SECTION IV

WASTEWATER INSPECTIONS

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CHAPTER 1

1.0 GENERAL WASTEWATER INSPECTION PROCEDURES

1.1 OBJECTIVE

This section provides general procedures to follow when inspecting a facility's wastewater generation and discharge.

1.2 PURPOSES OF WASTEWATER INSPECTIONS

Purposes of Inspections

There are many purposes for conducting wastewater inspections at industrial and commercial facilities. One of the primary purposes is to gather information about the facility's processes and operations and to characterize its discharges. This characterization should include the volume of wastewater discharges, the types of pollutants the facility discharges or has the potential to discharge, and whether or not the facility's discharge has the potential to cause damage to the receiving stream or the environment. Information gathered can be used to assess the need for pollutant controls and to develop discharge permit conditions or other associated requirements aimed at reducing pollutant discharges and thus reducing the negative impacts of these discharges on the environment. If facilities are required to submit information such as permit applications, or responses to surveys, inspections can also serve as a means of verifying the accuracy of data and information submitted by the facility. Once this information has been gathered, inspections should be performed to maintain and update information on facilities.

Information gathered during inspections can also be used to evaluate the facility's compliance with any standards or requirements and to support any necessary enforcement action for noncompliance. Inspections can also be performed to verify the correction of problems and the attainment of compliance, such as the installation of wastewater treatment equipment.

1.3 INSPECTION PROCEDURES

Inspection Procedures

As with all types of inspections, a wastewater inspection consists of three general steps; pre-inspection preparation, onsite activities, and follow-up activities. Pre-inspection preparation is important so that an inspection is well planned and efficient and that the inspection objectives are met. Onsite activities are the most essential part of the inspection and may include meeting with facility representatives, conducting a thorough inspection of the facility (including its operations and manufacturing processes, storage areas, and wastewater treatment systems), and examining records. Follow-up activities are necessary to ensure that inspection findings are properly documented. Each of these steps will be discussed in greater detail.

1.4 PRE-INSPECTION PREPARATION

Pre-Inspection Preparation

Pre-inspection preparation involves several activities including review of facility records and literature references, development of an inspection plan, notifying the facility (if applicable), and assembling and calibrating safety and sampling equipment. Each of these activities will be discussed in greater detail.

Records Review

The inspector should begin preparation for an inspection by reviewing any background information already gathered on the facility. Information to be reviewed may include data submitted by the facility such as responses to surveys or questionnaires or permit applications and correspondence. In addition, reports from any previous inspections or site visits and information relating to the facility's compliance history should be reviewed. During this review, any unresolved compliance problems should be noted so that the inspector can verify these problems onsite. In order to determine compliance, the inspector must be knowledgeable about any regulatory requirements that apply to the facility. If not familiar with these requirements, the inspector should review all relevant requirements, such as permit conditions prior to the inspection.

Literature Review

To perform a thorough but efficient inspection and to establish credibility with the facility, the inspector should have at least a basic working knowledge of the facility's manufacturing process. If the inspector is unfamiliar with the particular operation or manufacturing process performed by the facility, applicable literature sources should be reviewed in order to gain a better understanding of the specific process or operation.

Inspection Plan

Once the inspector is familiar with the facility's background information, an inspection plan should be developed. Basically, an inspection plan should outline the scope and objectives of an inspection and identify how the inspection objectives are going to be met. The objective of the inspection will determine the scope and depth of the inspection.

During preparation for an inspection, the inspector should note any questions that need to be answered during the onsite activities. By preparing a list of, the inspector can better ensure that all necessary information to develop a complete picture of the facility is gathered.

Facility Notification

In some cases it may be appropriate to notify the facility of an impending inspection. For instance, if a complete facility tour is desired, it may be beneficial to notify the facility so that the appropriate representatives are present. In other cases, such as if noncompliance is suspected or in the event of a spill, notification may not be desirable. The inspector should determine if notification is appropriate and, if so, should contact the facility by telephone or by sending a letter.

- Scheduled inspections are those that are scheduled in advance and that the facility has been notified of the approximate date and time the inspection will occur. Scheduled inspections are most often used for initial or routine inspections.

- Little or no advance notice is given to the facility in an unscheduled inspection. Unscheduled inspections are useful as random spot checks in certain cases such as the facility is suspected to be out of compliance.

- Demand inspections are generally conducted in response to a specific problem or emergency situation such as a spill.

Health and Safety

Ensuring inspector safety is very important during an inspection. Specific information on safety equipment necessary for the particular facility being inspected should be gathered prior to the onsite activities.

This information can be obtained from previous inspection reports, talking to people that have visited the facility in the past, or by obtaining the information directly from the facility. If the facility is notified of an inspection, this may be a good opportunity to inquire about safety equipment necessary for the inspection.

Equipment

Preparation

The final step prior to an inspection is to prepare any equipment necessary for the inspection. The type of equipment needed will be dependent on the nature of the inspection and may include safety and/or sampling and flow measurement equipment. The inspector should ensure that all equipment to be used is calibrated and is in proper working order. The inspector may also want to take a camera so that photographs of the facility can be taken.

1.5 ONSITE ACTIVITIES

Periphery Inspection

Prior to entering, the inspector should conduct an examination of the periphery of the facility. If an inspection has not been performed previously, the inspector should note the general size of the facility including the number of buildings at the site.

Any problems around the facility's perimeter such as apparent spills or improperly stored chemicals should be noted. Environmental conditions such as the condition of surrounding vegetation, odor problems, abnormal stack emissions, and whether the facility has a direct discharge to a receiving stream should be noted.

If outside chemical or waste storage areas are visible, the inspector should note the condition of these areas, including spill containment, and any associated problems such as leaking drums.

Finally, if located in an easily accessible area, the inspector may want to look at the facility's discharge points to see if there are any unusual discharges.

If sampling is to be conducted as part of the inspection, the inspector may want to set up the sampling equipment at this time. It may also be useful to perform certain analyses such as pH prior to entering the facility. Doing this may provide insight to additional problems that should be addressed during the inspection. Any problems noted during the examination of the facility's periphery should be addressed during the inspection.

Facility Entry

When entering the facility, the appropriate facility representative should be located. The inspectors should identify themselves and be familiar with and follow applicable procedures for facility entry. Inspectors should provide a copy of the written inspection order.

Opening Conference

It is generally a good idea to conduct an opening conference or pre-inspection meeting with facility representatives, particularly if it is the first visit to the facility.

During this meeting the inspector should briefly state the purpose of the inspection and inform the facility representatives of the intended schedule and order of the inspection. By doing this, it can be better assured that the proper facility representatives will be available to conduct the tour and answer questions. The inspector should also identify any additional records or information that will be needed so that the facility can gather the necessary information while the inspector is onsite.

The inspector should use the opening conference to ask any questions identified during the pre-inspection preparation and to obtain general background information such as the number of employees, production rates, wastewater flow rates, and any changes that have been made since the last inspection. Since many manufacturing facilities are noisy, it may be difficult for the inspector to hear during the tour. Therefore, it may be beneficial to have facility representatives give a brief description of the industrial processes during the opening conference, particularly if it is the inspector's first visit to the facility. If the facility has a plant schematic, the inspector should obtain a copy to make the tour easier to follow and to better ensure that all areas of the facility are covered.

Inspectors should also answer any questions the facility may have. From the start the inspector should strive to establish a good rapport with facility representatives so that they are comfortable and will more readily answer questions and provide the information the inspector needs.

Inspectors should also provide facility representatives with information on applicable regulations and their associated responsibilities. If the facility does not have copies of applicable regulations, the inspector should provide and review these during the opening conference. General information on pollution reduction and pollution prevention techniques such as brochures or guidance manuals should also be provided.

Inspectors need to remain flexible and be ready to make changes in their inspection plans. Based on the observations during the examination of the facility's periphery or information obtained during the opening conference, it may be necessary to change the objectives or order of the inspection. For instance, if it was noted during the examination of the facility's periphery that a sump collecting runoff from a hazardous materials storage area was being pumped directly to the surrounding ground, this area should be investigated as soon as possible so that the problem is not discovered and corrected by the facility before the inspector has a chance to investigate it.

Facility Tour

After the opening conference, the inspector should conduct a full tour of the facility. Conducting a tour is very important to allow a full description and understanding of the facility's processes and to verify information provided by the facility. Tours also allow the inspector to identify problem areas that can be improved through pollution reduction techniques. The tour should focus on areas of the facility where wastestreams and/or pollutants are produced, processed, pumped, conveyed, treated, or stored. Such areas may include the facility's production processes, storage areas, and treatment equipment. The inspector needs to gain a full understanding of the facility's wastewater generation and treatment. For better understanding of the entire process, it is best to tour the facility in order of production, starting from raw materials and following to the finished product.

Throughout the inspection, the inspector needs to locate all sources or potential sources of wastewater discharge. Sources may range from those that are easily identified such as a running water rinse from a plating bath to those more difficult to identify such as a discharge from a wet air scrubber. A description of each discharge should be obtained. This information should include whether the discharge is batch or continuous, the amount of discharge, pollutants potentially in the discharge, and frequency of each discharge. The inspector also needs to identify the destination of all wastewater generated and all discharge points. Some wastewater may be discharged directly to a receiving stream while some may be discharged to the sanitary sewer with or without first going to a pretreatment system.

If possible, all wastewater flows should be measured or information on wastewater flows from each process should be requested from facility representative. All recirculating systems such as air conditioners should be noted and it should be determined if these systems ever discharge. Evaporation, use in products, and washwater should be accounted for. Washdown of vessels and process areas can be a significant source of wastewater. It should be determined if any batch discharges occur. Reactors, plating tanks, and process tanks are often periodically discharged. The amounts and chemical nature and frequency of discharge, and treatment and disposal should be noted.

The inspector should also gather information on the flow of incoming water to the facility. With information on incoming water flow and wastewater generation and flow, the inspector may be able to calculate a rough flow balance. A flow balance compares the incoming water flow to the total outgoing wastewater flow to ensure all water use at the facility is accounted for. If the flow balance indicates discrepancies in flow volumes between the incoming water and outgoing wastewater, the inspector should discuss them with the facility representatives. Causes of the discrepancies may include evaporation or water that is used but not discharged such as water contained in the product used in a recirculating cooling system.

All industrial processes, raw materials, and finished products should be evaluated to determine pollutants being used or generated. For example, at a facility performing electroplating, quantities and types of plating and associated chemicals used, frequency of disposal and treatment and/or disposal methods should be noted.

Throughout the entire inspection process, inspectors should attempt to identify areas in which the industry can decrease its use of chemicals and reduce the amount and pollutant concentration of its discharges through pollution reduction technologies.

The inspector should require schematics of the facility from the industry before the first inspection. A schematic of the facility that shows the processes, their wastewater discharges, flow through the treatment system, and discharges points. A description and process flow diagram for each major product line should also be provided. Then, throughout the inspection, these schematics should be checked by the inspector to make sure these are accurate.

The quantities and types of raw materials, finished products, and wastes stored at the facility should be noted. The inspector should evaluate storage areas to determine the potential for spills to occur and to enter the sanitary sewer. The proximity of floor drains to any area where pollutants are stored or handled such as storage and processing areas should be determined.

If floor drains are present, the inspector should determine whether or not the floor drains are used. The condition of a floor drain may indicate whether or not it is used.

For example, the floor drain may be corroded, indicating that corrosive materials have been discharged. Floor drains that are permanently capped or welded shut are preferable to just being plugged since these can be removed. In cases where the floor drains are capped or plugged, but not welded, the inspector should inspect the floor drain for evidence that the cap or plug is simply removed when the facility wants to discharge material. The inspector should also determine where the floor drains flow. For example, some floor drains may flow to the wastewater treatment system while others may discharge directly to the sanitary sewer.

Spill containment structures such as berms and dikes should also be evaluated to determine if they are adequate to contain spills.

Inspectors should inquire as to the cleanup and disposal procedures the facility would follow in the event of a spill. The industry should have a spill plan on file at the facility. The inspector should evaluate the potential for a spill to enter the sanitary sewer when the facility's procedures are followed.

The wastewater treatment system should also be inspected to ensure that it is properly maintained and is in good working condition. Treatment systems may consist of physical, chemical, or biological processes that are used to remove or treat pollutants prior to discharging wastewater. Wastewater treatment can range from a simple oil and grease separator to a complex chemical system designed to remove metals. The inspector should note the type of treatment used, any associated chemicals used, and any circumstances under which the treatment system would be shut down or bypassed.

Information should also be obtained on any sludges or residuals generated during the wastewater treatment process and methods by which these sludges and residuals are disposed.

Operation and maintenance procedures implemented in the treatment system should be discussed and appropriate documentation should be reviewed. For example, if the facility continuously monitors pH, the pH logs should be reviewed and the inspector should determine the frequency at which the pH probe is calibrated, ink is added, or the paper is changed. In addition, the inspector should verify that adequately trained staff are available to properly operate and maintain the wastewater treatment system. It is also helpful to develop a diagram detailing the treatment process.

Many industrial processes such as cleaning, degreasing, grinding, and chemical wastewater pretreatment produce a sludge or other waste that must be disposed of. For instance, vapor degreasing often produces a sludge as well as spent solvent waste that must be disposed of. The inspector should determine the waste generation rates, how often disposal occurs, and the method of disposal.

If sampling is to be conducted at the facility, the inspector may want to identify an appropriate sampling location during the inspection.

The inspector should review any records the facility may have compiled that relate to its discharges. These records may include analytical results of its wastewater discharge, flow records, and treatment system operation and maintenance records.

Although general inspection procedures have been outlined in this presentation, questions to ask facility representatives and necessary information to gather depends on the type of facility being inspected. Checklists that detail questions for general industrial inspections as well as questions for specific types of industries are included as part of the handout. It may be useful to review these questions and take a copy of the checklist into the field. For example, specific information to obtain during inspection of a facility performing electroplating may include the following:

- Chemicals used in plating and cleaning baths (including cyanide)

- Volume of plating and cleaning baths

- Frequency at which plating and cleaning baths are changed

- Treatment and disposal methods of spent baths

- Description of all wastewater generated and methods of treatment and disposal

- Whether any floor drains are located in process or storage areas

- Whether any solvents or degreasers are used and, if so, methods of treating and disposing of spent solvents

- Whether any sludges are generated in plating baths, degreasing units, or wastewater treatment systems and, if so, how are they treated and disposed. The inspector should review any records or file with the industry showing how much sludge was generated and where it was disposed (onsite or offsite). If shipped offsite, the inspector should inquire as to the final destination. If these waste tracking records do not exist, the inspector may want the industry to start keeping records.

- Whether any air pollution control equipment uses water.

NOTE: The ventilation system above the plating tanks. The inspector should determine whether the collected vapors pass through a wet air scrubber.

Closing Conference

After conducting the facility inspection, the inspector should meet with facility representatives to ask for any further information or clarify any outstanding issues. The inspector should prepare a written summary of inspection findings. The inspector should also answer any of the facility's questions and allow the facility to respond to the inspection findings.

1.6 FOLLOW-UP ACTIVITIES

Follow-Up Activities

In order to ensure that the inspection is documented so that information can be readily retrieved for subsequent pretreatment program activities and to aid in any enforcement action necessary, an inspection report should be prepared. All inspection information including inspection notes, copies of file information, photographs, and other information should be carefully documented. Inspectors may also need to initiate or follow-up on any enforcement actions necessary based on the findings of the inspection.

CHAPTER 2

SAMPLING TECHNIQUES

2.1 PURPOSES FOR SAMPLING

Purposes for Sampling

Although inspections may indicate which pollutants are potentially in a facility's discharge, they cannot conclusively determine specific pollutant information. To determine the types and concentrations of pollutants in a facility's discharge, it is necessary to perform sampling. This specific pollutant information can then be used to identify which pollutants in a facility's discharge need to be reduced. Pollutant information can also be used to determine the significance of a particular pollutant in the discharge so that necessary monitoring frequencies can be determined. Sampling also provides a means to determine a facility's compliance with its discharge limits and as a basis for supporting enforcement actions. Finally, if a facility performs self-monitoring, sampling can be performed to verify the accuracy of that self-monitoring.

2.2 SAMPLING PROCEDURES

Preparation and Implementation of Sampling Procedures

It is important to be adequately prepared prior to going onsite so that all the equipment needed to perform the sampling is available and that personnel are properly prepared for the types of sampling required. Therefore, general sampling procedures should be developed and followed when sampling at all facilities. Sampling procedures should include designation of sample types, volumes, containers, and preservation methods to be used for each pollutant parameter as well as sample identification and documentation procedures. Although these general procedures apply to all facilities, specific information on each facility should also be developed. This information may include pollutant parameters to be sampled, sampling location, and safety concerns. Obtaining this information prior to the sampling trip will allow the sampler to bring the proper equipment, know where to sample and what pollutants to sample for, and be familiar with necessary safety precautions.

Coordination with Analytical Laboratory

The samplers should coordinate their sampling activities with the laboratory that will be performing the analyses. The laboratory can provide information on the types and volume of samples needed for particular pollutant parameters, sample preservation methods and holding times, and shipping instructions. Laboratories may also provide sampling equipment such as samplers, pH meters, sample containers, chain-of-custody forms, sample labels, tags, and seals.

Preparation of Sampling and Safety Equipment

Prior to the sampling trip, any required sampling and safety equipment should be assembled, cleaned, and checked to ensure that it is in proper working order. All necessary paperwork should also be prepared prior to the trip. This may include assembling and marking, as possible, the required sample container labels or tags, chain-of-custody forms, and lab request sheets. Sampling and field analytical equipment such as pH meters should be calibrated.

When conducting sampling, samplers need to be aware of health and safety hazards and take the proper precautions. Safety requirements can be gathered from file information, personnel that have previously sampled the facility, or by contacting the facility. Samplers need to be properly clothed and have adequate safety equipment available.

Samplers should not enter confined spaces unless they are properly trained and have the proper equipment such as rescue equipment and respirators. Confined spaces should never be entered unless first tested for sufficient oxygen and lack of toxic and explosive gases. Two persons should be present, one to enter the confined space and one to be outside of the confined space. The person entering the confined space should wear a safety harness that is attached to a retrieval system. Use of this type of system will allow the rescue of the person in the confined space without requiring anyone else to enter.

Sampling

Location

Samples should be collected from a location that is representative of the facility's discharge. If the facility has more than one discharge point it may be necessary to collect samples from several locations in order to adequately characterize the facility's entire discharge. Convenience, accessibility, and safety should also be considered when selecting a sampling site. Appropriate sampling sites may include manholes as shown here. Other appropriate sites may be a process tank.

Samples should be collected from the center of flow with the container facing upstream to avoid contamination. Samples should be collected in areas that are turbulent and well mixed and where the chance of solids settling is minimal. When sampling, the surface of the wastewater should not be skimmed nor should the channel bottom be dragged. Samples should not be collected from stagnant areas containing immiscible liquids or suspended solids.

Sample Types

There are two basic types of samples: grab and composite samples.

Grab samples are individual samples collected over a period of time not exceeding 15 minutes and represent wastestream conditions only at the time the sample is collected. Grab samples are usually taken manually but can be collected using an automatic sampler. Grab samples may be appropriate for batch discharges, constant waste conditions, to screen the discharge to see if particular pollutants are present, or if extreme conditions such as high pH are characteristic of the discharge. In addition, grab samples should be collected for pollutants that tend to change or decompose during the compositing period such as pH, cyanide, total phenols, and volatile organics. In addition, grab samples should be collected for oil and grease samples since the oil and grease tends to adhere to sampling equipment.

Composite samples are collected over time (either by continuous sampling or by combining individual grab samples) and reflect the average characteristics of wastewater during the sampling period. Composite samples are either flow proportional or time composited:

- In *flow proportional* sampling, the volume of sample collected is proportional to waste flow at the time of sampling. Flow proportional samples can be obtained by collecting various sample volumes at equal time intervals in proportion to flow or by collecting a constant sample volume per unit of wastewater flow.

- *Time composite* samples consist of constant volume sample aliquots collected in one container at equal time intervals. For example, 500 milliliters of sample collected every 15 minutes over a 24-hour period.

Composite samples may be needed to determine the average characteristics of wastestreams, particularly if the wastestream has a highly variable pollutant concentration or flow rate. Composite samples should be collected during the entire period the facility is operating and discharging. For example, if the facility has processes that discharge 16 hours a day, samples should be collected during the entire 16-hour period.

Sampling Equipment

Both grab and composite samples can either be collected manually or with automatic samplers. However, it is not recommended that automatic samplers be used to collect samples for certain pollutants such as oil and grease and volatile organics since oil and grease may adhere to the sides of the sampler tubing and air may be introduced into volatile organic samples.

Sample Volumes

Sample volumes needed for analyses depend on the type and number of analyses to be performed. The sampler should contact the person or laboratory that will be performing the analyses to determine sample volumes needed for a particular sampling event. Adequate sample volume should also be collected to allow for QA/QC and for spillage.

Sample Containers

Sample containers should be made of chemically resistant materials that will not affect the nature or concentration of pollutants being measured. Containers must be large enough to hold the required sample volume. Glass containers should be used for oil and grease, phenol, and organics samples. Amber glass sample containers should be used for pollutants such as iron cyanide that oxidize when exposed to sunlight. Containers with teflon lined lids should be used when collecting volatile organics. Plastic is easier to handle and is less likely to break, so it may be the best type of container to use when glass is not needed. Sample containers should be properly cleaned prior to use. The laboratory that will be performing the sample analyses should be contacted for specific cleaning instructions. Some laboratories may provide pre-cleaned sample containers.

Sample Preservation and Holding Times

Many pollutants are unstable and may alter in composition prior to analysis. Therefore, to ensure that samples remain representative, they should be analyzed as soon as possible after collection. If immediate analysis is not possible, samples should be preserved to minimize the changes in pollutant concentrations between collection and analysis. There are three basic types of preservation: cooling, pH adjustment, and chemical fixation. Cooling is accomplished by chilling samples to 4°C by either refrigeration or by placing on ice. Cooling suppresses biological activity and volatilization of gases and organic substances.

If composite samples are collected, the samples should be cooled to 4°C throughout the compositing period. Samples should also be kept cool during transport to the analytical laboratory.

Even with proper preservation, samples should be analyzed within certain recommended holding times. These holding times are the maximum times allowed between the time the sample is collected and when it is analyzed. If composite samples are collected, the holding time limitations begin when the last aliquot is added to the sample. Performing sample analyses within the allowable holding times helps ensure that the analytical results are valid and representative of the wastewater. Certain pollutant parameters such as pH have no standard method of preservation and should be analyzed immediately.

CHAPTER 3

WASTEWATER TREATMENT TECHNOLOGIES

3.1 INTRODUCTION

It is helpful to understand the types of wastes generated in various industrial categories and common waste treatment and reduction techniques. The following discussion will provide a brief description of some of the most common types of waste treatment.

3.2 TYPES OF WASTEWATER TREATMENT

Classification of Treatment Techniques

Wastewater treatment technologies can be grouped by type of treatment into four classifications:

Physical treatment technologies modify the physical structure of the wastewater and its pollutants or separate the wastewater into various components. Physical treatment does not change the chemical structure of the wastewater pollutants. Physical treatment is useful for separating hazardous and non-hazardous components of a wastestream, separating a wastestream into various components for different treatment operations, conditioning a wastestream for further treatment, and removing solid particles or objects. The most common physical treatment processes include; equalization, screening, sedimentation, flotation, filtration, adsorption, ultrafiltration, and stripping.

Chemical treatment technologies modify the chemical structure of the wastewater pollutants to aid removal of these pollutants from the wastewater. Chemical treatment technologies are usually relatively easy, but generate a solid sludge that must be managed and disposed. The most common chemical treatment processes include neutralization, precipitation, oxidation/reduction, and dechlorination.

Biological treatment technologies degrade organic components of the wastewater using microorganisms. These organics may be decomposed into water and methane, other less toxic simpler organics, or microbial matter. Toxic chemicals can inhibit biological treatment systems by killing the microorganisms. Also, high concentrations of inorganics and high temperatures can inhibit biological treatment. Also of concern, nitrogen and phosphorus are needed for biological activity to occur and are often not present in industrial wastewater. The most common biological treatment processes include stabilization, activated sludge, trickling filters, anaerobic digestion, and aerated lagoons.

Thermal treatment processes achieve significant reductions in waste volumes and achieve a high degree of destruction of organics. Unfortunately, thermal treatment often generates hazardous air emissions that must be controlled. The most common thermal treatment technologies include incineration and evaporation.

Probably the most appropriate way to discuss treatment technologies is in terms of the nature of pollutants to be removed (i.e., metals, organics, oil and grease, etc.). A brief discussion of various accepted treatment technologies for removing these pollutants follows; with a discussion of some treatment practices common to all types of wastewater treatment presented first.

3.3 FLOW EQUALIZATION

Flow Equalization

Combining wastewater flows to dampen fluctuations in flow rates and pollutant concentrations prior to further treatment or prior to discharge (i.e., equalization) provides an extremely valuable performance specification. Equalization typically occurs in tanks or basins that often contain a large capacity to handle wastewaters for an extended period of time. Often variable flowrates and pollutant concentrations can reduce treatment efficiency. For example, equalization before chemical treatment reduces the variability of flow, thereby reducing the necessary process controls, minimizing the likelihood of over-or under-feeding of the treatment chemicals. Equalization is useful for preventing slug loads from inhibiting further treatment processes or for preventing excessive concentrations in the treatment system effluent. Equalization can also act as neutralization where both acidic and basic wastes are combined.

Another technique for equalizing wastewaters is to hold high concentration wastes in a separate tank or basin and then bleed this waste into the more dilute waste stream over a period of time to minimize the impact.

3.4 TYPICAL TREATMENT FOR METAL FINISHING WASTEWATER

Chemical Treatment

Metal finishing/plating/printed circuit board manufacturing facilities are one type of facilities that most often use chemical treatment technology. Typically, these facilities will require four types of chemical treatment for pollutant removal; neutralization, hexavalent chromium reduction, cyanide destruction, and chemical precipitation. A discussion of these treatment technologies follows.

Neutral-ization/pH Control

Biological treatment operates most effectively at a pH of 7. Variations in pH can have a significant impact on the treatment efficiency of biological systems including total inhibition of microbial activity. Another reason for pH control is for treatment performance optimization. This is especially true for treatment to remove metals. Therefore, pH control is a crucial component in wastewater treatment.

A pH control system typically comes in one of three forms, continuous uncontrolled, batch controlled, and continuous controlled.

The simplest form is a continuous uncontrolled system that consists of running acidic wastewater through a bed of limestone chips.

Another method is to batch treat a wastewater, whereby the pH is taken, acid or base is added, the pH is reanalyzed, and the process continues until the desired pH is achieved. At that point, the wastewater can be discharged to the sewer or to additional treatment, if necessary.

The most advanced method of pH control is a continuous system where pH sensors are used to measure the pH and to add the necessary treatment chemicals. In a continuous system, a pH sensor determines the pH and signals a pump to add neutralizing chemical, and the wastewater is mixed to provide homogeneous chemical addition. More complex systems have multiple pH sensors and multiple chemical addition points to further refine chemical addition to obtain more constant pH values. Electrode maintenance is a must for proper operation of the system as the electrodes are prone to fouling, especially in extremely corrosive wastewaters.

Chromium

Reduction

Chromium is one of the most common plating metals. Wastewaters containing hexavalent chromium are generated from chromium electroplating, chromate conversion coating, etching with chromic acid, and metal finishing on chromium metal. Hexavalent chromium (i.e., Cr^{+6}) is the soluble ion most commonly used in the plating bath and is much more toxic than the trivalent form (i.e., Cr^{+3}). Hexavalent chromium, which includes chromic acid (H_2CrO_4), chromium trioxide (CrO_3) and chromates, must be reduced to the trivalent state to allow for chemical precipitation. Some manufacturers will use a trivalent form of chromium, such as chromium trichloride ($CrCl_3$) or chromium sulfate ($Cr_2(SO_4)_3$), in the process baths although these chemicals are more expensive to use and may not provide desirable qualities on the finished product that are achieved with hexavalent chromium. Once the chromium has been reduced to its trivalent state, it can be subjected to chemical precipitation to remove the chromium and any other toxic metals.

Reduction is typically done using gaseous sulfur dioxide or sodium bisulfite. Because the reaction proceeds much faster at low pH, the reduction should be performed at a pH of 2-3. The closer this reaction is to a pH of 3, the less sulfur dioxide will be released.

Iron or iron salts may also be used to reduce the hexavalent chromium to its trivalent state. A third, patented process, uses small pieces of scrap steel, adjusting the pH of the influent to a pH of 2.0-2.2, and then flowing the wastewater through the steel scraps.

Chromium reduction is a proven technology that is easy to use and well suited to automation. Reduction efficiencies of over 99.5 percent are easily achieved with concentrations of 0.05 mg/l readily attained. [Development Document for Effluent Limitations Guidelines and Standards for the Metal Finishing Point Source Category, June 1983] Chromium reduction equipment is very simple and should include: a separate wastewater collection system for wastewater that contains hexavalent chromium only (as chemical interference is possible if mixed metal wastes are subjected to the chromium reduction process), metering equipment, contact tanks with agitation, and pH and oxidation-reduction potential (ORP) instrumentation.

Cyanide Destruction

Cyanide may be used as a cleaning agent and a complexing agent in zinc, cadmium, silver, copper and other plating baths. Cyanide can be destroyed through oxidation techniques. Chlorine (elemental or hypochlorite) is the most common oxidation chemical used to destroy cyanide. Chlorine gas treatment is about half the cost of sodium hypochlorite treatment, but chlorine gas is dangerous to handle and should be accounted for when evaluating options.

The alkaline chlorination reaction, by far the most common cyanide destruction method, is a two step process and proceeds as follows:

1) $Cl_2 + NaCN + 2NaOH = NaCNO + 2NaCl + H_2O$
2) $3Cl_2 + 6NaOH + 2NaCNO = 2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

The destruction typically occurs in two tanks. In the first tank, the system is monitored to maintain a pH of 9.5-11 with an oxidation-reduction potential of 300-400 millivolts. This is where the cyanide is oxidized to cyanates. This is also where the metal complex is broken, thus allowing some of the metals to precipitate. In the second tank, the desirable pH is 8.0-8.5 with an oxidation-reduction potential of 600-800 millivolts.

Since cyanide is destroyed in the first stage reaction, many facilities have eliminated the second stage since this second stage is costly and poses a dangerous reaction situation (hydrogen cyanide gas generation) if the first stage is not adequately controlled.

Alkaline chlorination of cyanide wastes is a proven technology with destruction efficiencies of over 99 percent and effluent concentrations below detection readily available.

Very simple equipment is needed for cyanide destruction including a separate collection system for cyanide bearing wastewaters, contact vessels with agitation, chemical metering, and pH and ORP instrumentation.

Chemical Precipitation

The most common pretreatment technology for pollutant removal is chemical precipitation. Chemical precipitation is used to reduce the concentration of metals in wastewater to levels below concern.

Chemical precipitation is a three step process consisting of coagulation, flocculation, and sedimentation. Through chemical addition, the interparticulate forces in the contaminants are reduced or eliminated thus allowing interaction of particles through molecular motion and physical mixing.

Rapid mixing allows for dispersion of the treatment chemical throughout the wastewater and promotes collisions of particles. Collision of these particles causes the particles to aggregate and form larger particles, which is known as coagulation. The chemicals added to promote this aggregation, known as coagulants, serve two basic purposes: (1) to destabilize the particles, thus allowing for interaction, and (2) to promote aggregation of particles through floc strengthening.

Alum (i.e., aluminum sulfate) and lime (calcium oxide) are the two most common coagulants used in the U.S. although organic polymer coagulants (i.e., long-chain, water-soluble polymers) have gained widespread acceptance. Ferric compounds also are used as coagulants although these compounds are corrosive and difficult to dissolve in water. [Water Treatment Principles and Design, James Montgomery Consulting Engineers, 1985.]

After a rapid mix period, mixing must be slowed to allow for formation of larger flocs. (At higher mix rates, the aggregate floc will continue to be destroyed through excessive physical contact.) This process is known as flocculation. Because of the size of the particles, some mixing is required to cause contact between solid masses and to promote larger floc formations that will settle rapidly.

During precipitation, the solids are separated from the liquid, usually by settling. This should result in two distinct layers, one solid and one liquid that can be readily separated.

Typically, coagulation equipment consists of tanks with rotating impellers for rapid mixing, but in-line blenders and pumps or baffles may be used. Flocculation equipment consists of tanks with paddle type mixers for slow agitation and flocculation. Sedimentation equipment usually consists of a clarifier unit which has inclined plates (lamella separator) or tubes. These units operate by gravity, require little space, and have minimal installation and maintenance costs.

3.5 OTHER TREATMENTS FOR METALS REMOVAL

Ion Exchange

In the ion exchange process, wastewater is passed through a container of anionic or cationic resin particles. As the solution passes through the resin bed, there is an exchange of innocuous ions (e.g., H^+ or OH^-) from the resin for the undesirable similarly charged ions (e.g., Cu^{2+} or CN^-) dissolved in the solution. Each resin has a distinct number of ion sites that determines the maximum number of exchanges per unit of resin. As the resin exchanges ions, it will reach a state in which it has adsorbed its capacity of ions. The resin must then undergo regeneration during which the resin will be backwashed. The regeneration process results in a small volume of backwash solution which has a very high concentration of the removed ions.

Ion exchange units may be a batch tank, but are normally an enclosed pressurized column. The process may be operated as a single unit, in parallel, or in series.

The resin used in a column is selected for the constituents to be removed. Resins can be broadly classified as strong or weak acid cation resins or as strong or weak base anion resins. Strong acid and base resins operate independently of pH, while the operation of weak acid and base resins depends on the pH. Chelating cations may also be used, but are expensive.

As described above, typical ion exchange systems consist of one or more columns operated in a continuous mode, with separate columns included for each type of resin. Multiple columns of the same resin are used to prevent pass through of pollutants into the effluent after breakthrough has occurred. Additionally, duplicate systems are often employed to allow a flow to be diverted to a second unit during regeneration of the columns.

Reverse Osmosis

Osmosis is the spontaneous flow of water from a dilute solution through a semipermeable membrane to a more concentrated solution. Reverse osmosis includes the application of pressure to overcome osmotic pressure and force the flow of water through the membrane toward the more dilute solution. This increases the concentration of pollutants in the wastewater, but reduces the volume of contaminated water. Ions and small molecules can be separated using this technology.

Reverse osmosis units are sensitive to the environment and must be carefully checked for chemical attack, fouling, and plugging. Maintaining a pH of 4 to 7.5 will help to minimize fouling and plugging. Reverse osmosis is not effective for highly organic wastes as the organic materials act to dissolve the membrane. Oxidizing agents, such as iron and manganese, particulates, and oil and grease must be removed prior to reverse osmosis. Biological growth on the membrane (which is promoted at low organic concentrations) can also reduce unit efficiency, although addition of chlorine or other biocides can eliminate this fouling. Operating reverse osmosis units in series can improve the handling of variable flowrates and pollutant concentrations.

3.6 ORGANICS TREATMENT

Organics Treatment

Wastewater treatment to remove organic compounds has historically been through biological degradation (i.e., the breakdown of compounds through microbial digestion). While this method is quite effective for domestic type wastes, biological treatment of industrial wastes containing organic chemicals is not always as effective. Reasons for this ineffectiveness include; certain organic compounds may be toxic to the microorganisms thereby inhibiting the degradation activity, not all materials are biologically degraded, and it is often difficult to treat down to the necessary concentrations. As such, several techniques common to organic chemical production have been further developed as wastewater treatment technologies.

The treatment technologies found to be the most effective at reducing the concentration of organic pollutants in wastewater and used regularly in the treatment of organics include:

- Carbon adsorption
- Air stripping
- Steam stripping

Carbon

Adsorption
First, definition of the term "adsorption" is helpful when understanding the concept of carbon treatment. Commonly, this term is confused with "absorption." Adsorption is the taking up of a liquid, gas, or dissolved solids onto the surface of a solid or liquid. Absorption is the taking up of a liquid, gas, or dissolved solids into the molecular structure of the solid or liquid. The basis for carbon adsorption is the high surface area per weight on the activated carbon due to a very high porosity and the natural affinity of a liquid (or gas) to be attracted to and held on the surface of a solid. Surface areas of 100 m^2/g are common.

Carbon adsorption is typically the most effective technology for removing dilute concentrations of organic compounds from wastewater. Often it is used as a final polishing step prior to discharge. Carbon is widely used in the U.S. for drinking water treatment.

Two types of activated carbon application are used for wastewater treatment, granular and powdered. Granular carbon typically is contained in packed columns, with the wastewater flowing either up or down through the carbon packing.

Typically, carbon columns are operated in series, with two or more columns. This ensures that as the first column reaches its capacity and the effluent from this column becomes more contaminated, the second column can treat this contamination and prevent contaminated discharges to the municipal treatment plant. New carbon can then be added to the first column, the second column can become the first column while the old first column is being refilled, and the old first carbon column can now become the second column in series. A similar approach can be taken for more than two columns as well.

Powdered activated carbon is added to water to form a slurry and then introduced into the wastewater. This wastewater and carbon mixture is then agitated to increase contact between the carbon and contaminants, and then allowed to settle in a quiescent state. The treated wastewater can then be pumped off the top with the carbon sludge hauled off for disposal or regeneration.

Air Stripping
Air stripping defines the practice of removing volatile contaminants from wastewater by contacting the wastewater with a steady stream of air through a packed column (typically countercurrently). The air (which now contains the contaminants from the wastewater) can then be released to the atmosphere or preferably recovered or further treated using carbon adsorption, incineration, or open flame.

In a packed column, air is drawn up through the column with fans and the water trickles down the column. Packing materials, such as berl saddles or raschig rings, provide more surface area to promote mass transfer between the air and wastewater.

The benefits of air stripping columns are that they take up little space, operate in a continuous mode, and are inexpensive to operate. Energy costs comprise the sole operating cost.

Air stripping is a common practice for treatment of contaminated groundwater. Here, the water is pumped out of the ground and treated.

Steam
Stripping

Steam stripping operates similar to air stripping except that steam is introduced rather than air, thereby heating the water and improving the transfer of contaminants. This is similar to distillation of volatiles from the wastewater. One method to improve the efficiency of a steam stripper is to condense a portion of the vapor leaving the top of the column and return it to the column as a liquid. In the U.S., where organic chemical plants use stripping technology for wastewater, over 90 percent use steam stripping rather than air stripping. Halogenated aliphatics (e.g., methylene chloride, chloroform, and vinyl chloride) are very conducive to steam stripping technology.

For volatile pollutants, over 99-percent removal is common. Steam stripping is more effective than air stripping although considerably more expensive (because of energy costs).

3.7 OIL REMOVAL

Oil Removal

Many types of industrial facilities generate wastewater containing oil and grease, the concentration of which can vary drastically. For example, a textile manufacturer may generate wastewater with 10-50 mg/l of oil and grease; a food processor between 100-1,000 mg/l; a commercial laundry between 100-2,000 mg/l; and a metal fabricator between 10,000-150,000 mg/l. [Toledo Division of Continuing Education.]

To discuss oil and grease removal, the three types of oil and grease must first be identified. These include free oils (which rise to the surface and can be skimmed off), emulsified oils (which must have the emulsion broken before removal), and dissolved oils (which require biological treatment or more sophisticated treatment techniques for removal).

The simplest form of oil removal is gravity separation. Oil-containing wastewater is held in a quiescent state, where the free oil being lighter than water, will float to the top and can be skimmed or pumped off. Rotating belts are often used to remove the oil from the surface. Solids that settle to the bottom can also be removed.

Emulsion breaking is necessary to remove oils where the oils are present as an emulsion (e.g., coolants applied directly to metal components or metal fabricating equipment during operation). (Emulsified oils are often called "soluble oils" as the oil appears to be dissolved in water; however, the oils are actually present as tiny droplets suspended in water.) Typically, emulsions are broken by pH adjustment or chemical addition. Polyelectrolytes have come to be the treatment method of choice for emulsion breaking because of the wide selection of chemicals available and the limited volume of sludge produced (versus the older method of choice of lime or alum addition).

After breaking the oil emulsion, the oil can be removed using air flotation techniques; either dissolved air flotation or induced air flotation. In dissolved air flotation, the wastewater is pressurized in the presence of air, thereby dissolving the air in the water. When the water is discharged from the pressure line into an open tank, small air bubbles form which carry the free oil and suspended solids to the surface where they can be removed with skimming apparatus. Induced air flotation consists of introducing fine bubbles underneath a liquid and as the air rises, the bubbles collect the oils and suspended solids lifting them to the surface where they can be removed. (Air bubbles in induced air systems are an order of magnitude larger than in dissolved air systems.)

Recently, ultrafiltration techniques have been used to remove oil from wastewater. In ultrafiltration, the wastewater is pumped past a membrane where the water and other dissolved substances flow through the membrane. The large emulsified oil molecules are retained. Subsequent passes through an ultrafiltration unit can further purify the contaminant oil. Reductions in volume by 95-97 percent are achievable through ultrafiltration.

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CHAPTER 4

POLLUTION PREVENTION TECHNIQUES

4.1 INTRODUCTION

Introduction
Pollution prevention techniques are considered to fall under the first two tiers of the waste management hierarchy, that being, source reduction and recycling. As described previously, pollution prevention techniques under these two categories can be grouped into eight classifications. To better understand the impacts of these eight types of pollution prevention techniques, specific methods to reduce wastewater pollution in the electroplating/metal finishing industry are presented and discussed in detail.

4.2 PROCESS CHANGES

Process Changes
The greatest number of pollution prevention techniques in the electroplating/metal finishing industry can be classified as process changes. As mentioned above, process changes may affect either procedures or equipment and influence the quantity or toxicity of wastes generated.

Considering how a metal part is electroplated, in an ideal situation, all the water would drain off the workpiece as it is removed from the plating bath, negating the need for rinsing. However, it is clear that this is not the case and that even in the best of situations, a small amount of plating bath remains on the workpiece and must be removed to stop any further chemical action by this solution. This phenomenon leads to the first and often the most opportunistic area for pollution prevention at a plating facility: dragout. Dragout is the plating term for the plating solution that is carried out of the plating bath as the workpiece is removed from the bath. Minimizing the carryover of this dragout into subsequent rinse tanks can drastically reduce wastewater flow rates and pollutant loads, thereby reducing both the amount of raw materials that must be purchased and the cost of pollution control.

Plating Bath

The first area to consider for dragout reduction is the plating bath. Several modifications to the plating solution makeup can impact the amount of dragout. The most common techniques include:

- Increase the temperature of the bath, thereby reducing the surface tension and viscosity of the bath (promoting quicker drainage of the plating solution)

- Decrease the concentration of metals in the plating bath such that a more dilute solution is being carried over into the rinse tanks

- Add wetting agents/surfactants to the bath to reduce the surface tension (again promoting quicker drainage).

Plating Techniques

Even if the plating bath is adjusted as described above, dragout can still be a major source of wastewater pollutants if improper plating techniques are used. When plating, workpieces are either hung on a rack or loaded into a barrel (for small parts) and then submerged into the plating tank. After a specified period of time, the parts are lifted out of the bath and transferred to a rinse tank where the residual plating solution is cleansed off the parts. Techniques that can minimize carrying over dragout from the plating tank to the rinse tank include:

- Design plating racks that do not have cups or pockets that could possibly carry plating solution over into a rinse tank.

- Design racks that hold the workpieces in an optimum configuration to minimize dragout (i.e., the part should be at an angle with the smallest surface area the last to leave the plating bath). For example, if plating an axle, the axle should be removed from the bath near vertical rather than horizontal.

- Inspect racks regularly for worn insulation or corrosion that could form pockets for plating solution.

- Withdraw parts from the plating bath slowly and allow to drain over plating tank for at least 10 seconds.

- Install air knives over plating solution that drives the plating solution off the workpiece and back into the plating tank as the part is withdrawn from the plating bath.

- Install a fine mist spray (fog spray) over the plating bath to spray the plating solution off the workpiece and back into the tank. However, the flowrate of the spray cannot exceed the evaporation rate of the plating solution.

- Agitate the workpiece or barrel after it is removed from the plating bath, thus promoting drainage back into the tank.

- Install drain boards and drip guards between the plating tank and subsequent rinse tanks to catch any residual drainage and return this solution back into the plating tank.

Rinsing Techniques

When designing the rinse system, several configurations are recommended, including:

- Use a static rinse (often called a dragout tank or dead rinse) as the first rinse to cleanse off the most concentrated plating solution. After a period of time, the concentration of plating solution in this tank will increase to the point where it can either be fed directly back into the plating tank or can be purified using techniques such as evaporation or reverse osmosis and then fed back into the plating tank.

- Add air or mechanical agitation to the rinse tank and all subsequent rinse tanks to promote complete rinsing (this is especially important for complex workpieces with a lot of angles and crevices).

- Install rinsewater control hardware such as flow control meters, flow restrictors, foot-controlled spray nozzles, and photosensors (which turn on the rinsewater as the plated parts pass through the line of sight of the photosensor) to minimize and control rinsewater usage

- Use high-pressure spray rinses for effective cleansing with a minimal amount of water.

- Allow an adequate amount of time in the rinse tank to promote good rinsing (for rinsing simple parts in well agitated tanks, 5-10 seconds may be enough time, but, for complex parts in a poorly agitated rinse tank, 10 minutes may not even be enough time).

- Use multiple countercurrent rinse tanks.

Extending Plating Bath Life

In addition to dragout control, several techniques can be used to minimize contamination of the plating bath as well as any precleaning baths (e.g., acids or alkaline cleaners), thereby extending the useful life of the bath while at the same time promoting recovery/recycling techniques. These methods include:

- Preclean parts using mechanical methods, such as wiping, squeegeeing, or shot blasting

- Minimize dust and dirt in the plating room

- Cover plating bath to minimize contamination

- Replenish baths rather than batch dumping and replacing

- Reduce dragging of pre-plating solutions (e.g., acids or alkaline cleaners)

- Install a continuous filtering system on the bath to remove impurities

- Remove anodes from the plating tank when not in use.

Use of the process changes described above can save the plating shop a lot of time and money without changing the physicochemical process.

4.3 MATERIAL SUBSTITUTION

Material Substitution

The second pollution prevention category, material substitution, takes electroplating modification one step further. In this case, a plating facility may choose to modify the raw materials used at the facility to minimize pollution. These modifications may include:

- Use deionized water in the plating bath and dragout tank (i.e., the tank that will eventually be recycled back into the plating tank) to remove contaminants that will build up over time and contaminate the bath.

- Use high-purity raw materials (i.e., anodes, plating chemicals, acids, etc.) that will minimize contamination.

- Change to a non-cyanide plating bath (e.g., pyrophosphate copper, acid sulfate cadmium, or zinc chloride) to eliminate the use of toxic and hazardous cyanide.

- Use non-chelated chemicals (i.e., chemicals that do not form organic/inorganic complexes with the toxic metals, thereby inhibiting metal removal using conventional treatment technologies).

- Use aqueous cleaners rather than organic solvents to remove dirt and oil.

- Reuse spent acids and bases in other areas where purity is not as vital (e.g., similar to countercurrent plating baths, countercurrent acid rinses can minimize acid and water use)

- Use treatment chemicals that minimize sludge generation (e.g., magnesium hydroxide rather than lime or caustic).

4.4 MATERIAL INVENTORY AND STORAGE

Material Inventory and Storage

The process of electroplating requires the use of a wide variety of raw materials, from plating chemicals, to acid/alkaline cleaners, organic solvents, and wastewater treatment chemicals. Proper inventory and storage of these materials can minimize pollutant loadings to the environment. Considerations include:

Material Inventory

- Use raw materials before the shelf life or expiration date (use the first-in, first-out practice)

- Buy an appropriate amount of raw materials, only buying large amounts of materials with an unlimited shelf life (e.g., metal prices fluctuate regularly and the quantity and time of purchase is often highly dependent on the current price)

- Purchase raw materials from suppliers that will buy back chemicals that are out-of-date.

Material Storage

- Divert storm water away from material storage (including covering raw materials, either inside or under roof, tarp, etc).

- Install spill containment around raw materials and do not store materials outside this containment (as is often done with one drum or a few bags of a chemical).

- Store raw materials as specified by the manufacturer (e.g., proper light, temperature, etc).

4.5 WASTE SEGREGATION

Waste Segregation

Segregation of wastes is important for two reasons: (1) regulations differ for different wastes and by segregating, costs can be minimized, and (2) treatment techniques often are more effectively performed on individual wastestreams rather than on the combined wastestream. However, oversegregation of wastes can also be a problem, causing greater environmental release potential, repetitive equipment costs, and more difficulty meeting environmental regulations. Therefore, segregation of wastes should be analyzed in detail before designing wastewater management systems and procedures. Factors that should be considered include:

- Segregating hazardous and non-hazardous wastes to keep waste management costs to a minimum.

- Using separate treatment systems for different metals to produce higher quality sludge, thereby increasing its likelihood of reuse.

- Keeping non-metallic and metallic wastes separate to eliminate unnecessary metals treatment of nonmetallic wastes.

- Keeping hexavalent chromium and cyanide wastes separate to minimize the flow to be reduced or oxidized.

4.6 GOOD HOUSEKEEPING/PREVENTATIVE MAINTENANCE/ EMPLOYEE EDUCATION

Good Housekeeping

Proper operation and implementation of the equipment and procedures assure pollutant loading reductions. Good housekeeping practices that should be employed in a plating shop include:

- Use a dry floor for the plating line, rather than an overflow system where water overflows the plating line tanks into a sump. (This stresses the importance of keeping the plating area clean and dry and inhibits sloppy water use practices.)

- Keep area clean and dry at all times (so that if leaks, spills, or overflows occur, the source of the problem can be easily identified and corrected).

Preventative Maintenance

As with any manufacturing operation, preventative maintenance is essential if a facility intends to operate for any length of time without fear of equipment failure or loss of product quality. In the plating shop, this type of situation can occur quickly if proper preventative maintenance is not performed. Activities should include:

- Install high-level alarms on tanks that could overflow and cause environmental or safety hazards

- Regularly check for leaks in tanks, valves, fittings, pumps, etc. and repair immediately

- Keep a supply of extra parts on hand for commonly replaced components

- Maintain plating racks in good condition to minimize dragout or poor electrical conductivity

- Calibrate conductivity, pH, and flow meters regularly

- Inspect workpieces prior to plating to eliminate rejects before processing through plating line.

Employee Education

One of the most critical components of pollution prevention in a plating shop (especially in a small shop where parts are manually transferred from tank to tank), is the need for employee education and training. Throughout the U.S., plating shops have been found to have excellent equipment and procedures in place to minimize pollution, but for one reason or another, the plating line operators prevented these pollutant reductions from actually occurring. Steps that can be taken to improve employee habits include:

- Provide regular training to employees on proper operating practices, including the economic benefit of following those procedures.

- Provide employee incentives for beneficial suggestions or for meeting certain pollution prevention goals (e.g., no noncompliance events while maintaining a low wastewater flowrate).

- Educate employees on water conservation. [Water use can be a significant concern since many plating line operators will increase rinse rates to speed up the process, irrespective of supervisor's instructions.]

- Post important information on equipment and procedures for employees to use as a reference (e.g., dragout times and a clock, contents and concentrations in all tanks, markings on valves as to the proper open position, spill cleanup procedures and equipment).

4.7 PRODUCT CHANGES

Product Changes

Similar to material substitution, the plating facility should consider product changes that can minimize pollution. For electroplaters, this could include:

- Replace toxic metals with non-toxic metals (e.g., replace cadmium with aluminum).

- Replace hexavalent chromium with trivalent chromium. [Note: most trivalent chromium formulations produce a duller plate than the shiny plate produced by hexavalent chromium, trivalent chromium is more expensive than hexavalent chromium, and, excluding decorative applications, the physical and chemical properties of the trivalent chromium may limit the applicability.]

- Redesign manufactured parts to minimize pockets and cups that can dragout plating solution (often this is done simply by designing a hole in the location of the cup or pocket)

- Evaluate the possibility of non-plated parts (e.g., powder coating).

Most often, product changes resulting from material substitutions must be evaluated in great detail to determine the saleability of the redesigned product. In some instances (e.g., putting holes in the legs of chrome plated chairs and tables to promote drainage during plating), the change likely will not effect the resale value of the part. Conversely, a plater may be able to use this redesign to its advantage by advertising the new chair as an environmentally-sensitive design.

4.8 WATER/ENERGY CONSERVATION

Water/ Energy Conservation

Water/energy conservation is often the result of one of the other seven pollution prevention classifications. However, several steps can be taken in the plating shop to further minimize energy and water consumption. This includes:

- Reuse deionized rinsewater in other areas of the plating shop where purity is not as important.

- Cover tanks when not in use to reduce heat loss and evaporative losses (e.g., the use of polypropylene balls, which float on the surface of the bath, reduce evaporation significantly).

- Recycle once-through cooling water for rinse water or makeup water for other baths (it is unlikely that this water is suitable for the plating bath or the stagnant rinse tank).

- Turn off rinse tanks when not in use (e.g., use of photosensors which automatically turn the water on and off as working pieces are rinsed).

- Use conductivity sensors and pH probes to control rinsewater quality, whereby freshwater is added only when the conductivity or pH approaches a certain unacceptable level.

4.9 RECYCLING

Recycling

1. Waste Exchange. One technique that has been increasing in popularity in the U.S. as the cost of pollution control continues to rise is waste exchange. This technique encourages exchanging of wastes with others for reuse of the waste or recovery of valuable materials. Several types of wastes in the electroplating/metal finishing industry are conducive to waste exchange, namely metal

sludges, spent plating baths, and spent acids and alkaline cleaners. Some of the wastes suitable for exchange include pickling wastes (i.e., sulfuric acid and ferrous sulfate) for use in fertilizer production, sodium hydroxide from electrowinning for use in neutralization, and reclaimed oils available for reuse as fuel.

2. Wastewater Recycling. Several technologies are commonly used to reduce the volume of contaminated wastewater in the metal finishing industry with the purpose of recovering the concentrated solution for reuse. Techniques such as evaporation, ion exchange, reverse osmosis, ultrafiltration/ microfiltration, electrodialysis, and electrowinning are readily available technologies for the recover/recycle of raw materials.

3. Evaporation. Evaporators can be used to recover a wide variety of acidic and basic baths including; chrome plating, chromic acid etch, nickel plating, copper sulfate, precious metals, cyanide plating (zinc, copper, cadmium, silver), and zinc chloride. Recovery consists of boiling off water until the concentrate can be returned to the plating bath. Vapor is condensed and recycled for use as rinse water. Pressurized evaporation prevents thermal degradation of plating chemicals and reduces energy costs. Evaporation also concentrates contaminants in the plating bath which must be removed before reuse. Technologies such as carbon filtration or ion exchange may remove these contaminants to a sufficient concentration to allow for reuse.