher and an observer of the nozzle and hose as it moves through the conveyance piping.

The operator begins feeding the 80 to 100 feet of hose with the powerwashing 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. Beth Israel Hospital has determined that successful powerwashing occurred when cleaning operations began at the collection or treatment tanks in the lower floors, and worked backwards, towards the sources, in a reverse flow direction.



1993	L-BLD'G MG/LITER	L-BLD'G PPB	RABB MG/LITER	RABB PPB
12-6	0.0025	2.5	0.0162	16.2
12-7	0.0036	3.6	0.0014	4.0
12-8	0.0013	1.3	0.0286	28.6
12-9	0.0021	2.1	0.0018	1.8
12-10	0.0005	0.5	0.0057	5.7
12-11	0.0004	0.4	0.0020	2.0
12-12	0.0050	5.0	0.0000	0.0
12-13	0.0018	1.8	0.0033	3.3
12-14	0.0007	0.7	0.0219	21.9
12-15	0.0048	4.8	0.0248	24.8
Avg		2.3		11.3

Figure 7.1 Beth Israel Hospital Effluent SMART Testing Result 1993 (No Powerwashing)

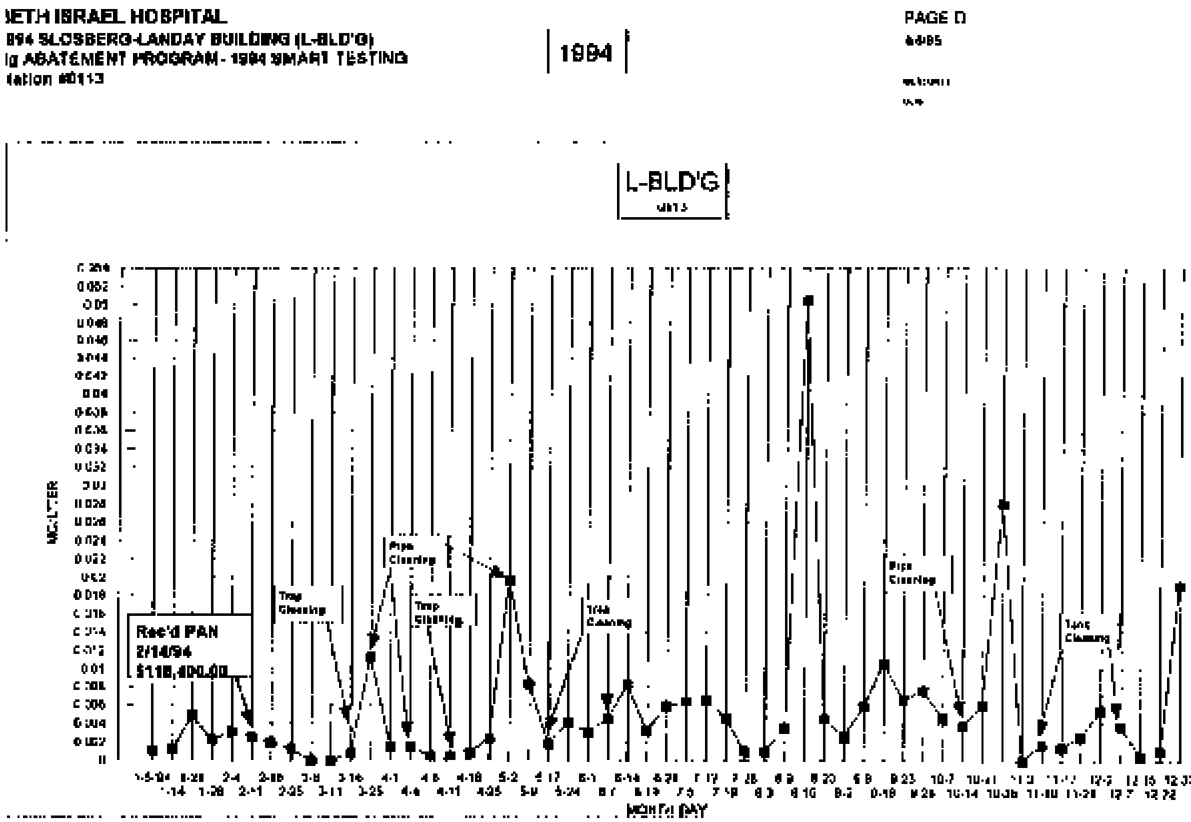


Figure 7.2 Beth Israel Hospital Effluent SMART Testing Result 1994 (Powerwashing - L-BLD'G 0113)

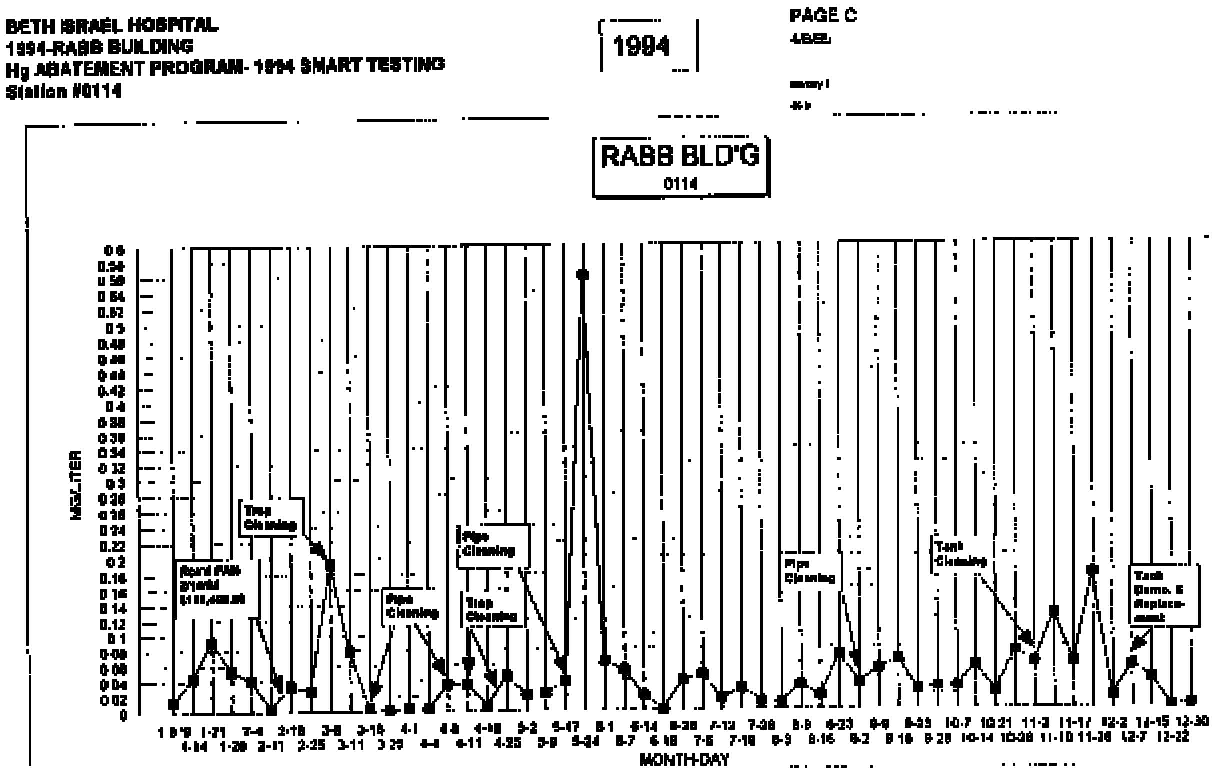


Figure 7.3 Beth Israel Hospital Effluent SMART Testing Result 1994 (Powerwashing - RABB BLD'G 0114)

Beth Israel Hospital, Project Number 8644.201
Riser Cleaning Program Results Summary, Updated thru 10-28-94
***Note: Mercury concentrations (mg/l) in grab samples taken at ends of risers*.**

		SLOSBERG LANDAY BUILDING					DANA	RABB		Research North		
Date	**Status**	**#2 RED STACK**	**#4 ORANGE STACK**	**#1 GREEN STACK**	**#3 BLUE STACK**	**Neut. Tank Sludge**		**RB-36-1**	**RB-36-2**	**Main**	**3 East**	**3 West**
3/16/94	Before Cleaning	0.0162	1.3300	0.1150	2.9000							
3/25/94	After Trap Cleaning	0.0097	0.0439	0.0019	2.0400							
4/11/94	After Power Washing				0.1560							
4/21/94	After Time to Settle		0.0565		0.4936		0.0537	0.0063	0.0197			
5/6/94	After 2nd Power Washing				4.01							
5/9/94	After Time to Settle				5.04							
6/10/94		0.259			3.83		0.0166	<North				
							0.327	<South				
7/28/94		19.1	0.203		1.8		0.0048	0.0218				
8/24/94		9.23	0.0642		0.305		0.0059					
9/1/94										ND	0.0002	ND
9/29/94	Total	0.0022	0.0030	0.0046	0.0027	7.1200						
	Dissolved	0.0005	0.0006	ND	0.0070	0.0088						
	Particulate	0.0017	0.0024	0.0046	0.0199	7.1112						
	% Dissolved	22.73%	20.00%	0.00%	26.02%	0.12%						
	% Particulate	77.27%	80.00%	100.00%	73.98%	99.88%						

This technique is preferred because the nozzle is designed with a reverse flow head configuration that literally "pulls" the hose away from the powerwasher operator and towards the sources while flushing biomass and debris down the line and on to the collection point. Another benefit to washing in a reverse flow direction is that most plumbing fittings have smooth swings in the reverse direction and this seems to help reduce the number of obstruction interferences. Though this is the preferred method, trial and error may have to be applied due to the complexities of the piping infrastructure. For immediate success, select straight sections that are observed to contain biomass. In other locations, piping may have to be removed or modified in order to reach areas of concern. Powerwashing on thermo-plastic piping will require a lot more trail and error and it may be necessary to remove piping sections to verify cleaning effectiveness. Note thqat the installation of a sight glass may help to minimize the amount of sections to be removed. Sometimes it will be difficult or impossible to feed the hose and nozzle in reverse direction. In these cases, an alternative method would be to 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 flushing debris as it moves along the piping. It may be necessary, in this instance, to apply additional water to aid the flushing process by turning on an adjacent sink that is tied into the same conveyance line.

7.2.2 Powerwashing Precautions

The following are some precautions that should be considered prior to implementing powerwashing procedures: 1) It should be assumed that all materials contained within the conveyance piping are hazardous, and, prior to beginning powerwashing activities, approval by the institution's Health and Safety Officer should be obtained to help ensure that proper personnel protective equipment is being used; 2) Powerwashing is not a delicate operation and sometimes conveyance fittings and piping, especially with glass fittings, can be cracked or broken. It is necessary to inspect the entire run prior to powerwashing, and identify any potential obstructions, so that if a fitting is broken, a replacement fitting is immediately available for instillation; and, 3) Conveyance piping that contains large amounts of biomass may, once dislodged, begin to collect and clog downstream conveyance piping sections. If the piping begins to clog and eventually prevents flow due to accumulation of this dislodged biomass, there will be a significant potential for wastewater backing up in the plumbing system and causing flooding at lower elevation locations.

7.2.3 Wastewater Disposal

All powerwashing wastewater that contains removed biomass should be assumed to contain levels of mercury above the MWRA's allowable discharge limit of one (1) ppb, and should be collected for off-site disposal. Refer to Section 10.0 for recommended mercury waste disposal procedures.

The collection of the powerwash wastewater will be a difficult task but, since powerwashing will usually occur during non-operating hours, the systems, hopefully, will be virtually drained. Once flow has stopped, the treatment tank can then be emptied and used as a powerwashing wastewater collection vessel. After powerwashing is completed or the treatment tanks are getting full, transfer all collected wastewater into storage containers. This is only one recommended method for collecting wastewater and, there are other collection and pumping methods that can be used on a case-by-case basis. However accomplished, it is very important that this wastewater is collected and not be allowed to be discharged.

7.3 Equipment

7.3.1 KJ-1250 Water Jetter

A typical piece of equipment that has been used by Beth Israel Hospital in the power washing of their infrastructure piping is the KJ-1250 Water Jetter (See Appendix C). This unit is a compact, portable machine designed to clear biomass, grease and sludges out of 1-1/4" to 4" diameter drain lines. It can be either hand carried or combined with a two wheel cart and hose reel for easy transport.

The equipment specifications are as follows:

Line capacity	1-1/4" to 4" drain lines through 150 feet
Motor	115V/60 Hz TEFC or 240 V/50Hz
Rating	11/2 Hp @ 1725 RPM
Pump>	Duplex Plunger
Pressure	1500 PSI
Flow Rate	1.5 GPM

Weight	70 lbs

7.4 Chemicals Used

7.4.1 Chemical Addition

The powerwasher mentioned in this section does not allow for the addition of chemistry as powerwashing is performed. This limitation is do to the long lengths of hose and the design of the equipment. A powerwasher with the capabilities of adding chemicals and high pressure water simultaneously could further enhance the effectiveness of the washing. Further investigation of other powerwashing equipment that aspirate chemical during powerwashing are currently available or facilities should work with vendors of existing equipment to see if their units could be modified to incorporate this feature.

7.4.2 Bleach Solution

The basic unit can be used with water only to provide a scouring agitation. However, it is recommended that a bleach solution be added to the length of piping at the source, if possible, to help disinfect that section prior to powerwashing. Before adding bleach or an other disinfectant chemical, it should all be analyzed to ensure that it is mercury free or of a "low" mercury content. The MWRA/MASCO Hospital Work Group, Operations Subcommittee has identified that several chemicals and reagents, including many disinfecting products that contain bleach, also contain considerable amounts of mercury

7.4.3 Other Cleaning Solutions

The addition of surfactants, dispersants, caustics and/or wetting agents could potentially increase the powerwashing effectiveness. To date, there have been eight cleaning chemicals and combinations of these chemicals investigated through a pipe cleaning protocol effort that was developed for Medical Academic and Scientific Community Organization, Inc. (MASCO). The results of this protocol are presented in Section 8.0 of this Guidebook.

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8.0 CHEMICAL CLEANING

8.1 Purpose

Chemical cleaning of "Special Waste" conveyance piping system has only been performed under laboratory conditions. A Pipe Cleaning Protocol "Protocol" was developed for the Medical, Academic and Scientific Community Organization, Inc. (MASCO) to determine if there were any chemicals which would, without employing mechanical agitation, remove, dissolve, disperse and/or eliminate biological growth within "Special Waste" conveyance piping. A copy of the MASCO Pipe Cleaning Protocol is presented in Appendix D. This protocol testing procured "Special Waste" plumbing samples from several host institutions and subjected them to eight different types of cleaning chemicals and combinations of these chemicals.

8.2 Plumbing Sample Procurement From Host Institutions

Several institutions volunteered to serve as a host for the Protocol testing, as follows:

- Beth Israel Hospital
- Lahey Clinic
- Massachusetts General Hospital
- Saint Elizabeth's Medical Center

Beth Israel (BI), Massachusetts General (MGH) and Saint Elizabeth's (St. E's) were all visited, prior to sampling, to ensure that plumbing samples obtained would be representative. Lahey Clinic (Lahey) was selected to be an alternate in the event that the visited institutions were not able to support the protocol with a sufficient number of representative samples. Of the three institutions visited, MGH was the only one whose plumbing materials were not accessible or had very little biomass observed in-place. As a result, MGH was eliminated from further consideration as a host site. Both BI and St. E's had representative and accessible samples. Figure 8.1 is a summary of the "Special Waste" plumbing samples obtained through April 10, 1995.

8.3 Bench Testing and Chemical Cleaning

8.3.1 Protocol Cleaning Chemicals

The cleaning protocol evaluated several different chemicals. The cleaning chemicals consisted of acids, bases and wetting agents. The following is a list of the concentrated cleaning chemicals evaluated:

- Sulfuric acid (H_2SO_4) @ 97%
- Hydrogen Peroxide (H_2O_2) @ 40%
- Potassium Hydroxide (KOH) @ 45%
- Sodium Hydroxide (NaOH) @ 50%
- Nitric Acid (HNO_3) @ 70%
- Triton X-100 @ 100% (Octoxynol - nonionic detergent, emulsifier, dispersing agent, surfactant)

All of these stock chemicals were diluted to a 5 to 40 percent working strength range, in accordance with procedures defined by the Protocol.

Institution	Date Samples Provided	Number of Samples	Sample types

Beth Israel	March 28, 1995	2	2" glass P-trap
		1	24"- piece of 3" dia. glass pipe
Saint Elizabeth's	March 1, 1995	4	2" polypro P-trap
	March 15, 1995	6	2" polypro P-trap (no biomass)
	April 6, 1995	2	2" polypro P-trap
		2	12" piece of 2" dia. polypro pipe
Lahey Clinic	April 10, 1995	4	12" pieces of 4" dia polypro pipe

Figure 8.1 "Special Waste" Plumbing Sample Summary

8.3.2 Protocol Samples

All samples generated via Protocol testing at the Deer Island Classic Laboratory were received by Deer Island New Central Laboratory. A summary of the samples obtained by the Central Laboratory is as follows:

Chemical Evaluated	Number of Samples	Date Samples Received	Date of Results
Sulfuric Acid	8	3/10/95	4/25/95
Hydrogen Peroxide	24	3/29/95	4/25/95
Hydrogen Peroxide / Sulfuric Acid Etch	7	3/29/95	4/25/95
Sodium Hydroxide	15	4/7/95	4/25/95
Potassium Hydroxide	15	4/7/95	4/25/95
Nitric Acid	14	4/14/95	5/26/95
Nitric Acid /Triton X-100	30	4/14/95	5/26/95
	113		

8.3.3 Summary of Protocol Analytical Data

Figure 8.2 provides a summary of the MWRA/MASCO Pipe Cleaning Protocol analytical results performed at the MWRA's Deer Island Laboratory. Columns A through E are chemical identification and testing concentrations. Specifically, Column D is the concentrated chemical concentration, and Column E is the testing concentration after being diluted with deionized water. The remaining columns, F through M, are mercury analytical results from treatment chemicals, dilution water, biomass solids and rinsing water during various phases of the protocol testing. The following is a brief explanation of the columns from F through M:

- **Column F** is the background mercury concentration of the treatment chemicals listed in Column C
- **Column G** is the mercury concentration of the deionized water used to dilute the treatment chemicals, in Column C, to produce the diluted treatment chemical concentrations in Column E
- **Column H** is the mercury concentration of the treatment chemicals after dilution

- **Column I** is the mercury concentration of the biomass obtained from the "Special Waste" plumbing sample prior to chemical cleaning

- **Column J** is the mercury concentration of the diluted treatment chemicals after being allowed to soak for a period of time within the plumbing sample

- **Column K, L, and M** are mercury concentration obtained after three rinsing steps. The rinsing solution used for these steps was the same previously analyzed deionized water in Column G. Column K was the only rinsing steps were the deionized water was allow to soak (stagnate rinsing), while Columns L and M were a once through flushing (continuous rinsing).

The Protocol procedure that generated the results in Column L was intended to remove the dislodged or dissolved biomass and, the next step that generated results for Column M, represented normal effluent conditions. All of the "Special Waste" plumbing samples containing representative biomass did not achieve complete biomass removal after chemical cleaning with the chemicals and procedures presented in the Protocol. Detailed observations and data interpretations are presented in the individual chemical sections presented below.

(Figure not currently available)

Figure 8.2 Summary of the MWRA/MASCO Pipe Cleaning Protocol Analytical Results

8.3.4 Sulfuric Acid

On March 10, 1995, protocol testing began at the Deer Island's Old Laboratory (Classic Lab) using sulfuric acid and plumbing samples obtained from Saint Elizabeth's Hospital. The samples consisted of 4 - 2" polypropylene P-traps. Only one of these traps was observed to contain substantial biomass which EARTH TECH interpreted to be representative. The biomass in the remaining three samples had little or very loose biomass with no skeletal remains.

A five percent dilution was prepared using the original 97 percent concentrated chemical. This concentration was used because a higher concentration evolved heat when diluting from concentrate. The representative plumbing sample had approximately 1/4" of biomass buildup that was adhered securely to the wall of the plumbing trap. The five percent solution of acid was allowed to soak inside the plumbing sample for approximately 1-1/2 hours. At the end of that soaking time, the solution appeared to have had little or no effect on the biomass within the plumbing sample.

The sample containing large amounts of representative biomass had an unexpected concentration of mercury of approximately 550,000 parts per billion (ppb). The analytical data indicates that the biomass mercury concentration was reduced to approximately 10 ppb but, as previously mentioned, the chemical cleaning did not remove all of the biomass.

Based on visual observations and data interpretations, it appears that this concentration, and possibly higher concentrations, of sulfuric acid will not achieve the goal for biomass removal within hospital conveyance plumbing. Furthermore, any concentration higher than this would not be recommend due to safety and conveyance piping ventilation concerns.

8.3.5 Hydrogen Peroxide and Hydrogen Peroxide / Sulfuric Acid Etch

Samples for the March 29, 1995, testing were obtained from Beth Israel Hospital. The samples consisted of 2 - 2" glass P-traps and one 24" piece of 3" diameter glass pipe. All the samples contained some visable amount of biomass and skeletal remains. Only one of the traps had dark brown heavy biomass buildup that EARTH TECH interpreted to be representative. Hydrogen peroxide was diluted, from the original 40 percent, to create 20 and 40 percent solutions. A third solution consisting of 20 percent hydrogen peroxide and 10 percent sulfuric acid was also mixed.

20% Hydrogen Peroxide Solution

The trap that contained the heavy representative biomass was subjected to the 20 percent hydrogen peroxide diluted solution. Immediately upon addition of the 20 percent solution, the sample began reacting aggressively with a foaming and bubbling action. As the solution was allowed to soak, most of the heavy built up biomass was up lifted and began floating on the surface. But, as the built up biomass was being lifted, it appeared that small amounts of the skeletal biomass remained unaffected. The solution continued to react for three hours with almost the same intensity. During these three hours of chemical soaking, it appeared that the solution had a minimal effect on the remaining skeletal biomass. Although the solution was reacting with the same initial intensity, after three hours EARTH TECH decided to remove the solution and continue with the protocol. When the solution was removed, there appeared to be some type of silvery metallic substance at the bottom of the trap. This metallic material appeared to be the cause of the vigorous reaction that had been observed. At the end of the Protocol rinsing steps, all of the large built up biomass was removed and only scattered small amounts of skeletal biomass remained.

40% Hydrogen Peroxide Solution

The three inch diameter pipe also contained large amounts of dark biomass build up that seemed to be very loose. Unlike the trap exposed to the 20 percent hydrogen peroxide solution, however, this sample did not contain very much skeletal biomass. When the 40 percent solution was added, once again the sample began reacting very aggressively with foaming and bubbling. Unlike the first time this was witnessed, however, this time it only lasted for approximately 20 - 30 minutes. After 45 minutes the chemical reaction appeared to be complete, so EARTH TECH decided to remove the chemicals and proceed with the remaining protocol steps. At the completion of the testing, the piping sample was relatively clean with most of the biomass removed.

The overall performance of the 20 and 40 percent solutions was fairly successful, but complete biomass removal was not accomplished. The 20 percent solution contains 8 percent hydrogen peroxide by volume which is a strong oxidizer and potentially hazardous material. During the reactions, there was significant fuming, probably hydrogen and oxygen gases. Given the amount of gassing and safety hazards associated with hydrogen peroxide, it would not be recommended for use in large volumes and/or in poorly designed conveyance piping and venting systems.

Hydrogen Peroxide / Sulfuric Acid Etch Solution

The third sample, a three inch glass P-trap, was exposed to a 20 percent hydrogen peroxide and 10 percent sulfuric acid etch solution. Of the three samples obtained from BI, this one contained the least amount of biomass. The biomass was a golden-light brown with small areas of skeletal remains. During chemical addition and throughout the soaking periods, the chemical reactions appeared slow and subdued. After 90 minutes, it was determined that the reaction was complete and the trap appeared to be clean except for small orange spots distributed over the lower portion of the trap. These orange spots may have been skeletal remains that were not removed.

The hydrogen peroxide / sulfuric acid etch solution removal capability appears to be unsatisfactory. Also, this material would have the same safety and conveyance piping concerns mentioned previously, which would preclude widespread use.

The plumbing samples contained expected mercury concentrations which were in the range of 550 to 2,300 ppb. All of the third rinsing samples resulted in less than 0.22 ppb, but complete removal of biomass, once again, was not achieved. Although the biomass that remained was that of an adhered or skeletal form, it can not be assumed that hydrogen peroxide will consistently yield effluent results below one ppb. This skeletal biomass probably contains high levels of mercury concentration as well and when the skeletal remains eventually break off that will result in effluent with elevated levels of mercury.

8.3.6 Potassium Hydroxide and Sodium Hydroxide

On April 7, 1995, protocol testing was performed on the third set of plumbing samples provided by St. E's. These samples were divided in half; two samples for potassium hydroxide testing and two samples for sodium hydroxide testing. Observations on the internals of these samples were hard to obtain, because the plumbing material was schedule 40 polypropylene. Two of the samples were observed to contain substantial biomass growth, but how much of it was skeletal could not be determined. Potassium hydroxide was added to two 12" pieces of 2" piping, at a 15 and 30 percent dilution.

The two piping samples had different amounts of biomass, one sample had heavy grayish-white buildup of biomass, while the other had a small amount of brown biomass that was very loose. The 30 percent solution was allowed to soak for approximately 90 minutes in the sample with the grayish-white biomass. Slight foaming and floating of the biomass was all that was able to be observed (internal observation could not be made as previously mentioned). After 90 minutes of soaking, the chemical was removed but a majority of the biomass still remained although it appeared to be looser. With minimal scouring, the remaining biomass was easily removed.

The 15 percent solution had little or no effect on the piping sample with the brown biomass. During 90 minutes of chemical soaking, there was no foaming or floating of the biomass. It appears that this was a different type of biomass from all the others we had encountered. It is possible that this material may have been some type of an adhesive or cement. We had expected the biomass to be loosened similarly to that of the 30 percent solution sample.

The performance of the 15 percent solution was unsatisfactory. Although the 30 percent solution did not achieve the Protocol removal goals, it did reveal that this chemical may be used as a softening or loosening agent to assist some type of physical cleaning procedures. However, there are still several safety and plumbing concerns with the use of this material. A 30 percent dilution, of 45 percent concentrated potassium hydroxide, contains approximately 13.5 percent, by volume, of potassium hydroxide. At these concentrations, it is not recommended for use, based on the previously mentioned safety and conveyance piping concerns.

Sodium Hydroxide

The two remaining samples, on April 7, 1995, were exposed to a 20 and 40 percent diluted solution of sodium hydroxide. One of the samples was a 12" piece of 2" polypropylene pipe and the other was a 1-1/2" P-trap. The trap had heavy build up of dark brown biomass while the piping had a thin film of gray-black biomass.

The 20 percent solution was added to the piping sample with no initial reaction. After 90 minutes, very few changes or reactions occurred. At the end of the protocol testing, hardly any biomass remained. It was difficult to determine the capabilities of this chemical, because the amount of biomass contained in the sample was so small.

However, the 40 percent solution was exposed to heavy dark brown representative biomass. The initial reaction with the biomass was a slight foaming action followed by a large amount of the biomass being dislodged and floating. This reaction continued until EARTH TECH decided to remove the chemicals approximately 90 minutes later. At the end of the testing, most of the biomass was removed though a thin film of biomass remained.

Sodium hydroxide, at a 40 percent strength, yielded similar results to the potassium hydroxide. The biomass appeared loose and with minimal scouring the remaining biomass was easily removed. This chemical would also require that all the previously mentioned safety and piping concerns be evaluated.

Another problem associated with the use of these chemicals is that potassium and sodium hydroxide were the first reagent grade treatment chemicals found to contain mercury. The levels of mercury for potassium and sodium hydroxide were 11.5 ppb and 3.68 ppb respectively (which for reagent grade chemistry was unexpectedly high). Samples KOH-1 and NaOH-4 both had some biomass removal success. But, after the third rinsing step, the analytical results indicate that the remaining biomass bits were still breaking off and causing elevated mercury concentrations very similar to the results with all the previously tested chemicals.

8.3.7 Nitric Acid and Triton X-100

Samples obtained from Lahey Clinic were tested on April 14, 1995 and contained very heavy amounts of black biomass. The samples included four 12" pieces of 4" schedule 40 polypropylene. The four samples were exposed to two combinations of chemicals. The first set were 10 and 20 percent diluted solutions of concentrated 70 percent nitric acid while the second set was the same, except that a 2 and 5 percent Triton X-100 soaking solution, respectively, was introduced. The Triton X-100 is a wetting agent or dispersant which is intended to help soften and loosen the biomass before an acid solution is introduced.

The 10 percent nitric acid solution had minimal effect on the sample over a 90 minute soaking period. The only observation was a strong pungent smell upon addition of the solution. At this concentration, only very small amounts of biomass were removed.

The 20 percent solution produced slight foaming reaction which caused large pieces of biomass to float to the surface. After 90 minutes of soaking, large amounts of biomass were dissolved and removed. It appears the biomass that remained after removing these testing chemicals was much looser. This solution achieved significantly better results than the 10 percent solution.

In both cases, there were strong odors and gases being evolved during chemical soaking. In addition, the concentration of nitric acid that was used would not be recommended for large volume applications. Furthermore, it appeared as though the addition of Triton X-100 had little or no effect on the biomass.

8.4 Conclusion

During the period of March 10, 1995 through April 14, 1995, EARTH TECH performed chemical testing on plumbing samples from three (3) different medical institutions using eight (8) different chemicals and/or combinations of these chemicals. Plumbing sample materials consisted of polypropylene and glass and, in every instance, these samples confirmed the existence of biomass containing mercury. The different types of chemicals evaluated were acids, bases, oxidizers and dispersants. All of the chemicals evaluated were unsuccessful in obtaining the Protocol's objective of removing biomass completely using only chemical methods. Some of the chemicals were successful in removing bulky biomass, while others were successful in softening and loosening the biomass. Not one chemical alone or in combination appeared to remove all of the biomass solids. In addition, use of some of the chemicals might pose some significant health, safety and\or hazardous waste disposal issues if employed in full-scale use within a facility. Consequently, none of the chemicals evaluated in this Protocol would be recommended for *in situ* pipe cleaning.

Although the data presented in Column M of Figure 8.3 indicates that four chemicals tested were successful in producing effluent concentrations of mercury below 1 ppb, it should not be assumed that application of these chemicals constituted a viable solution to the problem. The documented presence of residual biomass containing mercury following these chemical applications means that the potential exists for higher concentrations of mercury to be detected at any time, due to the tendency of this material to slough off and enter the wastewater stream. If additional rinsing was performed on these samples, the analytical results of the rinse water could easily have been greater than one ppb.

The Protocol was developed with the assumption that the support laboratory would generate testing results immediately or as soon as the analytical equipment could produce them. This assumption was made to allow EARTH TECH time to evaluate the efficiency or inefficiency of each chemical and adjust the testing as needed. Since analytical results were not available soon after testing, EARTH TECH modified the testing to establish baseline testing for all the suggested Protocol chemicals.

The concentrations of the diluted chemicals used in the Protocol were much higher than recommended concentrations for full-scale cleaning. Even after being diluted, some of these cleaning chemicals were still very reactive or corrosive. Considering the amount of "Special Waste" piping requiring cleaning in most facilities, employee exposure to hazardous chemicals would be a serious concern even with the utilization of isolation valves. Employees involved with such chemical cleaning operations would almost certainly require health and safety training. Of additional concern is the fact that most of the chemicals evaluated in the Protocol would likely be characterized as hazardous waste for either reactivity, corrosivity or content. Two of the chemicals tested, sodium and potassium hydroxide, were even found to contain, themselves, concentrations of mercury in excess of 1 ppb.

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9.0 SAMPLING

9.1 Sampling Techniques

The validity of results from any laboratory testing is dependent upon the sample being representative of the source from which it was taken. It is the operator's responsibility to see that all personnel who might participate in the sampling program be personally instructed as to the appropriate sample techniques. The two types of samples taken for wastewater laboratory analyses are known as grab samples and composite samples, and each can be obtained either manually or automatically.

9.1.1 Grab Sample

A grab sample is an individual sample which is taken from a wastestream on a one-time basis without regard to the flow in the wastestream. These samples must be collected over a period of time not exceeding 15 minutes. A grab sample shows the wastestream characteristics at the time the sample is taken.

9.1.2 Composite Sample

A composite sample is a combination of individual samples of wastewater taken at pre-selected intervals to represent the integrated composition of a wastestream. A composite sample is always to be collected over the entire process day (or as close to it as possible). Although the MWRA's regulations 360 CMR 10.00 requires at least 8 grab samples to make up a composite sample, it does not follow that 8 samples taken over a time period of 2 hours for an industry that discharges for 8-24 hours is acceptable. In all cases, even if it is necessary to overlap calendar days, the composite must cover the entire process day. The daily average limit, the highest allowable concentration for any pollutant in a wastestream discharged during one day by an industrial user, is based upon a representative composite sample.
A composite sample can be prepared proportionally according to time or flow. A composite sample based on time can be obtained if the flow of the wastestream is relatively constant over the entire time period, even though the wastestream characteristics may change. In this case, equal amounts of each individual sample can be combined into one composite sample. To prepare a flow-weighted composite sample, each individual sample is combined with the others in proportion to the volume of flow at the time the sample was collected.

9.1.3 Permit Sampling

Permit sampling shall be representative of the typical volume and nature of the permittee's discharge. The sample must be taken at a location, permitted by the MWRA, that is free of any uncontaminated water, sanitary waste or other non-process water. These samples shall be collected, preserved and handled in accordance with the procedures established in 40 CFR Part 136 and amendments. When performing permit sampling, it is important to review your discharge permit for the correct sample type. Each individual pollutant/parameter requires either a grab or composite sample. A mercury sample obtained via composite sampling at an MWRA permitted discharge location during a representative discharge event at a location free of any uncontaminated water, sanitary waste or other non-process water is an example of a reportable sample under the MWRA's SMART program (See Section 9.3 for SMART definition).
The results of analysis of representative samples obtained beyond the requirements of an institution's discharge permit, for any pollutant/parameter being discharged, using test procedures prescribed in 40 CFR Part 136 or other United States Environmental Protection Agency (EPA) approved methods, are required to be submitted to the MWRA.

Samples obtained outside of these requirements are not representative and should not be submitted to the MWRA as SMART data. Mercury results of a grab sample obtained or those from a non-permitted MWRA sampling location may be an example of a non-SMART reportable result. The results are non-reportable because the sample was obtained via a grab sample and at a non-permitted location. Appendix F contains a copy of a letter from Mr. Eugene B. Benson, Associated Counsel for MWRA, TRAC to Mr. Robert K. Gingras, Senior Project Manager for EARTH TECH (formerly HMM Associates) clarifying when to and when not to submit sampling data.

9.2 Standard Operating Procedures for Sampling

When performing sampling, it is important to establish a set of standard operating procedures. This will allow a facility to obtain representative samples repeatedly. Presented in Appendix A is a copy of the MWRA's Standard Operating Procedures (SOP) from their sampling manual. It would be advantageous to develop a SOP very similar to the MWRA's

9.3 SMART (Self-Monitoring Analytical Report Tracking) Data

It is important to clarify the difference between SMART and NON-SMART reporting requirements. Self-Monitoring Analytical Report Tracking (SMART) is a program the MWRA has provided to all DEP Certified Laboratories. The SMART program generates both a computer diskette containing the sampling analysis results and a paper copy of the information on the diskette. The MWRA enters the results from the diskette into its computer system and retains the paper copy in the permittee file.
A summary of the MWRA's permit sampling requirements are as follows:

- Sampling must be performed by a DEP certified independent laboratory unless otherwise approved by the MWRA.
- All analytical testing must be performed at a DEP certified independent laboratory. A listing of Massachusetts certified independent laboratories is presented in Appendix B.
- The appropriate sampling technique must be used (i.e. grab or composite) and the sample field preserved.
- The sample must be analyzed within allowable holding times using EPA approved methods.
- Samples must be taken at the permit prescribed sampling location, or at another representative location after pretreatment.
- Samples taken at another representative location for non-permitting purposes must also be reported using SMART program.

Refer to the copy of Mr. Eugene Benson's letter presented in Appendix F and your current MWRA permit for additional SMART data reporting clarification.

9.4 Sampling Port

The MWRA has developed and published written standard sampling port guidelines for its permitted Industrial Sewer Users. Figure 9.1 and 9.2 illustrates a detailed cross section and elevation view of a standard sampling port developed by Flow-Tech Associates, Inc., on behalf of the MWRA Infrastructure Subcommittee, and presented to the MWRA for approval. The MWRA has approved and prefers this "Typical" design set-up, but this is not the only type of sampling port that is approved by the MWRA.

The sampling port, in most instances and especially during low flow situation, is only designed for a single sampler. Sampling locations that are equipped with single sampling port are to be used on a ***first come first serve basis***. E*xample: Self-monitoring sampling has begun and the MWRA shows up to perform their required unannounced sampling*. If an institution has already begun sampling, prior to the MWRA's arrival, the MWRA would be obligated to reschedule their sampling. The MWRA would not force an institution to terminate its sampling to fulfill their own sampling requirements. Although it is possible to have a dual sampling port at the same location it is strongly discouraged for the following reasons:

- During low flow situations, composite samplers would be competing with each other for wastewater samples.
- During moderate to high flow conditions, there may be sufficient flow for dual sampling but, when using automated composite sampling equipment, there is a back flushing step that the sampler goes through before and after a discrete sample is obtained. A potential problem would result when one sampler is backwashing while the other sampler is drawing a sample. The net effect would be one sampler sampling the other sampler's backwash.

Both of these issues are variables which will effect the quality of the sample and produce non-representative data. These are sampling conditions that should be avoided.

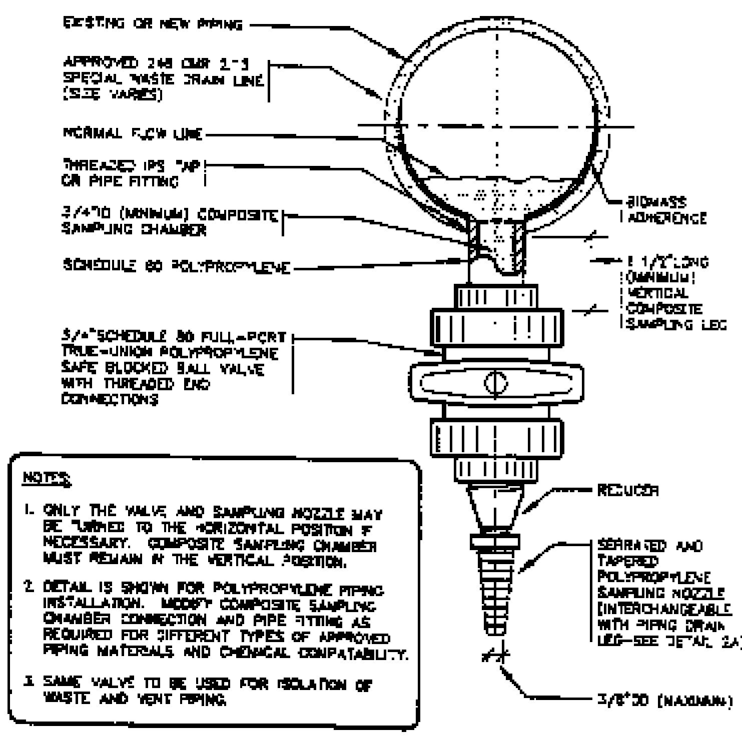

Figure 9.1 Standard MWRA Sampling Port (Cross Section View)
Source: Flow Tech Associates, Inc., Detail 1A

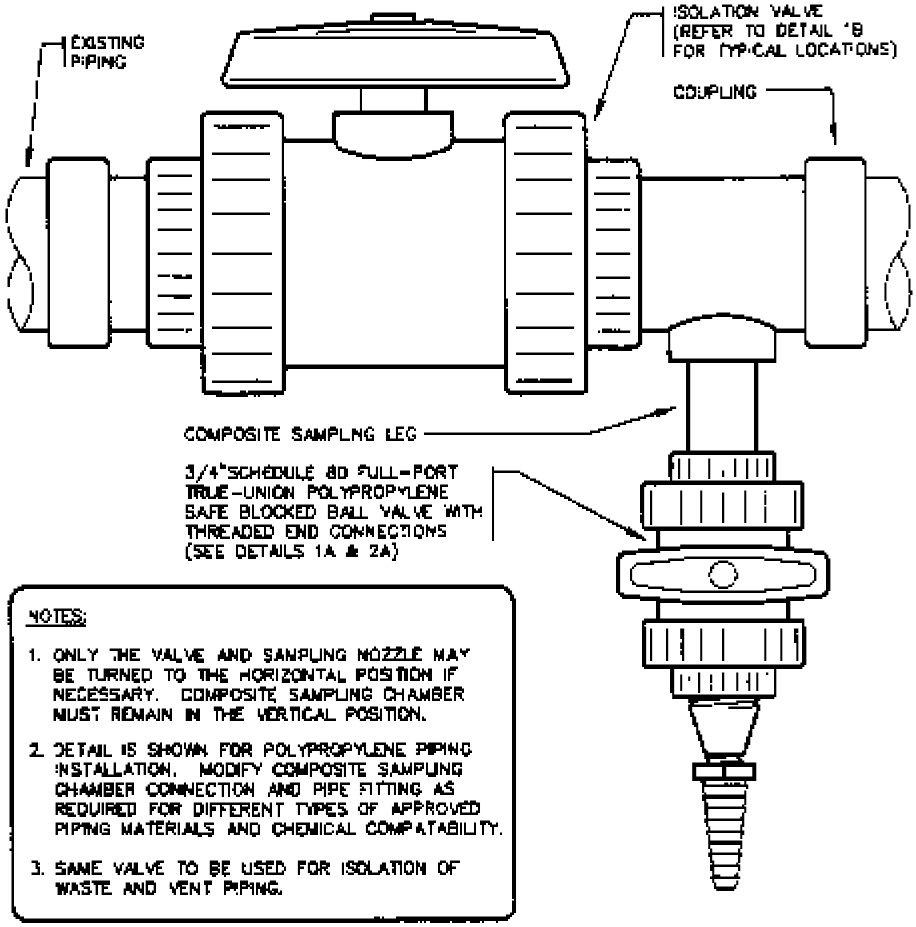

Figure 9.2 Standard MWRA Sampling Port (Elevation View)
Source: Flow Tech Associates, Inc., Detail 2B

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10.0 WASTE DISPOSAL

10.1 Purpose

The following section provides an explanation and general overview of mercury waste disposal. All waste disposal activities should be approved by an Environmental, Health and Safety Officer or the person responsible for waste disposal. The MWRA prohibits the disposal of chemicals into the sewer system except aqueous solutions of non-toxic and non hazardous chemicals. The Massachusetts Department of Environmental Protection (DEP) prohibits the improper disposal of hazardous wastes. The following waste disposal guidelines were established to satisfy both the MWRA and the DEP regulation requirements.

10.2 Waste Disposal Procedures

10.2.1 Mercury Limits

Based on TCLP test data, the Massachusetts Hazardous Waste Regulations at 310 CMR 30.00 consider a concentration of waste with less than 200 ppb of mercury to be a **non-regulated material (MA99)**. Non-regulated materials are exempt from all of the DEP's hazardous waste regulations and can be accepted by landfill for final disposal.
Wastestreams determined, from TCLP testing, to have mercury concentrations equal to or greater than 200 ppb are hazardous waste which are given the code number D009.
The MWRA has a more stringent limit for total mercury which is prohibited. As a matter of policy, however, at the present time the MWRA will not enforce the discharge limitation for wastewater discharges containing less than one ppb.

10.2.2 Waste Determination

It is possible that significant mercury concentration will be found in infrastructure piping where old biomass is present. Powerwashing and trap cleaning operations typically yield wastewater mercury concentrations in the 1 to 200 ppb range. This means that most infrastructure cleaning operations will require the wastewater to be collected and, in most instances, to be handled as a non-hazardous waste. The determination of whether a waste material is hazardous waste or non-regulated material should be made based on TCLP analytical testing. It is possible to use generator knowledge to assume a waste is a hazardous waste if it is based on accurate and available information regarding similar wastestreams. Some of this experience and information could be previously analyzed wastewater samples, chemical vender material safety data sheets (MSDS) and testing. Due to potential liability, extreme care should be taken when deciding that a wastestream is not a hazardous waste without the benefit of analytical testing.
Analytical testing is the most conservative method for waste characterization. Although this is the best method for determining if a waste is regulated, it can be very expensive when the generator has no knowledge of the waste. This means that several different analytical test would be required to ensure that all potential waste characteristics have been evaluated.
The combination of generator knowledge and analytical testing are the most common procedures used for hazardous waste determination. Using generator knowledge of the waste enables a generator to eliminate a majority of analytical testing for materials that are known not to be present.
After the waste has been collected and a determination made about the waste, one of the following methods of disposal may occur:

- Discharge to the MWRA
- Off-Site Disposal as Non-Regulated Material (MA99)
- Off-Site Disposal as a hazardous waste (D009)

10.2.3 Waste Disposal

Discharge to the MWRA

If it is determined that the collected wastewater contains mercury below one ppb and that all other pollutant concentrations are below discharge limits, this waste can be discharged to the sewer only after written approval from the MWRA has been obtained. The MWRA requires a notification prior to all non-typical wastewater discharges.

Off-Site Disposal as Non-Regulated Material (MA99)

If the waste contains mercury at a concentration greater than 1 ppb, but less than 200 ppb, it is most likely a non-regulated material under the Hazardous Waste Regulations 310 CMR 30.00. Although non-regulated, the mercury concentration is above the MWRA's discharge limit and must be disposed off-site.

Prior to transporting a waste material to a licensed waste disposal facility the material usually will require pre-approval. The pre-approval process is a requirement of most licensed disposal facility and typically includes analytical testing and generator knowledge of the waste.

It is important that each waste shipment have all the same characteristics as initially approved by the licensed disposal facility. If the original waste approval was for powerwashing with water only and the next time powerwashing is performed but now with bleach and water, a new approval for disposal may be required. The addition of the bleach has now possibly changed the characteristics of the waste.

Off-Site Disposal as Regulated Material

Wastes that contain mercury concentrations equal to or greater than 200 ppb are characteristic hazardous wastes (D009). Regulations governing the handling and storage of hazardous waste in Massachusetts are located at 310 CMR 30.00.

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Appendix D

Host Institution Pipe Cleaning Protocol

Objective: To determine if there are any chemicals which will remove, dissolve, disperse and/or eliminate biological growth inside hospital conveyance piping.

CAUTION !!! - Do not begin this Protocol until you are completely familiar with its entire contents.

I. PLUMBING SAMPLE SELECTION (Refer to Section 5 - *Health & Safety* - prior to handling any plumbing samples)

1. The following is a list of plumbing material, in order of preference, that may be used in this protocol.

   Glass
   Polypropylene
   PVC
   Iron & Brass (not desired due to amalgamation)

2. The following is a list of plumbing sample types, in order of preference, that may be used in this protocol. The following samples types were selected because they will probably contain the largest volumes of growth and the removal of these plumbing samples tend to be easier. It is very important that the plumbing sample material and type be recorded in the protocol spreadsheet (refer to Appendix A - Protocol Spreadsheet).

   P Traps
   Other Traps
   90o Elbows
   Couplings & Union with small section of piping attached
   Conveyance Piping

   A sample will not be used if it does not contain biomass growth.

3. For each chemical, that is being evaluated for biomass removal, approximately five (5) to ten (10) plumbing samples will be required. The number of samples required are due because of the different chemical concentrations that will probably be needed.

4. After the section of plumbing sample has been selected and removed, take the necessary general precautions to avoid contaminating the plumbing samples (i.e. avoid touch growth, avoid losing growth, avoid setting plumbing samples down on table top,.......)

5. The plumbing sample must be given an identification name and label that includes the following information:

   Institution Name
   Building and / or Floor NumbeR
   Sink, Trap and / or Piping
   Internal Tracking Identification Number

   EXAMPLE: *Saint Elizabeth's Hospital, Mary Rose Building - Second Floor, Sink Number 214 - 1 is where the plumbing sample was removed. Identification Name: STE-MARY-*

2ND-214-1

6. In addition to the sample identification label, a sample inventory sheet should be prepared for all the samples transported to the analytical laboratory (refer to Appendix C - Sample Inventory Sheet). This sheet will further assist the laboratory technician in identifying the samples.

7. The plumbing sample must now be prepared for transportation to the analytical laboratory for chemical treatability testing. Each sample must be preserved until it reaches the laboratory, this will be done by filling the plumbing sample with source water and capping both ends. The end caps must be secured tightly to ensure that no water will leak during transportation to the laboratory.

8. After the plumbing sample is filled with source water and capped, all samples should be placed in a proper shipping container that meets all DOT regulation requirements for transportation of infectious materials.

REQUIRED EQUIPMENT & MATERIALS FOR SECTION I

- Protocol Sample Inventory Sheet
- Plumbing tools for the removal of plumbing samples
- Replacement plumbing stock for the removed plumbing samples
- Caps for sample preservation
- Plumbing sample labeling material
- DOT shipping containers, labels and papers

II. CHEMICAL CLEANING PREPARATION (Refer to Section VI - *Chemical Support Information* - prior to handling any chemicals)

1. Upon receipt of the plumbing samples, the laboratory technician will verify that the samples are all present and accounted for by means of the protocol sample inventory sheet prepared by the sampler at the host institution. This will ensure that all the samples have an identification name and institution source location.

2. This protocol has a spreadsheet which will be used to record all analytical results and observations performed by all laboratory technicians (refer to Appendix A - Protocol Spreadsheet). When a plumbing sample is selected for chemical cleaning, the sample identification name used in section I (5) will be entered in the protocol spreadsheet when testing commences.

3. The following is a list of suggested chemicals that will be used for this pipe cleaning protocol:

   Potassium Hydroxide
   Sodium Hydroxide
   Hydrogen Peroxide
   Trisodium Phosphate (TSP)
   Surfactants
   Sulfuric Acid / Hydrogen Peroxide Etching Solution
   Sodium Hypochlorite

   Each of the chemicals used will require a background mercury concentration be obtained (refer to Appendix B - Mercury - Analytical Methods).

4. These chemicals will not be used in their full strength concentration, they will require diluting in the 1 - 10 percent range. It is recommended to start with a 5 percent concentration and adjust the concentration up or down pending the results of the 5 percent solution. If the concentrations in the 1 -10 percent range have little or no effect on the samples, then increase the concentration to 25 - 50 percent range, but not exceeding 50 percent. It is important to record each individual chemical concentration for each plumbing sample on the protocol spreadsheet (refer to Appendix A - Protocol Spreadsheet).

5. The water used for diluting concentrated chemicals must be analyzed for total mercury prior to mixing (refer to Appendix B - Mercury - Analytical Methods). **Remember, the proper way of combining acid or base is adding acid or base to water.**

6. After the diluted chemical solution is prepared, it will also require total mercury analysis (refer to Appendix B - Mercury - Analytical Methods).

7. Sufficient volume of diluted chemistry should be prepared to ensure that the plumbing sample's internal surfaces will be completely wetted.

8. At this point a chemical should be selected, sufficient volume of diluted chemistry prepared and a sample of concentrated chemistry obtained for mercury analysis.

9. Remove the end caps and dispose of any wastewater inside the plumbing sample. All wastes and wastewaters must be disposed via laboratory procedures.

10. Observe the physical appearance and condition of each plumbing sample and record all observations on the protocol spreadsheet (refer to Appendix A - Protocol Spreadsheet). For samples that have different amounts of biomass, recorded observations will be important for interpreting test results.

11. After all the wastewater has drained out of the plumbing sample, it is important to obtain a **representative** sample of biomass solids. This will act as the background mercury for that plumbing sample. You will need approximately 1.0 gram of biomass, this will be enough for the total mercury analysis (refer to Appendix B - Mercury - Analytical Methods).

REQUIRED EQUIPMENT & MATERIALS FOR SECTION II

- Protocol Spreadsheet for recording observations and analytical results.
- Sampling Inventory Sheet from Institution sampler.
- Approximately 30 gallon container for dilution and rinse water storage. *(quantity = 1)*
- A large container, approximately 3 - 5 liters, for diluting treatability chemicals.
- Graduated cylinder for chemical dilutions.
- Sampling containers for mercury analysis.
  (quantity = 3 liquid samples per chemical being evaluated and 1 biomass sediment per plumbing sample)
- Grease pencils for labeling sampling containers and chemical containers.
- A mercury analyzer that can satisfy the required analytical methods in Appendix B

REQUIRED ANALYTICAL TESTING FOR SECTION II

- Concentrated chemicals for total mercury background concentration
- Dilution water for total mercury concentration

- Diluted chemicals for total mercury concentration
- Biomass for total mercury background concentration

<u>All analytical results must be recorded on protocol spreadsheet!!!!!!!!!!</u>

III. CHEMICAL CLEANING

1. Prior to introducing the plumbing sample to diluted chemicals make sure there is sufficient volume of diluted treatment chemical prepared to completely wet the entire internal surfaces of the plumbing sample, and a sample of diluted treatment chemical should also have been obtained.

2. Make sure a biomass sample has been taken for mercury analysis and observations are made about the sample prior to submerging into diluted chemicals.

3. Make sure that one end of the plumbing sample is water tight prior to the addition of the treatment chemical. Be careful when filling the sample with treatment chemical not to pour the chemistry directly at or into the plumbing sample, this is done to avoid physical removal of the biomass.

4. Plumbing samples should be allowed to soak for a limited period of time. The maximum amount of soaking time is 2 hours. During that soaking period there should be observation taken approximately every 15 to 20 minutes to evaluate the chemicals performance. All of these observations must be recorded and will be used to help determine the length of soaking that will be required when the chemical is used full scale.

5. Once a visual determination is made that the chemical appears to be finished cleaning, or the soaking period has elapsed, then the treatment chemical can be removed from the plumbing sample. After removing the treatment chemical, allow sufficient time for the sample to drip dry into the collected used treatment chemical. The length of the soaking time and final visual observations should be recorded on the protocol spreadsheet.

6. If after 2 hours of chemical soaking and none of the protocol's objectives are met, then the testing is completed for that chemical concentration. If the same result occurs at a concentration of 50 percent for the same chemical than that chemical will no longer be tested. Remember to record all observations, especially for chemicals that have no effect on the biomass.

A **<u>representative</u>** sample of the residual chemical, which now contains biomass, must be obtained and analyzed for total mercury (refer to Appendix B - Mercury - Analytical Methods).

REQUIRED EQUIPMENT & MATERIALS FOR SECTION III

- Protocol Spreadsheet for recording observations and analytical results

- Large clean containers, approximately 3 - 5 liters or large enough to contain the volume of the plumbing sample.
  (quantity = 1 per chemical concentration being evaluated)

- Timing device for keeping track of soaking times.

- Sampling containers for mercury analysis.
  (quantity = 1 liquid samples per chemical being evaluated)

- Grease pencils for labeling sampling containers and chemical containers.

- A mercury analyzer that can satisfy the required analytical methods in Appendix B

REQUIRED ANALYTICAL TESTING FOR SECTION III

- Residual chemical(s) for total mercury concentration

<u>All analytical results must be recorded on protocol spreadsheet!!!!!!!!!!</u>

IV. CHEMICAL RINSING

1. The plumbing sample will be triple rinsed to determine if complete growth removal was successful.

2. First rinsing step (Rinse Water I) will be a 20 minute soaking in previously analyzed water. The plumbing sample's internal surfaces must once again be completely wetted. At the end of the 20 minutes remove the rinse water and allow to completely drip dry. Set aside the used rinse water for mercury sampling.

3. Second rinsing step (Rinse Water II) will consist of pouring previously analyzed water through the plumbing sample and into a clean beaker or container. The volume of rinse water that should be used in this step will be approximately 2 liters. Set aside the used rinse water for mercury sampling after you have allowed the sample to drip dry sufficiently.

4. Third rinsing step (Rinse Water III) will consist of pouring an additional 2 liters of previously analyzed water through the plumbing sample, same as Rinse Water II step, and collecting all rinse water in a clean beaker or container. Set aside the used rinse water for mercury sampling.

5. It is important to allow sufficient drip time between rinsing steps. This will minimize the amount of chemical and biomass dragout between rinse stations.

6. After Rinse Water III step, record any final observation and dispose of the plumbing sample via laboratory disposal procedures.

7. Obtain a **<u>representative</u>** sample of the rinse waters for steps I, II and III and have them analyzed for total mercury (refer to Appendix B for Mercury Analytical Procedures). It is very important that the samples of rinse water obtained are **<u>representative</u>**.

8. After the three **<u>representative</u>** rinse water samples have been analyzed and **<u>you are satisfied</u>** with the analytical results, then all spent rinse water may be disposed via laboratory procedures.

9. After all the information is entered in to the protocol spreadsheet and any final observations or comments are made and recorded, then the treatability testing for this chemical is completed.

REQUIRED EQUIPMENT & MATERIALS FOR SECTION IV

- Protocol Spreadsheet for recording observations and analytical results

- Large clean container, approximately 3 liters or large enough to submerge plumbing sample, for chemical rinsing in step I.

(quantity = 1 per chemical concentration being evaluated)

- Large clean container, approximately 3 liters, for collecting water from rinsing steps II and III.
  (quantity = 2 per chemical concentration being evaluated)
- Timing device for keeping track of soaking times.
- Sampling containers for mercury analysis.
  (quantity needed = 3 liquid samples per chemical concentration being evaluated)
- Grease pencils for labeling sampling containers and chemical containers.

- A mercury analyzer that can satisfy the required analytical methods in Appendix B

REQUIRED ANALYTICAL TESTING FOR SECTION IV

- Rinse waters from phases I, II and III for mercury concentration

All analytical results must be recorded
on protocol spreadsheet!!!!!!!!!!

V. HEALTH AND SAFETY

- Prior to handling or removing any "Special Waste" conveyance plumbing, the Host Institution's Safety Officer must give the sampler and laboratory technician training in sampling. If the Host Institution is unable to supply the sampler and technician with this training, then they must obtain contract services to provide the necessary training and sampling protocol.

- When dealing with any conveyance plumbing there is always the risk of coming in contact with infectious diseases and it will be imperative that samplers and laboratory technicians receive required training.

- The types of plumbing samples that are preferred, would be samples from research and clinical laboratories that do not deal with highly infectious diseases and radioactive materials.

VI. CHEMICAL SUPPORT INFORMATION

- Material Safety Data Sheet MSDS must be obtained and present for all chemicals during testing.

- When handling and dispensing chemicals always refer to manufacturers material safety data sheets (MSDS) on all safety and precaution issues. MSDS's should be reviewed prior to starting work.
- Prior to handling protocol treatment chemicals the Analytical Testing Laboratory Safety Officer must give the laboratory technician Hazard Communication Training for all chemicals and procedures of the laboratory. The Hazard Communication Training should include, but not limited, to the following:

  - MSDS Awareness
  - Laboratory Hazards
  - Personnel Protective Equipment
  - Spill Response Procedures and Equipment
  - Emergency Showers and Eye Wash Stations

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