# Best Management Practices
# For
# Hospitals and Medical Facilities

Palo Alto Regional Water Quality Control Plant

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**To:** File

**From:** Ken Torke

**Subject:** Hospital BMP updates.

The following items will be added to the next revision of the Best Management Practices for Hospitals and Medical Facilities.

> Some stool preservatives contain copper or mercury (Para-Pack LV-PVA Fixative). Non-mercury containing alternatives are available. Alpha-Tec Systems= ATS Para-Set SAF contains sodium acetate, acetic acid and formaldehyde.
>
> A lab reagent, cysteine broth with sodium selenite, can be replaced with a selenium free version.
>
> Pre-filled formaldehyde containers for specimen collection should be bought in various sizes. A four mL containers can be used for the common Apea-sized@ and smaller specimens instead of the often used 90 mL containers.
>
> Chromic acid solutions should not be used for glassware cleaning. Chromium free products such as No-Chromix are available.
>
> Chromic acid developer systems cleaners should not be used for X-Ray processors. Kodak now manufactures a chromium free alternative.
>
> Chromium containing products such as Surgipath=s Sta-On should not be used. This is a bath for floating thin slices of paraffin imbedded specimens. This is used to transfer the specimen slice to a slide. Alternatives such a pre-charged slides or silane are available.
>
> A non-mercury weighted Bougie tube is now available.
>
> Mercury free Hematoxylin stains are available.

**TABLE OF CONTENTS**

# INTRODUCTION

The final waste water discharged from hospitals and medical facilities to the sanitary sewer contains relatively low concentrations of pollutants. However, because of the large flows from such facilities the mass contribution for some pollutants can be significant. This is especially true in light of the tightening restrictions on the discharge from the Regional Water Quality Control Plant (RWQCP) to the South San Francisco Bay. Among the metal pollutants of most concern are nickel, copper, zinc, silver and mercury. Other non-metallic pollutants of concern include cyanide, phenolic compounds, solvents and formaldehyde.

The RWQCP has reviewed many of the activities at the hospitals within its service area. By evaluating the waste generating activities and the waste management practices at these facilities, the following Best Management Practices (BMPs) have been developed. The BMPs contain information that can be used to evaluate the activities at hospitals and similar facilities. While the information was collected from larger hospitals, many of the same waste streams and opportunities for minimization will exist at smaller facilities such as clinics, medical laboratories and veterinary services.

There are numerous chemicals used in various areas throughout hospitals. These uses can be minimized in many cases and eliminated in others. For many chemicals, the only option may be collection for disposal as a hazardous waste. The following information concerns the identification of several waste streams that should be collected and disposed of as hazardous waste as well as pollution prevention opportunities for waste streams that may be commonly found. It is important to remember that all new products, processes, laboratory methods and waste streams requiring disposal should be carefully evaluated and the most appropriate option should be implemented.

The main areas discussed include:

- Laboratories
- Dialysis
- Gross Pathology and Necropsy
- Central Sterilization and Infectious Waste
- Patient Care Areas
- Pharmacy
- X-Ray, Radiation Therapy, and Radioactive Waste
- Facilities
- General Environmental Strategies

# Laboratories

Hospitals and medical facilities have numerous associated laboratory operations. These in-house labs and similar contract labs perform a variety of functions that commonly include but are not limited to research, chemistry, hematology, pathology, histology, microbiology and immunodiagnostics. These varied laboratories pose one of the largest potentials for pollutant discharges to the sanitary sewer at a hospital. There are typically a wide variety of processes and testing methods conducted in a number of different laboratory locations. Many of the activities produce hazardous waste, including concentrated metal containing solutions that can be collected, reduced or eliminated. Examples from some of the more common activities are described below:

## Chemistry Labs

The chemistry labs of many hospitals may perform some more specialized tests as well as numerous "general" analyses. The lab work conducted can include common blood (hematology) and other body fluid parameters. Common analytes include such things as glucose, albumin, calcium and chloride. The majority of lab analysis is now run on automated systems or other instruments that use very small volumes of samples and reagents. Analyses are rarely performed on a "test tube" scale. The advantages of such systems include waste minimization as well as increased productivity. There are usually several methods available to choose from for any one parameter and the careful choice of methods can reduce or eliminate many waste problems. It is important for the lab managers and analysts to be aware of the many options available and to use the one that produces the best results with the least amount of waste.

## Hematology

Blood chemistry is normally handled by a separate laboratory group. Cell sorting and counting instruments use a cyanide-containing cell lysing solution. A small quantity of the solution is used for each sample, which is then diluted with a saline solution during analysis. The most common instruments do several different tests. The cyanide concentration in the final waste solution is usually below the hospital's discharge limit. The manual Iron Cyanide test yields a concentrated cyanide waste that should be collected, stored in secondary containment and disposed of as a hazardous waste. All concentrated cyanide solutions should be stored in secondary containment and segregated from all acidic solutions.

There are several other waste streams in the hematology and chemistry labs that should be reviewed and possibly collected for disposal. Some of them are listed below:

- Chromic Acid solutions should not be used for cleaning glassware. Use of Non chromium containing products such as Fisher Scientific's No Chromix or Sigma Chemical Company's Sigma Clean are safer to use and eliminate a chrome containing hazardous waste.

- Bouin's solution contains formaldehyde and is used for washing bone marrow cells and as a preservative.

! Chloroform and methylene chloride are used to extract blood and urine samples for analysis by gas chromatography (GC). The sample sizes should be minimized to reduce the quantity of solvent used and all waste solvents should be collected for disposal as hazardous waste. Solvents used for thin layer chromatography (TLC) analysis should also be minimized and collected.

! Atomic Absorption (AA) is used to determine copper and other trace metals in blood and other samples. Waste from heavy metal Atomic Absorption standards should be collected and disposed of as hazardous waste. Standards should be produced in small quantities and only as needed.

! Xylenes for extractions and slide cleaning should be minimized and any waste should be collected. Terpene-based solvents (such as Hemo-D) are available and may be substituted for xylenes used in slide cleaning.

! Chloride can be analyzed either by ion selective electrode (ISE) or by a colorimetric method. The ISE method requires only a buffer while the other method requires a mercury reagent. The mercury waste stream must be collected, which may be difficult. Disposal is expensive. A titrametric method is still commonly used for analyzing chloride in sweat and may be used for other chloride analysis. All solutions from this test are hazardous and must be collected.

Other metal-containing reagents that have been found in the labs include the following:

! An albumin method uses a reagent with 80g $CrK(SO_4)_2$ per liter.

! A total protein method uses a reagent with 1.5g of $CuSO_4$ ! $5H_2O$ per liter.

! A preservative for stool samples contains a concentrated copper solution.

! A glucose test kit uses zinc.

These are only some of the many reagents and test methods that may contain pollutants of concern. It is important that the laboratory personnel know the constituents of each reagent and the proper disposal. When waste concentrations exceed the discharge standards the solutions must be collected and disposed of as hazardous waste. The pollutants of greatest concern are cadmium, chromium, copper, cyanide, lead, mercury, nickel, selenium, silver and zinc. The RWQCP's treatment system is unable to remove these pollutants to levels suitable for discharge to the Bay.

**Pathology/Histology**

The most common hazardous materials used in pathology and histology labs are preservatives and fixatives used to prepare specimens. Waste glutaraldehyde, formaldehyde, alcohols, xylene and other solvents should be collected and disposed of properly whenever concentrations are above the discharge limits. The Department of Toxic Substance Control (DTSC) has reviewed testing on 14 day old glutaraldehyde solutions and may consider them to be non-hazardous waste. Small quantities of the spent solution may be discharged to the sanitary sewer as long as all Federal, State, and local regulatory requirements are met. The Formalex brand formaldehyde and glutaraldehyde treatment system has also been reviewed and approved as a waste treatment technology by the DTSC. It should also be noted that glutaraldehyde gives a false positive for some analytical methods used for the determination of formaldehyde.

There are several areas where waste production and hazardous materials use can be reduced. The most significant is the use of two tissue fixatives: Zanker's solution and B5. Zanker's solution contains 72 grams (g) of mercury and 5g of chromium per liter; B5 contains 37g of mercury per liter. Both of these solutions are extremely hazardous and should be used in the smallest possible volumes with the excess being rinsed to a waste container. Rinsing to the sink should be avoided. The use of Zanker's solution and B5 can also be minimized by substitution of other fixatives in all but a few cases. However, different fixatives have different fixing and subsequent staining properties and require the ability to interpret differently prepared specimens. Zanker's also tends to produce easier specimens for interpretation. For these reasons some pathologists are unwilling to expend the extra effort necessary to get good results with less hazardous material use.

**Microbiology**

Most of the chemical usage in the microbiology labs is for preparation of slides. All staining supplies should be stored in secondary containment. Slides should be stained with a few drops of stain rather than dipping in baths whenever practical. This reduces the amount of stain that is rinsed to the drain or must be collected either as rinses or from waste baths. Stains containing heavy metals or other hazardous ingredients should be collected if above discharge limits. Several stains contain mercury, such as hemotoxylin which should be avoided or collected for disposal as a hazardous waste.

**Immunodiagnosis Lab**

Several slide preparation solutions used in the immunodiagnosis lab contain heavy metals and should be collected for disposal. Copper sulfate solutions are used for at least one slide preparation method. Thimerosal is a preservative that contains mercury and is used in some buffer solutions and possibly in other solutions throughout the hospital. Alternatives to Thimerosal such as sodium azide are available for many applications and do not cause the same water pollution problems.

**General Lab Work**

All laboratories should implement the procedures outlined in the Laboratory BMPs available from the RWQCP. These are general practices and procedures that help to eliminate or reduce the likelihood of chemical discharges and spills to the sanitary sewer. There are numerous reagents that are used in the different laboratories. Each of these should be checked for their chemical composition. There are many instances where a solution can be collected, used in smaller quantities or even replaced with less harmful alternatives.

## DIALYSIS

The waste water from a dialysis center commonly consists of effluent from patient treatment and from cleaning and disinfection of the equipment. The dialysate from patient treatment consists of a saline solution and patient waste products.

Domestic supply water must be treated before use in dialysis. The water is deionized first. This is accomplished by reverse osmosis (RO) filtration of water that has been pretreated with sand and charcoal filtration and often softened to remove calcium and magnesium (hardness). The RO membrane must be periodically disinfected. Among the disinfectants typically used are bromine and formaldehyde. The disinfectant is typically recirculated through the system and then discharged to the sanitary sewer. When formaldehyde is used the resulting waste will typically be above the discharge limit and should be collected or another method should be used. A solution of peracetic acid, acetic acid and hydrogen peroxide (Renalin/Actril) is now available for this function. However, the RO system must be compatible with the solution and the membrane must be pretreated to remove any iron. Iron causes catastrophic holes in the membrane when it reacts with the oxidizing solution. The advantages of this system include lower exposure of both employees and patients to formaldehyde, which is a suspected carcinogen. The spent Renalin/Actril type products may also be safely disposed of in the sanitary sewer because the decomposition products are easily handled by the RWQCP's biological treatment processes.

The dialysis units themselves must also be disinfected. The small membrane cartridges are disinfected after each use. The peracetic acid disinfectants are preferable for this application for the same reasons. The system tubing and pumping equipment is also similarly treated on a regular basis. Older machines must be modified to use the peracetic acid disinfectants but newer machines should all be compatible. Equipment that can be heat disinfected may be available in the near future. Systems still using formaldehyde for these two processes should collect the solutions and dispose of them as a hazardous waste.

## GROSS PATHOLOGY AND NECROPSY

In gross pathology, the larger tissue and organ specimens are prepared and stored. These procedures often include the use of alcohols, formaldehyde and some metal-containing fixatives. All formaldehyde solutions and specimens stored in free solutions should be stored in secured secondary containment and away from sinks. All metal containing waste solutions should be collected, including the rinses from silver staining and Zanker's fixing (contains mercury and chrome). The use of the metal-containing solutions can be eliminated in most if not all cases. All waste solutions above discharge limits for metals or formaldehyde should be collected and disposed of as hazardous waste.

Morgue and necropsy work may also involve large quantities of formaldehyde, glutaraldehyde, and alcohols. All of these solutions should be stored properly and wastes should be collected for proper disposal. The use of Zanker's and zinc sulfate for fixing can be eliminated in most cases.

# CENTRAL STERILIZATION AND INFECTIOUS WASTE

## Central Sterilization

Most hospitals have one or more central supply processing and distribution centers that wash and sterilize the reusable equipment. The most common disinfection procedures used include ethylene oxide, liquid sterilants and steam. The sterilization method is most often chosen by the properties of the equipment.

Liquid ("cold") sterilants, such as glutaraldehyde, formaldehyde and phenols are common in hospitals. Solutions containing these ingredients have been commonly discharged to the sanitary sewer in the past. The use of these chemicals should be minimized or eliminated where possible and hazardous wastes should be collected. The solutions should be either disposed of as a hazardous waste or treated with an approved treatment process (such as Formalex). These cold sterilants are primarily used on equipment that either cannot be subjected to the high temperatures or moisture in autoclaves, cannot withstand the oxidative properties of ethylene oxide, or must have a fast turn around time. Currently, the only piece of equipment that cannot be treated with other methods is the endoscope. There may soon be an endoscope on the market that can be sterilized in a more environmentally acceptable manner.

Sonic sterilization can be used alone or in conjunction with sterilizing solutions. When it is used with solutions that do not pose a threat to the sanitary sewer the solutions may be discharged and the waste produced can be minized.

The use of glutaraldehyde and formaldehyde is also discussed in the Pathology/Histology section.

There are several sterilants which are formulations of peracetic acid, acetic acid and hydrogen peroxide (Renalin, Actril, etc.). These products are currently being used primarily for dialysis equipment but may have other uses. The chemicals in the spent solution appear to be less hazardous than aldehydes and phenols and do not pose a problem for the RWQCP.

Steam sterilization (autoclaving) is used on most equipment that is rugged enough to handle the heat and moisture and does not have absorbent surfaces. This method produces little or no chemical waste. All autoclaves should be fitted with either recirculated cooling water or a minimum of controls that supply cooling water only when needed. These water saving modifications easily pay for themselves with water and sewer bill savings. Without these modifications autoclaves can be one of the hospital's largest water users.

Large industrial-type dishwashers are also used for cleaning and some sterilization. These commonly use hot water, steam and caustic cleaners. Water and chemical use should be minimized where practical for these areas. Concentrated cleaning chemicals should be stored in secondary containment to avoid spills of concentrated chemicals to the sanitary sewer.

Ethylene oxide (EtO) is a gaseous, cold sterilant that is applied to equipment held in a sterilizing chamber. The waste gas has been simply released to the atmosphere in the past. This practice is being replaced by other methods due to action by Air Quality Management Districts and the U.S.

Environmental Protection Agency (EPA). Emission control methods include scrubbers that convert the EtO to an ethylene glycol solution that is discharged to the sanitary sewer, combustion, or collection of the gas. The gas has been typically supplied with a freon based carrier (88% freon), so collection and recycling equipment has been developed to recover the freon. The manufacture and use of freon will be banned in the near future. Manufacturers have proposed the use of 100% EtO or carbon dioxide as an alternative carrier gas. Other proposed alternative sterilization methods include electron beam, gas plasma and microwave. None of these appear to pose significant risks to the sanitary sewer.

**Infectious Waste and Incinerators**

Hospitals generate a large quantity of infectious or "red bag" waste. This waste is commonly incinerated or it is sterilized and then landfilled. Incineration can be conducted either on or off site. The costs of infectious waste disposal is high. The waste water produced by incinerator scrubbers can contain significant amounts of metals. The partial solution to both of these problems is to minimize the amount of infectious waste that is generated. A large portion of the red bag waste is often non-infectious "office products." These items are often placed in the infectious waste because the container is more convenient or the user is unaware that the item can be discarded as normal trash. An educational program should be in place that encourages the segregation of non-infectious waste. Many components of infectious waste may also be recycled after sterilization. Companies that provide this service are available in some areas. The inclusion of such items as batteries, X-ray film, electronics, thermometers, hazardous waste, packaging (often with metal-containing pigments) and other items in the red bag waste contributes to the metals discharge in the waste stream. Incinerators may require a treatment system, including suspended solids removal and metals treatment, in order to meet discharge limitations.

## PATIENT CARE AREAS

Patient care areas include the surgery, nursing and hospital room areas. The waste water discharged from the patient care areas is very similar to domestic waste water from a hotel or residence. The primary contributing flows include showers, rest rooms, and cleaning. The potential concerns include disinfection supplies, the introduction of medicines and other pharmaceutical products, and spills from mercury containing equipment such as thermometers and blood pressure cuffs. Pollutant sources that can be found in the patient care areas are described below:

**Housekeeping**

Housekeeping includes normal cleaning operations as well as disinfection of critical areas. Phenolics are still used in large quantities by many hospitals and are considered by some to be the only acceptable disinfectant for immune-depressed-patient care areas. Discharge of phenolics to the sewer is regulated. These substances may pass through the treatment system and into the Bay due to the biological treatment system's inability to remove them. Phenolic compounds are toxic and some have been shown to be persistent and bioaccumulate in the environment. Use of phenolic disinfectants should be eliminated in non-critical areas. If phenolics are implemented, the minimum required concentration should be used. The available quaternary amine substitutes have been shown by many infection control departments to be suitable and less likely to cause discharge problems. However, both types of solutions should be handled as hazardous materials. The concentrated solutions should be stored in secondary containment to avoid spills to a drain and concentrated solutions of either material should never be discharged to the sanitary sewer.

Several methods are available to control and minimize the use of these products. These include premeasured doses, pumps and auto-feed systems that supply the appropriate dose when preparing a solution. The minimum amount of disinfectant necessary should be determined for each solution use and a minimum amount of solution should be prepared. Measures may be necessary to ensure that these controls are not overridden.

There are several other products that may be used in the housekeeping program that should be avoided. These products contain tributyl tin as an active ingredient. The tributyl tin will be listed as tributyltin chloride, tributyl tin neodeconate, bis tributyltin oxide, tributyl tin benzoate, etc. The products containing tributyl tin include mildew controlling carpet shampoos, toilet cleaners and germicidal surface cleaners.

**Mercury-Containing Equipment**

Mercury-containing equipment such as thermometers, blood pressure cuffs and the manometers on laboratory and patient care equipment are found throughout hospitals. Studies of mop water have shown elevated levels of mercury. The presence of mercury is unlikely to be eliminated from water discharged from hospitals as long as mercury-containing equipment is used. Any mercury spills should be cleaned up properly. Mercury spill clean-up kits should be available in all areas where mercury-containing equipment is used and individuals designated by the hospital should take care of all spills and recycle the mercury or dispose of it properly.

Hospitals can eliminate or at least greatly reduce the use of mercury thermometers. Electronic sensors and temperature strips (such as Temp-a-dots) are adequate for most general use. While the electronic thermometers with disposable sleeves are more costly, they also eliminate the liability, risk and cost of disposal and breakage problems associated with mercury thermometers. Other advantages of electronic thermometers include a faster response time. Sending mercury thermometers home with patients should not be a waste minimization technique. Alcohol (red) and digital thermometers can also be used for equipment such as lab ovens and water baths.

Blood pressure cuffs with electronic sensors are available but not as widely used. Hospitals should replace mercury-containing devices for all non-critical uses. It may be practical to replace the mercury-containing equipment in operating rooms and other critical areas as the use becomes more accepted or better equipment becomes available.

Bougie tubes and Canter tubes are two other common mercury-containing pieces of equipment found in hospitals. The Canter tube is a six foot long rubber tube that is filled with mercury for weight. It is swallowed by the patient to trace the gastrointestinal tract. The tubing is relatively thin and breakage has occurred during use. The Anderson tube contains no mercury, is available, and can be used in place of the Canter tube. The Bougie tube is a heavily constructed, mercury weighted device that is used to "pound" an opening in the esophagus when there are cancerous growths or other restrictions. Breakage from this piece of equipment is not as likely and a substitute is not currently available.

## PHARMACY

The primary function of the pharmacies is to dispense medications and prepare IV solutions. The pharmacies of most hospitals have significantly changed in the past years. In the past the pharmacists prepared many medicines from chemical ingredients. Very little compounding is done in the hospital pharmacies now. Almost all of the dispensed products are commercial preparations that are repackaged or sent "as is." Some items such as IVs are still prepared. The IVs are salt solutions with the additions of medicines or nutrients. Small amounts of copper, selenium and other nutrients are also added to IVs. Heavy metals are ingredients in some pharmaceuticals and other commonly used products. While there may be limited ways of eliminating the amount of metals in the medicines and ointments which are used by patients, their use can be reduced. Some of the potential discharge issues associated with pharmaceutical products are described below:

### Selenium, Zinc and Barium

Selenium and zinc are two of the metals that are currently a discharge problem for the RWQCP. Selenium shampoos are a significant source of the selenium discharged to the treatment plant. Zinc ointments may be the hospital's biggest contribution of that pollutant. Both selenium dandruff shampoos and zinc-containing ointments can be found in the pharmacy. In hospitals these are primarily prescribed for outpatient use and are the same or similar to over-the-counter preparations (such as Selsun Blue and Desitin). Much of the waste from the hospital use as well as the home use is likely to be discharged to the sanitary system during bathing or laundering of patient clothing and linens. Use of these products should be minimized and substitutes should be used when available. Barium used for radiological imaging is also commonly discharged in large quantities to the sanitary sewer; however, barium is not currently a discharge problem for the RWQCP.

### Silver Solutions and Ointments

The pharmacies in hospitals with burn units prepare concentrated silver nitrate solutions for burn treatment. Solutions with silver concentrations above 5 ppm must be collected and treated as hazardous waste.

### Chemical Storage and Disposal

Most of the metal-containing chemicals found in pharmacies are no longer used. The most significant task left for pharmacy personnel is to go through the chemical stores and properly dispose of all the chemicals that are no longer needed. No metal-containing products should be discarded to the sanitary sewer. The chemicals that are likely to be found and are a problem for the RWQCP include silver, cadmium, chromium, copper, cyanide, lead, mercury, nickel, selenium and zinc.

The pharmacy staff must identify the chemicals of concern among those that are still used. Chemicals that are not eliminated should be stored properly. Acids should be stored separately from bases; flammables from oxidizers. All containers should be clearly labeled and secondary containment should be provided for all chemicals that are stored in locations with access to drains. Further information on storage can be found in BMPs for Laboratory Facilities and other publications.

Although the metals may no longer be commonly used in compounding, they may still be constituents of the commercially available preparations that are now being used in their place. It will be more difficult to identify these ingredients. All items sent from the pharmacy should be closely evaluated for content and substitutions should be made whenever practical.

**Compounding**

Any compounding done in the pharmacy should follow the recommendations in the BMPs for Laboratory Facilities available from the RWQCP. Minimum amounts should be prepared and all waste should be collected. The pharmacist should make a concerted effort to be aware of and eliminate hazardous materials when substitutes are available. For example, alternatives to zinc-containing ointments and selenium-containing dandruff shampoos are available and should be used when appropriate.

## X-RAY, RADIATION THERAPY, RADIOACTIVE WASTE

**X-ray Processor Solutions**

The quantity and silver content of the X-ray processor waste stream has the potential to add a significant amount of metal to the hospital's waste stream. The X-ray processor solutions should be handled according to the requirements of Palo Alto's Silver Ordinance. The Ordinance states that spent fix must be treated or disposed of as a hazardous waste. With larger operations, it may be more cost effective to treat the fixer waste rather than to have it hauled away, although it is often easier to have the spent fixer solution hauled away as a hazardous waste. If the hospital treats its spent fixer, a single treatment location may be the most convenient. Centralization reduces the amount of sampling required and the number of systems to be maintained, which easily offsets the increase in collection and transportation time. Efforts should also be made to consolidate X-ray processor use in order to reduce the number of machines that are needed and to reduce maintenance and equipment costs. The newer and better maintained processors tend to have lower chemical and water use and lower carry-over of silver-bearing fixer into the rinse water. The X-ray processors may be the single largest non-domestic water user on the site.

X-ray processor systems may be periodically cleaned with a chromic acid solution such as Kodak's Liquid Developer System Cleaner. This solution contains a high level of chromium. Waste solutions will also contain the silver that has been cleaned from the processor. This solution is a hazardous waste and must be collected for proper disposal. The solution should not be combined with the other photoprocessing waste. Preventative maintenance of the system may eliminate the need for use of this hazardous chemical. Kodak also now makes a non-chromium containing system cleaner which should be substituted for the chromiun product and may be sent for proper disposal with the spent fixer.

**Radiation Therapy Wastes**

During radiation therapy, lead shielding is used to protect the patient from radiation exposure to areas around the actual target area. This lead shielding must be individually prepared for each patient. Shielding may be prepared by either machining lead blocks or by pouring a low melting lead alloy into molds. If work must be done with lead blocks, the lead waste produced from sawing, filing and washing operations must be collected and disposed of as a hazardous waste. For these and employee health reasons the machining of lead blocks should be avoided. The low melting alloy Cerrabend 158, (mp=158F), which is lead with Bi, Sn, Cd, can be used in most instances. Any wastes from washing, filing or other working of the casts should also be collected as a hazardous waste.

**Radioactive Wastes**

Radioactive wastes result from the use of tracers and other radioactive diagnostic and treatment procedures. There are numerous procedures that involve the use of various radioactive isotopes and equipment. It is important that the radiation safety officer follows all Nuclear Regulatory Committee (NRC) and California Department of Health Services, Radiologic Health Branch regulations regarding the disposal and storage of such materials. Limited amounts of some routine materials are acceptable for disposal to the sanitary sewer. Care must be taken to follow the prescribed guidelines for such activities.

Long and short-term storage areas for radioactive waste should include proper containment to prevent releases to sewers or storm drains.

## FACILITIES

A hospital's facilities department is responsible for general maintenance and operations of the building and grounds. In most respects, these activities are the same as for any business or industry of a similar size. The RWQCP has developed BMPs for machine shops, vehicle service facilities and cooling towers that should be consulted and applied in the appropriate areas. These BMPs are available from the RWQCP. There are also other sources of information for waste minimization in these general areas. Several items that are more specific for hospitals and medical facilities are described below:

**Hot Water Systems**

Most larger buildings have recirculating hot water systems that keep hot water near each point of use at all times. Hospitals normally implement some method of disinfection beyond the level provided in the incoming water supply in order to combat infectious agents which otherwise might exist within the system. The primary infectious agent of concern is *Legionella*. Some systems incorporate additional chlorination and some maintain the water temperature above "household" levels either constantly or intermittently. Hospitals using elevated temperature water temperatures incorporate valves before each faucet that mix cold water with the hot to eliminate the possibility of scalding from the high temperature water. Either chlorination or high temperature water can be effective and have been approved by most hospital's infection control groups. Another system exists which uses electrolysis to introduce copper and silver ions into the water. These electrolysis systems should be avoided because they add copper and silver to the waste water and other options are available.

Another concern with any of these methods is that they may lead to an increased amount of corrosion within the copper piping of the recirculating loop. Corrosion leads to both costly repairs and the introduction of lead (from older solder) and copper into the hot water and waste stream. The system used should be evaluated to maximize infection control and minimize corrosion. Corrosion controls may include such tactics as reduced or intermittent chlorination, lowered or intermittent high temperatures, protective magnesium anodes, alternate piping materials (particularly non-copper), slower recirculating rates, pH adjustment, and chemical controls such as sodium bicarbonate addition.

**Cooling Systems**

There are numerous cooling water applications throughout the hospital including cooling towers, small recirculating systems and single-pass systems. Single-pass systems waste water and should be eliminated. They can be found on such things as vacuum pumps, laboratory equipment, and autoclaves. Recirculating water systems that have been treated with metal-containing chemicals should not be discharged to the sanitary sewer. The BMPs for cooling towers should be followed including the elimination of any treatment chemicals that contain copper, zinc or tributyl tin.

**Dehumidifiers and Air Conditioners**

Operation of dehumidifiers and air conditioners will produce a waste water stream consisting of condensation water from the atmosphere. This water can be contaminated with small amounts of dirt, corrosion from the system and oil. Dehumidifiers are used to remove the water from outside air which is then supplied to patient and surgery areas. Air conditioning systems have cooling coils which can also condense water from the atmosphere. These and all similar condensate flows should be reused when possible (in cooling towers, etc.). New lines should not be plumbed to the storm drain and existing lines which can be easily relocated should be moved for reuse or for discharge to the sanitary sewer. Non-copper drain lines are recommended for all equipment.

**Vacuum Pumps**

Vacuum is generally supplied either by centralized "house" vacuum systems or by smaller sources such as small pumps or aspirators. A house vacuum should be available in all areas. Centralized systems can provide more consistent service with fewer pumps that require monitoring and maintenance. One commonly employed alternative to centralized vacuum is the use of water aspirators. Aspirators draw a vacuum by entraining air in a fast flowing water stream. These have been used to provide vacuum for such things as distillation and removal of wastes from containers. This is likely to introduce chemicals into the waste water stream and is a tremendous waste of water. Cold traps can be used for volatile chemicals; however, these may still be inadequate to keep solvents out of aspirator or pump seal water. Aspirators are prohibited in new facilities.

Two other common vacuum sources are water seal and mechanical pumps. Water seal pumps have the potential to entrain solvents in the seal waste water. Mechanical pumps have no water seal and are preferable. They reduce the use of water and do not require a connection to the sanitary sewer. However, they do use vacuum pump oil which must be disposed of as a hazardous waste.

Many vacuum applications incorporate the use of mercury-containing devices such as manometers, traps, bubblers, seals and others. These should be eliminated where possible and protected from breakage, spills and introduction to the vacuum line where still used.

Single pass cooling or seal water should be avoided for vacuum pumps. Some single pass cooling systems use as much as ten gallons of water per minute. These pumps should be replaced or retrofitted to recirculating cooling water systems. The savings from reduced water and sewage fees can quickly pay for such modifications.

**Water Softening**

Water hardness, which is primarily composed of calcium and magnesium carbonate, can make the water less desirable for certain uses. Softening is used for such things as laundries or as a pretreatment before deionization. Common softeners exchange sodium for the calcium and magnesium that are found in the water supply. A large volume of concentrated salt solution is discharged to the sewer each time softener is regenerated. Water softening adds a considerable salt load to the waste stream. This will become an issue in the future as efforts are made to recycle the RWQCP's effluent. Water softening should only be used where necessary, such as for dialysis water preparation. Softened water is more corrosive and should not be plumbed through copper piping when avoidable. Water softeners have been banned in certain service areas and may be banned in the RWQCP's service area in the future.

**Deionized Water Systems**

Water delivered from the city may contain dissolved salts that make it unacceptable for some uses. The dissolved salts (ions) are commonly removed with ion exchange resins and/or reverse osmosis (RO). Deionized (DI) water is typically used throughout the facility for such things as laboratory reagents. RO systems are routinely maintained with treatment chemicals such as disinfectants, sulfuric acid, sodium hydroxide and sodium hypochlorite. Ion exchange resins are often regenerated off site, but may be handled at the facility. The acids and bases used to regenerate the resins must be neutralized before discharge to the sanitary sewer. The RO system and ion exchange maintenance chemicals are hazardous and should be stored and used properly. All of the chemicals should be stored in secondary containment. Acids and bases should be kept separated. Disinfection should be accomplished without the use of formaldehyde. Other systems are available such as sodium hypochlorite, bromine and peracetic acid disinfectants. RO systems for dialysis were discussed in an earlier section.

## Limestone Sumps

Acidic waste water from laboratory areas may need to be neutralized before discharge to the sewage collection system. Limestone neutralization sumps are fairly common in older construction. A limestone sump consists of a basin that is filled with limestone chips. As the water passes through the basin any acid solutions are neutralized by the limestone. However, the sumps are not highly efficient. Such sumps can be a collection point for sediments (including elemental mercury) that must later be discarded as a hazardous waste along with the remaining limestone at a considerable cost. The pH of waste water from laboratory areas can be controlled in the lab with proper training and collection or neutralization of acids and bases. Therefore, the limestone sump is often not necessary. If a neutralization system is necessary, an appropriate equilibration tank or neutralization basin should be installed.

Limestone sumps may have been installed for the waste water flow from the laboratory areas in many hospitals. This discharge location is a valuable sampling point for determining the effectiveness of the laboratories pollution control efforts.

## Plumbing

Mercury from broken equipment and poor disposal practices has often found its way to sewer lines and sumps. Elemental mercury can settle at a low point such as a sump or trap. Often the slow dissolution of the mercury in a sump, trap or pipe is significant enough to cause violations of waste water discharge standards even after poor disposal practices are eliminated. Whenever traps or sumps are moved or cleaned it is important that the solid contents are handled as a hazardous waste unless proven otherwise.

## Laundry

While the operation of hospital laundry facilities is tightly regulated for health concerns, discharge to the sewer is currently regulated only by local agencies such as the RWQCP. The United States Environmental Protection Agency (EPA) will issue proposed rules for laundry facilities in December of 1996; a final rule is scheduled for December of 1998. The EPA's rule will establish a category for laundries and will set pretreatment discharge standards. The standard will target hospitals as well as other industrial laundries. Laundry facilities wash hospital and surgery linens including sheets, pajamas, towels, surgery scrubs, and washcloths. It is important to ensure that no hazardous materials are allowed in the laundry. This includes items such as thermometers or rags that have been used to clean up hazardous materials spills.

The operation of hospital laundry facilities is tightly regulated (JCAHO); however, efforts can be made to reduce the amount of pollution produced while still meeting requirements. The water consumption of the laundry can be a considerable portion of the hospital's use. Efforts should be made to reduce water use. Potential water conservation measures include recycling of gray water and purchase of water efficient equipment such as tunnel washers and other automated systems.
The discharge from the hospital laundry facility may contain a significant load of metals as well as organics. Some of these may come from the laundry chemicals, but a majority come from soils and components of the laundered material. Treatment methods used at laundry facilities include

the following:

- ! Equalization;
- ! Coagulation/Flocculation;
- ! Dissolved Air Flotation;
- ! Micro/Ultra Filtration;
- ! Clarification; and
- ! Oil/Water Separation.

Many hospitals send their laundry to commercial laundry facilities that usually have some water treatment before discharge. The City of Palo Alto does not currently require treatment of hospital laundry waste water. However, if studies indicate that treatment is practical, local requirements may be set before the Federal standards are set in 1998.

The chemicals used in the laundry are concentrated and should be stored properly. Chemicals that are incompatible should be separated from each other and secondary containment provided for all of the materials.

## GENERAL ENVIRONMENTAL STRATEGIES

Many waste minimization and pollution prevention measures are not specific to hospitals but may lead to significant improvements in the hospital's environmental, health and safety program status. Several items are outlined below:

### Personnel

Hospitals and larger medical facilities should have at least one employee who is dedicated to developing and implementing environmental programs. It is difficult for someone to track and take care of the numerous permits and programs consistently on a part time basis. Internal audits should be conducted regularly by staff or consultants. It may also be useful to form a committee consisting of interested members of affected groups (facilities, housekeeping, nurses, etc.) that can provide feedback and information on programs that apply to their area.

### Training

All personnel should be well trained and aware of their role in pollution prevention and waste minimization. Annual safety training and other related meetings should be used to remind employees of their responsibilities and the potential problems encountered in specific areas. Posters, fliers and labeling should be used to keep this information current and available. For example, signs should be posted above sinks stating that hazardous chemicals should not be disposed of in the sink. Specific requirements for work groups such as nursing, housekeeping, laboratory and radiology should be regularly addressed.

**Labeling and Storage**

All hazardous materials and wastes should be segregated, labeled, and stored according to Federal, State, and local regulatory requirements. Much of the information contained in the Best Management Practices for Laboratories applies to hospitals. The BMPs primarily emphasize segregation of non-compatible wastes and providing secondary containment that keeps spilled materials from entering a storm or sanitary drain. Floor drains should be eliminated in all areas where hazardous materials are handled. Drains for safety showers must be provided with a temporary plug which remains closed except when the shower is in use, or the drain must be protected from spills by either a covered sump or a berm system. Material Safety Data Sheets (MSDSs) should be available for each material that is used on site. The product's application should be evaluated to ensure that the material is being handled properly. It is important to remember that many MSDSs do not list all ingredients. Some components, such as copper and zinc, are problems for disposal to the sanitary sewer but will often not be listed on the MSDS because they are not safety issues or there are no reporting requirements. Knowledge of the products and supplier information should be used to identify these pollutant sources.

A central receiving department and a tracking program can be used to label such products with use and disposal cautions. Containers, instruments or processes that involve the suspect products can also be labeled so that users are aware of their responsibilities. A chemical/material inventory program can be used to follow the purchasing and use throughout the hospital. Purchasing minimum amounts of chemicals and reducing duplication within the institution can reduce the amount of outdated or unneeded materials which must be disposed of as hazardous waste.