

# **Pollution Prevention & Best Management Practice For Metal Finishing Facilities**

## **INTRODUCTION**

The Broward County Environmental Protection and Growth Management Department (formerly known as the Department of Natural Resource Protection), (DNRP) in cooperation with representatives of the metal finishing industries of Broward County has developed Pollution Prevention and Best Management Practices (P2-BMP) for Metal Finishing Facilities. The purpose of this P2-BMP is to foster a working relationship between the regulated community and DNRP as a regulator in achieving regulatory compliance and in preventing pollution in Broward County. This P2-BMP is intended to serve as an instrumental compliance tool enabling the protection, preservation, and maintenance of Broward County's environmental resources.

**The OVERALL GOAL of this document is to DEVELOP A POLLUTION PREVENTION AND BEST MANAGEMENT PRACTICE FOR METAL FINISHING FACILITIES OPERATING IN BROWARD COUNTY WHICH FACILITATES COMPLIANCE WITH APPLICABLE ENVIRONMENTAL REGULATIONS, MINIMIZES WASTES, AND FOSTERS A POLLUTION PREVENTION ATTITUDE WITHIN INDUSTRY.**

This document has been developed in a cooperative effort with the metal finishing industries of Broward County to insure that it accomplishes the Department's objectives and at the same time is implementable and free of any undue technological or economic burdens. The industry's hands on involvement and active participation in the development process has aided in the formulation of a P2-BMP that serves the needs and expectations of all affected parties.

The Pollution Prevention Act of 1990 established a clear national policy that pollution should be prevented or reduced at the source whenever possible. The Environmental Protection Agency (EPA) defines pollution prevention as "any effort to reduce the quantity of industrial, hazardous, or toxic waste through changes in the waste generation or production process at the source." This includes all pollution, hazardous and non-hazardous, regulated and unregulated, across all media and from all sources.

Complying with environmental regulations and incorporating pollution prevention techniques are complementary activities. Many pollution prevention practices are low-cost, low-risk alternatives to hazardous waste disposal. Most of the approaches do not require a great deal of sophisticated technology. Many facilities may already be incorporating pollution prevention practices in their facility without realizing it.

The Pollution Prevention and Best Management Practices (P2-BMPs) have been developed to enable the metal finishing industries operating in Broward County to achieve compliance with all federal, state, and local environmental regulations, prevent the release of chemicals to the environment, and develop a comprehensive Pollution Prevention Program.

Each Pollution Prevention Program will identify ways in which a given facility can reduce the use of hazardous materials and the subsequent generation of hazardous and non-hazardous wastes. In addition the Program will also seek to establish enhanced water and energy conservation practices.

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The P2-BMPs promote the use of good housekeeping measures, development of a preventive maintenance program, employee training in pollution prevention, and other pollution prevention techniques recommended for metal finishing operations. These techniques can be applied so as to maximize the use of resources through source reduction, energy efficiency and water conservation, waste tracking and reduction. Since the most appropriate method of preventing pollution can depend on site-specific considerations, the P2-BMPs have been developed to be a flexible tool for identifying and matching source reduction obligations to the needs and capabilities of each individual facility. This built-in flexibility should enable selection and implementation of the most cost-effective options for pollution prevention.

The Pollution Prevention and Best Management Practices (P2-BMPs) which follow are applicable to all types of electroplating, plating, polishing, anodizing, coloring, and metal finishing facilities located in Broward County and licensed by DNRP as hazardous materials facilities. The P2-BMPs also apply to any other related industries that perform these types of activities and are licensed as a hazardous materials facility within Broward County.

### **INDUSTRY PROFILE**

The metal finishing processes improve the surface of a basic material by cleaning it, hardening or softening it, smoothing or roughening it, depositing another metal on it by chemical exchange, electroplating another metal or series of metals on it, converting its surface by chemical deposition, coating it with organic materials, and oxidizing by electrolysis.

The corresponding changes produced by metal finishing processes on the basic material serve to enhance the value of the treated item by providing such improvements as corrosion resistance, durability, aesthetic appearance, and electrical conductivity.

Electroplating and other metal finishing operations use a wide variety of processes to provide desired surface properties:

- **Physical processes**, such as buffing, abrasive blasting, grinding, tumbling, and polishing.
- **Chemical processes**, such as degreasing, cleaning, pickling, etching, coating, and electroless plating.
- **Electrochemical processes**, such as electroplating, anodizing, electrocleaning, and electropolishing.

Physical processes involve the use of solid materials (abrasives). Chemical and electrochemical processes involve the use of a wide variety of materials such as acids, alkalis, cyanides, chromates, metal oxides, solvents, aldehydes, surfactants, and other organic additives. These operations are typically performed in baths (tanks) and are then followed by a rinsing cycle. Part of the process chemicals are carried to the rinse water (drag-out). The most likely sources of pollutants include:

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- Preparation and production process/operation areas.
- Material, product and waste storage areas.
- Storage tank areas.
- Material handling or transfer areas.
- Loading/unloading areas.
- Equipment and vehicle maintenance areas.

Typical operations using materials which may generate hazardous wastes are illustrated in Table 2.

It is a common belief among those involved that the metal finishing industry is the second most regulated sector, following the nuclear industry. The fact is the metal finishing industry is regulated on a federal, state and local level under: The Clean Water Act, The Clean Air Act, Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), Superfund Amendments and Reauthorization Act (SARA), Emergency Planning and Community Right-to-Know Act (EPCRA), Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA), Occupational Safety and Health Administration (OSHA), Department of Transportation (DOT).

The metal finishing processes generate wastes, non-hazardous and hazardous, in all physical states: liquid waste, solid waste, and air emissions, illustrated in Table 2. Therefore, the metal finishing facilities have a high potential for multi-media contamination if these wastes are released to the environment.

**Table 1 Typical Wastes Generated By Electroplating Processes**

STATES	WASTE	SPECIFICATION
Liquid waste	<ul style="list-style-type: none"> <li>➤ Industrial waste</li> <li>➤ Spent plating baths.</li> <li>➤ Spent process baths.</li> <li>➤ Strip and pickle baths.</li> <li>➤ Exhaust/scrubber solutions.</li> <li>➤ Spent solvents.</li> <li>➤ Samples of plating solutions.</li> </ul>	<ul style="list-style-type: none"> <li>• Rinse water, cooling water, steam condensate, boiler blow down and wash water.</li> <li>• Contaminated or spent electroplating or electroless plating bath solutions.</li> <li>• Contaminated or spent etchants and cleaners (alkaline, acid, and cyanide cleaning solutions).</li> <li>• Nitric, sulfuric, hydrochloric/hydrofluoric acids used to strip metals from work piece racks.</li> <li>• Solutions collected in exhaust and air emission control devices.</li> <li>• Halogenated solvents, alcohols, acetone, methylene chloride and others used for degreasing.</li> <li>• Samples provided by vendors that are not intended for use.</li> </ul>
Solid waste	<ul style="list-style-type: none"> <li>➤ Industrial waste water</li> </ul>	<ul style="list-style-type: none"> <li>• Sludge containing metals such as</li> </ul>

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STATES	WASTE	SPECIFICATION
	treatment sludge. ➤ Miscellaneous solid wastes.	cadmium, copper, chromium, nickel, tin, zinc. • Absorbents, filters, still bottoms, contaminated solvent rags, empty containers, aisle grates, and abrasive blasting residues.
Air emission	➤ Volatile organic compounds (VOC's) ➤ Acid/alkali mists or particulates, vapors emitted.	• From degreasing, solvent cleaning, open containers. • From process and plating baths, exhaust ventilation, spills, leaks, samples.

**Table 2 Typical Operations Using Materials Which May Generate Hazardous Wastes**

TYPICAL PROCESS OR OPERATION	TYPICAL MATERIALS USED	TYPICAL MATERIALS INGREDIENTS	GENERAL TYPES OF WASTE GENERATED
Cleaning and degreasing.	Degreasers, cleaners, solvents, alkalis, and acids.	Methylene chloride, carbon tetrachloride, dichlorobenze, trichloroethylene, acetone, xylene, toluene, benzene, kerosene mineral spirit acids.	Ignitable, combustible, spent solvents, still bottoms, waste acid solutions.
Forming or processing.	Acid solution, coolants, nitrates.	Acids (hydrochloric, sulfuric, chromic) sodium nitrate	Strong acids and alkalis, oxidizers.
Pickling.	Acids.	Hydrochloric/ sulfuric acids	Strong acids.
Plating.	Strong acids and alkalis, cyanide and heavy metal solutions.	Sodium hydroxide, various acids (acetic, sulfuric, perchloric, nitric.	Spent plating solutions, all cyanides, acidic, alkaline, heavy metal, cleaning, and stripping bath solution, heavy metal sludges.
Treating wastewater.	Flocculents, acids, bases, carbonates,	Aluminum compounds, acids (sulfuric,	Heavy metal wastewater sludges

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TYPICAL PROCESS OR OPERATION	TYPICAL MATERIALS USED	TYPICAL MATERIALS INGREDIENTS	GENERAL TYPES OF WASTE GENERATED
	sulfides.	hydrochloric), bases (lime, sodium hydroxide), sodium carbonate, sulfides.	with arsenic, lead, chromium, cadmium, mercury.

**P2-BMPs OBJECTIVES, STRATEGIES, AND REQUIREMENTS**

The P2-BMPs have been developed to achieve the following objectives:

- A** Facilitate compliance with all federal, state, and local environmental regulations governing the use, storage, generation, and disposal of hazardous materials and hazardous wastes within the metal finishing industry.
- B** Prevent the release of chemicals to the environment as a result of leaks, fugitive emissions to air, accidents or improper disposal or discharge.
- C** Develop a comprehensive Pollution Prevention Program for each facility in order to reduce the use or release of hazardous materials, generation of hazardous and non-hazardous wastes, and to achieve a program of water and energy conservation.

**OBJECTIVE A: FACILITATE COMPLIANCE WITH ALL FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS GOVERNING THE USE, STORAGE, GENERATION, AND DISPOSAL OF HAZARDOUS MATERIALS AND HAZARDOUS WASTES WITHIN THE METAL FINISHING INDUSTRY.**

The following are the strategies and typical requirements, but are not all inclusive:

- A1. The owner/operator is responsible for compliance with all applicable requirements of the federal and state environmental regulations, and Chapter 27 of the Broward County Code of Ordinances.**
- A2. All hazardous materials used, processed, generated, stored, or handled shall be identified and listed by category:**
  - Section 302 Extremely Hazardous Substances (EHS).
  - CERCLA Hazardous Substances that exceed reportable quantities.
  - Section 313 Toxic Chemicals.

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Title III SARA "Consolidated List of Chemicals" should be used. [EPCRA, Chapter 252 Part II Florida Statutes, Broward County Ordinance no. 93-47 Article XII of Chapter 27 Sec.27-356 (b)(2)], and Article III Sec.27-104 (1).

The up-dated Material Safety Data Sheets (MSDS) for each and all hazardous materials identified above shall be maintained on-site in accordance with 29 CFR # 1910.1200 promulgated pursuant to the Federal Occupational Health and Safety Act, 29 U.S.C. # 651, et seq, as amended.

- A3. All hazardous waste streams that the facility discards shall be identified and quantitatively and qualitatively evaluated.** [40 CFR Part 261, Broward County Ordinance no. 93-47 Sec. 27-356 (b)(2)].
- A4. The owner/operator shall be responsible for hazardous waste management, as required by RCRA (40 CFR 262):**
- a. Determining which of the wastes generated by the facility is hazardous waste as defined or identified as a hazardous waste in 40 CFR 260-265 and appendices, promulgated pursuant to the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. # 6910, et seq., as amended, and Rule 17-730, F.A.C. [Broward County Ordinance 93-47 definition Hazardous waste].
  - b. Notifying Florida Department of Environmental Protection (DEP) about its regulated waste activity by file EPA Form 8700-12, "Notification of Regulated Waste Activity", in order to obtain a U.S. EPA/DEP Identification Number [CFR 40 Sec 262.12 and adopted by Florida Statutes Sec. 403].
  - c. Evaluating the facility hazardous waste category [40 CFR Part 262]:
    - **Generator**, if in a calendar month the facility generates 2.2 or more pounds (1 kg) of acutely hazardous wastes, or 2,200 or more pounds (1,000 kg) of hazardous wastes.
    - **Small Quantity Generator (SQG)**, if in a calendar month the facility generates between 220 and 2,200 pounds (100-1,000 kg) of hazardous wastes.
    - **Conditionally Exempt Small Quantity Generator (CESQG)**, if in a calendar month the facility generates less than 2.2 pounds (1 kg) of acutely hazardous wastes, or less than 220 pounds (100 kg) of hazardous wastes.
  - d. Complying with all regulatory requirements that apply to facility hazardous waste generator category as required by 40 CFR Parts 262, adopted by Florida Statutes Sec.403.

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**A5. The owner/operator must determine if the facility is subject to the Emergency Planning and Community Right-To-Know Act (EPCRA), Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) and Florida Statutes, Chapter 252, Part II.**

A lot of substances used in metal finishing operations are subject to these laws, such as: metal compounds (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc), cyanide compounds, strong acids, and chlorinated solvents.

It is important to review each EPCRA subtitle and section independently of one another, to determine whether the facility needs to comply with a particular section:

- **Subtitle A** deals with emergency planning and notification of a hazardous materials incident (sections 301 - 304).
- **Subtitle B** deals with the reporting of hazardous chemical inventories and toxic releases (sections 311 - 313).
- **Subtitle C** deals with administration, enforcement and trade secret protection (sections 321 - 330).

The determination should be based on the presence of hazardous materials at or above established threshold amounts.

The facility determined as a SARA Title III facility shall comply with multiple reporting requirements provided by the laws cited above (A5).

**A6. The owner/operator manager must apply to the Broward County Department of Natural Resource Protection (DNRP) and obtain all required environmental licenses.**

The following are the Hazardous Materials Facility License as provided by Broward County Ordinance no. 93-47 Article XII Hazardous Material and other applicable Chapter 27, Pollution Control, of the Code of Broward County requirements, but are not all inclusive:

- a. An up to date inventory list of hazardous materials and hazardous wastes generated, used, stored, handled, processed, or disposed, including those stored in tanks over 110 gallons (excluding process tanks) shall be submitted to DNRP with the Hazardous Material License Application [Sec.27-356 (b)(2)].
- b. All primary containment of hazardous material or hazardous waste shall be product tight and labeled in compliance with current federal, state and local regulations [Sec.27-356 (b)(4)(b).(2.)]. Consequently, all process tanks must be of sound structure and leaking tanks shall be repaired or replaced.

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- c. All storage containers of hazardous materials or wastes shall be designed and constructed in accordance with the applicable standards established by the National Fire Protection Association, the American Society for Testing and Materials, and the EPA [Sec. 27-356 (b)(4)(b.)(5.)]. Individual storage containers shall be labeled and maintained in accordance with all applicable federal and state standards [Sec.27-356 (b)(4)(a.)(1.)].
- d. Defective storage containers shall be removed from service. Such containers shall be repaired or decontaminated and disposed of in accordance with local, state, and federal regulations. [Sec. 27-356 (b)(4)(c.)(3)].
- f. Any floor drains in a hazardous materials handling, usage or storage area which lead to a drainfield, septic tank, or stormwater system must be secured or permanently sealed to prevent the release of hazardous materials. [Sec. 27-356 (b)(4)(b.)(4)]. This applies also to clean out effluent contaminated with hazardous materials.
- g. Hazardous material may be placed into a sanitary sewer system only in accordance with federal and state regulations. Any release of hazardous material into a sanitary sewer system without permission or approval and/or in excess of Public Owned Treatment Works (POTW) system standards is prohibited [Sec. 27-356 (b)(4)(c.)(8.)].
- h. All drums containing hazardous materials and hazardous wastes shall only be stored within a secondary containment area or in building or other secure area which meets the requirements of secondary containment and is protected from weather and in accordance with all applicable fire codes. Reactive or incompatible materials, such as acids and bases, shall be stored in separate containers, in secondary containment areas, and in a manner which eliminates the potential for commingling in the event of a release [Sec. 27-356 (b)(4)(c.)(5.) and (6.)].
- i. All secondary containments shall be constructed of materials of sufficient thickness, density, and composition so as not to be structurally weakened as a result of contact with the discharged hazardous materials [Sec 27-356 (b)(4)(b.)(3.a)].

For tanks or containers larger than one hundred ten (110) gallons, the secondary containment shall hold one hundred ten (110) percent of the volume of the largest tank or container. For tanks or containers of one hundred ten (110)



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gallons or less, the secondary containment shall hold twenty (20) percent of the combined volume of all the tanks and containers within the secondary containment, but no less than the volume of the single largest tank or container. All materials in a secondary containment shall be stored in a manner which prevents contact with an incompatible material or container in the event of a release. A double-walled tank shall be considered secondary containment [Sec 27-352 Definitions]

- j. All outdoor secondary containments shall be provided with a roof to prevent rainwater from entering the area, or as an alternative, be equipped with a lockable valve to enable the controlled release of any accumulation of clean rainwater. The valve shall remain locked or be secured in a manner which, if accessible to the public, prevents the release of hazardous material. All rainwater must be removed from the secondary containment area within twenty-four (24) hours of its accumulation. Any and all rainwater which has come into direct contact with any hazardous materials shall be collected and disposed of in accordance with all applicable federal, state and local regulations [Sec 27-356 (b)(4) (b.) (3.) (b)].
- k. All discarded hazardous material shall be transported by a licensed DNRP waste hauler and be disposed in accordance with federal, state, and local regulations [Sec. 27-356 (b)(4) (c.) (10.)].
- l. Sump pumps used to remove clean rainwater from secondary containments shall be manually operated to prevent an automatic discharge of hazardous materials to ground [Sec. 27-356 (b)(4)(a.) (3.)].
- m. Provisions shall be made to prevent the unauthorized entry into a hazardous material storage area [Sec. 27-356(b)(4)(a)(2)].
- n. Outdoor use of hazardous material including disassembly of any machinery, equipment or vehicles is not permitted unless drip pans, secondary containment, or other steps are taken to prevent any discharge or release [Sec. 27-356 (b)(4)(c.) (4.)].
- o. Any hazardous material transfer, dispensing or mixing activities shall be designed, constructed, managed, and performed so as to prevent any unauthorized discharge or releases [Sec 27-356 (b)(4)(c.) (7.)].
- p. The abandonment or unauthorized release of hazardous material is prohibited [Sec. 27-353 (a)].

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- q. No person shall cause, permit, suffer, or allow the usage, storage, abandonment or disposal of hazardous material:
- (1) In a manner which violates a provision of any federal, state, or local government regulations; or
  - (2) In a manner which causes, or may causes, an unauthorized release of hazardous material. [Sec. 27-353 (g)].
- r. In the event of an unauthorized release of a hazardous material to the environment in an amount that is above the reportable quantity threshold, or the discovery of the presence of any contaminant in the air, water, soil or other natural resource of Broward County at a level which exceeds any applicable federal, state or local regulatory cleanup standard or for which DNRP has determined poses an actual threat or potential risk to water supplies, the environment or to health and safety, the responsible party shall take the necessary measures to stabilize the situation and shall immediately report such incidents by telephone to DNRP. Written notification of verbal reports to DNRP must be provided within seven (7) calendar days. Written notification shall include at the minimum the location of the release, a brief description of the incident that caused the release or discovery, a brief description of the action taken to stabilize the situation, and any laboratory analysis, if available. Based upon DNRP's review of the information provided, the responsible party(s) may be required to obtain an environmental assessment and remediation license in accordance with Section 27-356(e) of the Code. [Sec.27-355(a)(1)].
- s. No remedial actions, with the exception of Initial Remediation Actions, shall be initiated at a contaminated site, until a Remedial Action Plan (RAP) has been approved by DNRP or by the Florida Department of Environmental Protection (DEP). This prohibition does not apply in cases where the United States Environmental Protection Agency (EPA) is the lead agency and has initiated a Corrective Action under the provisions of the Resource Conservation and Recovery Act or a remedial action under the provisions of CFR Part 300, as amended. [Sec. 27-353 (e)].
- t. The owner/operator is required at a minimum to develop procedures to insure for the appropriate and safe handling and cleanup of any release of hazardous material. The owner/operator is required to prepare a spill contingency plan in accordance with all applicable federal and state environmental regulation and provisions of Broward County Ordinance 93-47 Article XII Sec. 27-356 (b)(4)(a).(5.).

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- u. Hazardous waste shall be kept on-site for a period of time no longer than allowed in accordance with federal and state regulations [Sec. 27-356 (b)(4)(c.)(9.)].
- v. The transportation and disposal of hazardous material shall be conducted in accordance with federal, state, and local regulations. Prior to disposal, all hazardous materials shall be properly stored and handled on site and be accessible to inspection at any time [Sec. 27-356 (b)(4)(c.)(1.)].
- w. Reports and Records, including hazardous waste manifests, bills of lading, or other equivalent manifesting for all hazardous material disposal shall be maintained on-site for five (5) years, and shall be available upon request for inspection by DNRP. The records, at a minimum, must identify the facility name and address, type and quantity of waste, the shipping date of the waste, and the hauler's name and address. [Sec. 27-356(b)(4)(d.)].
- x. The facility must comply with all federal, state and local regulations regarding air quality and air pollution control, (VOC's control and particulate matter control).
- y. As a result of the 1990 Clean Air Act Amendments, by the end of 1994 EPA will promulgate regulations that may apply to metal finishing facilities. At that time, the owner/operator shall be required to inform DNRP Air Quality Division about the facility operations, description of the ventilation system, scrubbers, and other air pollution control equipments for evaluation and licensure if necessary.
- z. The owner/operator is responsible to notify in writing DNRP at least thirty (30) days prior to cease operations, initiate a temporary shutdown (other than routine shutdown or vacations), transfer facility's Hazardous Material License or be permanently removed from use or operation. [Sec. 27-355(a)(3)]. The owner/operator is also required to conduct appropriate activities to insure for the proper removal and disposal of all hazardous materials at the facility. At the time of notification, DNRP will specify those closure activities which are determined to be necessary to meet the requirements of this license condition. Failure to notify DNRP or to perform the required closure activities will constitute a violation and may subject the owner/operator to enforcement action. [Sec. 27-356(b)(4)(e.)].

### **OBJECTIVE B: PREVENT THE RELEASE OF CHEMICALS TO THE ENVIRONMENT AS A RESULT OF LEAKS, FUGITIVE EMISSIONS TO AIR, ACCIDENTS OR IMPROPER DISPOSAL OR DISCHARGE.**

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Broward County Ordinance no. 93-47 Sec.27-353. Prohibitions. (g) provides that no person shall cause, permit, suffer, or allow the usage, storage, or disposal of hazardous material in a manner which causes, or may cause, an unauthorized release of hazardous material.

Possible sources of chemical release in metal finishing operations include process fugitive emissions, process tank leaks, equipment leaks, spillage between process tanks, overflows, accidental opening or rupture of a valve, accidental spilling in storage area, or during transfer dispensing, transport from one location to another, or mixing activities.

The owner/operator is responsible for prevention of release of chemicals to the environment by implementing these strategies:

- Initiate improvements in current operational procedures and housekeeping practices.
- Implement a regular inspection program focused on early identification of potential facility conditions and activities that may result in release of chemicals to the environment.
- Establish a preventive maintenance program for the facility.

Since the most appropriate method of preventing pollution can depend on site-specific considerations, the owner/operator can define by himself the methods of implementing the above strategies, or can choose the following recommended procedures which ever better apply to the conditions of the facility.

### **B1. Initiate improvements in current operational procedures and housekeeping practices, such as:**

- a. Protect against corrosion by using process tanks made of corrosion resistant materials such as polypropylene, fiberglass, stainless steel. Metal tanks should be lined. Do not line the inside and the outside of steel tanks because it makes pinholes impossible to detect until the tank collapses.
- b. Provide sealed curbing around plating and other process tanks, and plating bath filters to recover leakage.
- c. Install drain boards between process tanks (plastic coated drain trays, tank lining continued from one tank over the next, etc.), drip trays, splash guards, containment dikes or other systems to prevent and contain drips, spills and leaks.
- d. Prevent accidental bath overflows of process tanks by:

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- Installing high-level alarms or spring-load nozzles.
  - Separating water lines for fill-up.
  - Installing float level controllers if water is added directly from piping or other systems.
- e. Protect all bare concrete surfaces subject to chemical spills or splashes with sealing materials.
- f. When appropriate, remove all valves from the bottoms of tanks containing process solution or concentrated rinsewater and seal them with a cap.
- g. Make chemical additions easy to do. Add only small amounts at any given time. Instruct operators to dissolve all solids before adding them to the tank.
- h. When hazardous materials are moved in and out of a storage or process area, they should remain in the travel path only for the time reasonably necessary to transport the hazardous materials from one location to another. Such movement shall always be performed in a manner which will minimize the likelihood of an unauthorized discharge or release.
- i. Install a proper ventilation system. The ventilation system should be designed to control, capture and remove chemical vapors and aerosol mists from plating and process tanks, to meet air emission regulations. The traditional method of air pollution control is the use of add-on control devices, such as condensers, carbon absorbers, scrubbers, and fabric filters, placed on the exhaust stream from the process. Improving indoor air quality by working with open doors and/or windows is not an acceptable procedure.
- j. Use a plastic cover over each process tank and/or a layer of polypropylene balls to drastically reduce the fugitive emissions to air (a 75-80% reduction of chromium emissions from the electroplating bath has been achieved).
- k. Keep covers on tanks when not in use. Keep chemicals in closed containers.

### **B2. Implement a regular inspection program focused on early identification of potential facility conditions and activities that may result in release of chemicals to the environment.**

This program should consist of regular inspections on a weekly basis of all equipment and the infrastructure of the facility, that include:

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- a. Inspect all tanks and tank linings for deterioration. Make immediate repairs on tanks identified as "critical." If damage is detected, always carefully inspect the adjacent tank. Replace the leaking tanks.
- b. Inspect all flow regulators, control valves, and pumps, focusing on seals and make necessary repairs immediately. Keep spare parts.
- c. Inspect metal tanks for stray currents and correct as soon as possible.
- d. Inspect all filter hoses and connections for integrity.
- e. Inspect all heat exchangers, steam traps, and instrument sensors to insure good working condition.
- f. Inspect the ventilation system for signs of damage to ducts, scrubbers, packed towers, fans fan belts, and hoods.
- g. Inspect containment dykes and other containment systems for signs of leakage. Make repairs as soon as damage is found.
- h. Inspect flooring and repair any cracks subject to wetting by chemicals immediately. Inspect joints and repair any detected damage.
- i. Review piping plans for cross connections, find and eliminate illicit connections.
- j. Laboratory discharges should be routed through the wastewater treatment system, to prevent an unauthorized discharge into a sanitary sewer system.
- k. Clean equipment, machinery, parts, etc. only in areas draining to wastewater treatment process, to prevent an unauthorized discharge of hazardous material.
- l. When appropriate, prohibit the cleaning of the outside of the tanks and the suprastructure with a high pressure water hose. This procedure results in the generation of many gallons of diluted waste water that requires treatment. Also this procedure adds to the already accelerated corrosion faced by all construction in the facility.
- m. When appropriate, replace "hose downs" with "sponge-ups." The sponged up chemicals can be returned to the process tank, or smaller volumes of concentrated clean up solution from segregated areas can be used for pH adjustment.

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#### **B3. Establish a preventive maintenance program for the facility.**

Preventive maintenance should consist of cleaning, lubricating, testing, measuring, and replacing of worn or broken parts, on a routine basis.

This program improves the efficiency and longevity of equipment, reduces slow-downs or shutdowns from equipment failures, and reduces the likelihood of producing rejected, off-specification products.

Many of these procedures to prevent release of chemicals have been recommended at the 14th American Electroplaters and Surface Finishers Society (AESF) Conference on Environmental Control for the Surface Finishing Industry and Regulatory Compliance Workshop Update '93 held with the participation of Pollution Prevention Research Branch of EPA, Office of R&D, Risk Reduction Engineering Laboratory, The 80th Annual AESF Technical Conference SUR/FIN '93, and Plating and Surface Finishing, monthly Journal of the AESF.

#### **OBJECTIVE C: DEVELOP A COMPREHENSIVE POLLUTION PREVENTION PROGRAM FOR EACH FACILITY IN ORDER TO REDUCE THE USE OR RELEASE OF HAZARDOUS MATERIALS, GENERATION OF HAZARDOUS AND NON-HAZARDOUS WASTES, AND TO ACHIEVE A PROGRAM OF WATER AND ENERGY CONSERVATION.**

The Pollution Prevention Program can be developed by the company itself, with the free, non-regulatory technical assistance of DEP's Waste Reduction Assistant Program (WRAP), or by hiring a private consulting firm which offers source reduction services. In addition, the references listed in the bibliography section of this document contain considerable process-specific information which may prove useful for developing a comprehensive pollution prevention program. These references are available for review by contacting DNRP's Pollution Prevention and Remediation Programs Division.

#### **C1. In six (6) months, upon adoption of P2-BMPs, the facility is required to draw up its own Pollution Prevention Program.**

This program should consist of an assessment and projects to systematically reduce the use or release of hazardous materials, generation of hazardous and non-hazardous wastes, and to achieve a program of water and energy conservation.

Conducting a facility assessment - by collecting data and information of production processes, materials usage, waste streams generated, and waste management - and elaborating a comprehensive waste minimization plan are required. The identification,

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selection and implementation of the cost-effective options are voluntary. Once having pinpointed the sources of pollution, the company will realize the opportunity to save money and protect the environment.

#### **C2. The Pollution Prevention Program should be developed by the facility with consideration given to the following recommended criteria as appropriate:**

- a. A written statement of company's policy, goals, and objectives.
- b. A list of production processes that use or generate hazardous substances.
- c. A list of processes that generate wastes, hazardous and non-hazardous.
- d. An inventory of all hazardous substances and the amount used or generated.
- e. An inventory of all wastes, hazardous and non-hazardous, and the amount generated.
- f. Identify major losses by developing a mass balance analysis of all raw materials and water used in contrast with the wastes generated.
- g. A list of prioritized processes, operations, and waste streams for various reduction actions.
- h. A list of selected assessment targets, identifying and evaluating waste reduction options.
- i. A list of selected options specific to its operations for source reduction and recycling/resource recovery for selected targets.
- j. Establish quantitative reduction goals estimated to be achieved and select the most useful analysis methods to measure progress. Looking at both inputs and outputs provides a more complete understanding of progress.
- k. Evaluate the cost effectiveness of the program. The value of reduced waste production is estimated based on volumes of waste and cost of waste treatment and disposal. The economics of the process can then be evaluated by any of several techniques such as payback period, net present value, or return on investment.
- l. Schedule implementation of selected options for selected targets.



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- m. Acquire Data, keep tracking of results, analyze these results, measure progress against goals, and report in a timely manner (quarterly, semi-annually, annually).
- n. Types of employee awareness and training programs related to pollution prevention goals.

### **C3. The Pollution Prevention Program is required to be revised and improved annually, which will demonstrate the facility's continuing commitment to the program.**

The items C4 through C14 are typical strategies to develop the Pollution Prevention Program recommended by EPA/625/R-92/011 October 1992 publication "Guides to Pollution Prevention-The Metal Finishing Industry," Pollution Prevention Planning - Guidance Manual - implemented in some states such as Washington and California, and 1993 AESF conferences, publications, and journals.

### **C4. Management initiative, commitment, and involvement.**

- Setting Management Policy: a written policy articulating management support for the program and a commitment to implement planned activities and achieve established goals.
- Owners/managers set the tone of the company's activities. Through them employees understand how reduction of hazardous substance use and of hazardous waste fits into company policies and practices.

### **C5. Set overall program goals.**

- Identify the scope and objectives of your program. Scope includes the processes that your program will cover. Objectives define what you plan to accomplish. They may include such things as reducing hazardous substance use and waste generation by a specific percentage or amount, eliminating a work place hazard, reducing raw materials toxicity, eliminating an extremely hazardous waste, or reducing releases reported under SARA Title III-S. 313.
- Although pollution prevention commitments should begin with management, the employees are often the best source for suggesting improvements in the day-to-day operations of the business. Employee incentive programs encourage employees to design and use new pollution prevention ideas.

### **C6. Prioritize the processes, materials and waste streams and select assessment targets.**

Production processes, that are high percentage contributors to the use, generation, or release of hazardous substances and wastes, should be targeted.

### **C7. Conduct a Pollution Prevention Assessment of each facility's operations,**

**Pollution Prevention & Best Management Practice For Metal Finishing Facilities manufacturing processes, waste streams, and waste management practices, or for selected targets only.**

Analysis of operations can identify the facility changes that will reduce chemical loss and water use. Resulting savings can quickly repay costs involved in implementing the program.

One of the first steps of the assessment is to gather background information on production processes, operating procedures, waste streams, and waste management practices. Collecting data will create a basis of tracking the flow and characteristics of the waste streams over time. This will be useful in identifying trends in waste generation and will also be critical in the task of measuring the performance of implemented waste reduction and recycling options later.

Here is a listing of typical steps involved in a facility assessment for pollution prevention purposes:

- a. Locate or prepare drawings of the layout of the process and storage areas. These drawings should be to scale, showing the location of all relevant equipment and tanks, identifying:
  - Plating and other processes lines.
  - Gutters, sumps, and sewer lines.
  - Water lines, control valves, and flow regulators.
- b. Review piping plans for cross connections and eliminate all illicit connections.
- c. Review all operations of the facility that relate to chemical or water use, examine each plating line, documenting:
  - Estimates of production units, such as square meters plated, number of parts, barrels or racks to pass through a line sequence.
  - Purchases of chemicals and break-down of where each chemical is used and how much.
  - Rinsing systems, rising and draining times on automatic lines or efficiency of operators on manual lines.
  - Relative amount of dripping onto the floor if applicable.
  - Drag-out measurements performed at plating tanks to determine the pollutants contributed by these sources.
  - Batch dumps that result from the process, which can contribute significantly to effluent concentrations of pollutants and cause pH fluctuation in the facility wastewater stream.

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- Other major losses and their causes.
  - Sampling and analysis to determine the nature and characteristics of waste streams. The final effluent should be analyzed to identify which pollutants are not in compliance with requirements. Sample all individual rinse tanks, overflows, batch dumps, and plating solutions to isolate sources of pollution, to calculate chemical losses and to evaluate potential benefits of drag-out reduction and flow minimization techniques.
- d. Determine the water use at each process step, especially rinse flow rates, where most water is used. Water meters on each line would be extremely useful. Make individual flow diagram and mass waste loads for each process area and for the whole facility, balance of total water influent and wastewater effluent.
- Compare the total amount of water measured with water bills to determine the non-rinsing uses of water, such as for fume scrubbers, heat exchangers, boilers, or wash-downs and unattended running hoses.
- e. Use all this information to analyze the entire plating operation. The objectives are the elimination, recovery or reduction of wasted chemicals and wasted water. Accomplishing these objectives will save money, and at the same time reduce or eliminate pollutant discharges from the facility.

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- f. Review the facility wastewater management practices. Usually, the electroplating wastewater management is characterized as end-of-pipe treatment, discharge and disposal. Conventional treatment technologies are used to lower contaminant concentrations in the wastewater from the metal finishing processes. Generally, the toxic contaminants are part purged in the sludge from the treatment processes and part in the wastewater discharged to a publicly owned treatment wastewater plant (POTW). Compare the POTW effluent standards with the analysis results of facility wastewater treated effluent to verify the compliance with the pollutant requirements.
- g. Verify the integrity of all wastewater treatment equipment such as process tanks, pumps, pipes, review piping plans for cross connections, and find and eliminate illicit connections to ensure that no unauthorized discharge occurs.
- h. Identify and evaluate current reduction, on-site recycling, and treatment activities and their efficiency.

Since pollution prevention is an ongoing effort, the assessment should be repeated at least once a year. To summarize, the types of data and information that are useful for conducting an assessment are listed below:

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PROCESS	DATA
Production processes and operational procedures	<ul style="list-style-type: none"> <li>• Production rates.</li> <li>• Process descriptions and efficiencies.</li> <li>• Conditions of process equipment.</li> <li>• Sources or potential sources of leaks/spills.</li> <li>• Operating procedures.</li> <li>• Maintenance procedures and schedules.</li> <li>• Operating and maintenance costs.</li> <li>• Energy/utility usage and costs.</li> </ul>
Material usage, handling, and storage	<ul style="list-style-type: none"> <li>• Material inventory.</li> <li>• Raw material accountability (i.e. how much of the raw material is actually used in the process, how much is lost through evaporation or other means, and how much enters a waste stream).</li> <li>• Raw material costs.</li> <li>• Material transfer and handling procedures.</li> <li>• Storage procedures.</li> <li>• Sources of leaks or spills in transfer and storage areas.</li> <li>• Condition of pipes, pumps, tanks, valves, and storage/delivery areas.</li> </ul>
Waste stream	<ul style="list-style-type: none"> <li>• Activities, processes, or input materials that generate waste streams.</li> <li>• Physical and chemical characteristics of the each waste stream.</li> <li>• Hazardous classification of each waste stream.</li> <li>• Frequency of waste stream generation.</li> <li>• Rates of generation of each waste stream and variability in these rates.</li> </ul>
Waste management	<ul style="list-style-type: none"> <li>• Current treatment and disposed of each waste stream.</li> <li>• Cost of managing waste streams (treatment/disposal).</li> <li>• Operational procedures for waste treatment units</li> <li>• Efficiency of waste treatment units.</li> <li>• Quantity and characteristics of all treated wastes, sludges, and residues.</li> <li>• Waste stream mixing (hazardous wastes mixed with non-hazardous wastes).</li> </ul>
Waste reduction	<ul style="list-style-type: none"> <li>• Current waste reduction and recycling methods being implemented.</li> <li>• Effectiveness of those methods.</li> </ul>

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### **C8. Collect data of accounting information regarding:**

- Product, energy, and raw material costs.
- Water and sewer costs, including surcharges.
- Hazardous waste handling, treatment, and disposal costs, including liability, compliance, and fees.
- Cost for non-hazardous waste disposal (trash, cardboard).
- Operating and maintenance costs including oversight cost.

### **C9. Develop a mass balance analysis of all raw materials and water used in contrast with wastes generated for the selected targets (at least one), to identify major loses and their causes.**

In a material balance, try to account for all materials that enter and leave a processing area. This can help to improve process control and other operational aspects, such as cleanup procedures.

### **C10. Consider waste minimization opportunities and identify the cost effective options for source reduction, material/chemical substitution, recycling, and resource recovery.**

When identifying and evaluating waste reduction options for the facility's operations, the emphasis should be placed first on the simple, low, or no cost material handling and process changes. After these alternatives have been considered, then the more expensive equipment modification and waste recovery options should be evaluated.

The recommended approaches for metal finishing operations are:

- Source reduction methods.
- Material/chemical substitution.
- Recycling/resource recovery methods.

The description of these approaches starts on page 30.

### **C11. Select options for source reduction, material/chemical substitution and recycle/resource recovery methods.**

General and site-specific factors must be considered when evaluating the waste minimization opportunities for selected targets. An option must be shown to be technically and economically feasible for adoption at a facility:

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- A technical evaluation determines if both process and equipment changes need to be assessed for their overall effects on waste quantity and product quality.
- An economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value.

Option screening should consider these questions:

- Which options will best achieve the goal of waste reduction?
- What are the main benefits to be gained by implementing this option?
- Does the technology exist to develop the option?
- How much does it cost?
- Can the option be implemented within a reasonable amount of time without disrupting production?
- Does the option have a good "track record"?
- What other areas will be affected?

#### **C12. Establish schedule implementation of selected options.**

The options that passed both technical and economical feasibility reviews should be implemented. An implementation schedule for each selected option should be established.

#### **C13. Establish quantitative goals of toxic use and waste reduction, water and energy conservation and methods to measure progress.**

The quantitative reduction goals should be established, for each of the categories listed below:

- Toxic and hazardous materials to be reduced/eliminated.
- Hazardous and non-hazardous wastes to be reduced or eliminated.
- Hazardous and non-hazardous waste to be recycled on site.
- Hazardous waste to be treated.
- Solid waste.
- Waste water.
- Energy conservation.

The methods to be utilized to measure progress against goals should be established.

#### **C14. Specify the types of employee awareness and training programs related to pollution prevention program.**

Effective communication between managers and employees is a critical requirement for maintaining a successful program. Good suggestions should be put into practice and recognized. For example, one way to highlight the concrete value of pollution prevention is by establishing the award as a set percentage of the estimated annual savings to be realized by the production unit. Specialized training on pollution prevention policy, procedures and techniques should be provided to employees.



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These strategies will ensure the development of a comprehensive pollution prevention program, beneficial for the company and the environment. EPA's Waste Minimization Assessment Worksheets may also be helpful. It's use is optional.

### **WASTE MINIMIZATION APPROACHES RECOMENDED FOR METAL FINISHING OPERATIONS**

#### **I. SOURCE REDUCTION**

Source reduction approaches decrease the amount of generated waste and they are usually the least expensive method of minimizing waste. Many source reduction options require only simple housekeeping changes or in-plant process modifications.

##### **a. Improved operations and housekeeping practices.**

Many practices are easy to implement and require little or no capital investment. Material and waste handling and storage improvements are the simplest and often most effective first steps toward reducing wastes, such as:

- Implement an effective inventory control system to prevent waste generation due to excessive purchases and expiration of a product's life (first in, first out).
- Match chemical purchases with operational needs.
- Ensure that containers are completely empty before new containers are opened.
- Develop strict procedures for mixing chemicals, to ensure that the baths are operated at the lowest possible concentration to reduce drag-out loss.
- Return to the process bath the unused portion of analytical samples.
- Test sample bath chemistries only if supplier agrees to accept unused portion. Avoid the temptation of accepting "free" samples from suppliers or other shops, that are going out of business. Usually much of it is useless and must be disposed of.
- Use the minimum number of material types due to increasing the potential for recycling and reduction of waste requiring disposal.
- Minimize the volume of water or absorbent used during cleanup operations.

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- Improve operation and maintenance of container and drum storage areas by:
  - Providing adequate aisle spacing to facilitate container transfer and easy access for inspection.
  - Properly labeling containers with material identification and health hazard
  - Stacking containers according to manufacturers' instructions to avoid damaging from improper weight distribution.
  - Segregating different hazardous substances to prevent cross contamination and mixing of incompatible materials.
  - Storing containers on pallets or similar device to prevent corrosion which can result when containers come in contact with moisture on the floor.
  
- Segregate waste streams to allow for certain wastes to be recycled or reused and to keep non-hazardous materials from becoming contaminated as follows:
  - Hazardous from non-hazardous wastes.
  - Liquids from solids.
  - By hazardous constituent, such as chlorinated solvent from non-chlorinated solvents.
  
  - Routing condensate from exchangers and coils in cyanide streams separate and directed to the cyanide treatment system.
  - Condensate from exchangers and coils in chromium stream should be separately directed to the chrome treatment system. This prevents the possibility of a toxic chromium-cyanide reaction.
  - Waste streams containing recoverable metals from waste streams containing chelating agents.
  
- Track wastes and include careful labeling to ensure safe handling of wastes and identification of wastes which have the potential for recycling or resale.
  
- Properly clean and rinse parts prior to plating to minimize contamination of the plating bath. Areas that are not to be plating should be masked or stopped off with tape or wax to limit corrosion from these areas.
  
- Parts should be removed from the bath when not being plated.
  
- Remove quickly dropped parts and tools from process baths to reduce contamination of the bath. Having rakes handy to recover dropped items can

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be useful.

- Schedule weekly inspections to ensure that equipment is operating at optimal efficiency and implement preventive maintenance.
- Examine operator's production procedures, such as drain time and rinse methods.
- Improve the schedule of batch production runs to reduce the frequency of equipment and tank cleaning.
- Recordkeeping and documentation of operational procedures promote the consistency of these operations, reduction of unacceptable products which must be discarded, and help to identify practices that need to be improved. An operating manual can assist the operators in monitoring waste generation and identifying unplanned waste releases and assist in responding to equipment failures.

Recordkeeping should include the following items:

- Documentation of process procedures, control parameters, operator responsibility, hazards, MSDS.
- Waste generation, waste handling and disposal cost.
- Unplanned waste releases such as equipment failures or spills and leaks, and costs of cleanup.
- Educate and train properly the employees directly involved with processes and activities that generate wastes to ensure their understanding of why and how wastes are generated, managed, and disposal cost.  
Employee training should include:
  - Health and safety aspects of all hazardous substances being handled.
  - Proper operation of process equipment for waste recycling and treatment.
- Implement cost accounting practices that allocate waste treatment and disposal costs directly to the groups that generate the waste, rather than to general accounts.

### **b- Drag-out reduction.**

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Drag-out refers to the plating solution that adheres to the parts after they are taken out of the plating bath and is carried-over into the rinsewater. Drag-out represents the largest volume source of wastewater in electroplating. Minimizing drag-out will reduce the amount of contaminants entering the next process bath or rinsewater, thus reducing the volume of waste that must be treated and disposed.

Many techniques are used to reduce drag-out by altering the process parameters such as viscosity, chemical concentration, surface tension, velocity of withdrawal, and temperature.

The following drag-out reduction methods are inexpensive to implement and are repaid through savings in plating chemicals:

- Lower the concentration of plating bath constituents to the minimum possible that will still maintain high quality, to reduce solution viscosity. This will save material cost and reduce the toxicity of bath solutions generated.
- Increase plating solution temperature to reduce both, viscosity and surface tension of the solution.
- Use nonionic wetting agents (surfactants) to reduce solution surface tension up to two-thirds, with a proportional reduction in drag-out.
- Increase the drain time over the plating tank by withdrawing work pieces at a slower rate to allow maximum drainage back into process tank.
- Install drainage boards between tanks to route drag-out into the correct process tank. These will save chemicals by making up for evaporative losses, reduce rinse requirements and prevent unnecessary floor wettings.
- Carefully rack and remove parts so as to minimize entrapment of bath materials on surfaces and in cavities:
  - Parts should be racked with major surfaces vertical.
  - Parts should be oriented so that the smallest surface area of the piece leaves the bath surface last.
  - Parts should not be racked directly over one another.
- Design plating racks with a minimum surface area, minimum horizontal surfaces, no pockets, and an effective orientation to promote drainage.
- Provide drain bars over the plating tank from which the rack can be hung to

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drain for a brief period of time, or rotate the barrel over the plating tank to remove excess plating solution.

- Use air knives with oil-free compressed air to knock plating films off parts and back into the plating tanks.
- Use fog and spray rinses with deionized water over the plating tank if the evaporation rates are sufficient to accommodate the added volume of spray water.
- Use drag-out tanks with product agitation.
- Install drag-out tanks to recover process chemicals.

#### **c- Improved bath processes and extended process bath life.**

Plating solutions contain valuable metals in high concentrations, as well as chemical salts and additives. Over a period of time, contaminants can build up in the plating bath and reduce the effectiveness of the plating operations.

When plating solutions become spent plating baths, they should be taken off line and treated on site or placed in containers for off-site disposal. For economic reasons, these plating baths are rarely changed out or dumped. However, the lifetime of a plating solution is limited by the accumulation of impurities and by depletion of constituents due to drag-out.

Waste volume and bath replacement costs can be decreased through filtration, replenishment, precipitation, monitoring, housekeeping, drag-in reduction, purer anodes and bags, and ventilation exhaust systems.

Several methods are available to maintain the quality of the plating bath and these include:

- Testing process bath for pH, metals, and other indicator parameters to determine when additional chemicals should be added or when metal contaminants should be removed. Monitoring should be considered as an ongoing process, not an event.
- Removing impurities from plating baths:
  - Suspended solids can be removed by filtration, usually for acidic electroplating baths.

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- Nickel baths can be purified by activated carbon adsorption.
- Carbonates in cyanide baths can be removed by chemical precipitation.
  
- Using deionized, distilled, or reverse osmosis water instead of tap water for makeup and as rinse water. Contaminants found in tap water, such as calcium, iron, magnesium, manganese, chlorine, carbonates and phosphates reduce rinse water efficiency, interfere with drag-out recovery and contribute to sludge volume when they are removed from wastewater during treatment.
  
- Replenishment of baths by adding necessary chemicals.
  
- Using purer anodes and cloth bags around anodes to prevent insoluble impurities from entering a bath.
  
- Reducing drag-in by better or modified rinsing to prevent cross-contamination between baths. Ensure rinsing the drag-out from one process bath before the item is processed in another.
  
- Preventing foreign materials from entering or remaining in a bath:
  - When a part falls off the rack into a bath, it should be removed immediately.
  - The racks should be kept clean and free of contaminating material.
  - Protect anode bars from corrosion, using corrosion-resistant tanks and equipment.
  - Properly design and maintain racks to reduce build-up of corrosion and salts deposits which will contaminate plating solution.
  
- Covering baths with lids when not in use to reduce product losses through evaporation.
  
- Using adequate ventilation/exhaust system:
  - If segregated, some wastes from scrubbers can be returned to process baths after filtering.
  - Updraft ventilation allows mist to be collected in the ductwork and flow back to the process tank.
  - Process baths that generate mist should be in tanks with more freeboard to reduce the amount of mist reaching the ventilation system (e.g., hexavalent chromium plating baths, air-agitated nickel/copper baths, etc.).

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- Foam blankets or floating polypropylene balls can be used in hard or decorative chromium baths to keep mists from reaching the exhaust system.

### **d- Improved rinse operation.**

Most hazardous waste from electroplating comes from wastewater generated by the rinsing operations that follow cleaning, plating, and stripping operations. Increasing rinse efficiency and reducing the amount of rinse water generated will reduce the water and sewer bills, costs of chemical treatment of wastewater and sludge disposal fees.

Methods available include:

- A "static" rinse tank with purified water can be used prior to the rinse tanks with flowing water. As the concentration of the plating solutions in this rinse tank builds up over time, the rinse water can be returned to the bath to make up for evaporation losses.
- Rinse water agitation can be obtained by manually moving the work piece rack or creating turbulence by pumping either air or water into the immersion tank, or with a mechanical agitator. Rinsing is more effective when pieces are raised out and lowered into the tank, rather than agitating the pieces while they are submerged.
- Contact time between the work piece and the rinse solution can be increased.
- Water supply control devices can be used to regulate the feed rate of water to an optimum level. Flow control devices include:
  - Flow restrictors which limit the volume of rinse water flowing through a rinse system by maintaining a constant flow of fresh water once the optimal flow rate has been determined.
  - Pressure-activated flow control devices, such as foot pedal activated valves or timers, can be helpful to ensure that water is not left on after the rinse operation is completed.
  - Conductivity-activated flow controllers control fresh water flow through a conductivity sensor that measures the level of ions in the rinse water and activates a water flow valve according to the preset concentrations.
- Spray or fog rinses can be installed above heated process tanks if the volume of the rinse water is less than or equal to the volume of water lost to heat evaporation. The drag-out and the rinse solution can be drained directly into the process bath, to replenish the bath solution. Deionized or reverse osmosis water should be used. These methods can reduce water usage up to 75%, but are effective on simple work

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pieces, such as sheets, having limited application for odd-shaped pieces:

- In spray rinsing, the process solution films are washed off the parts through use of impact and diffusion forces.
- Fog rinsing method uses water and air pressure to produce a fine mist which reduces the concentration of drag-out film.
- Cascade rinse water recycling method uses the overflow from one rinse tank as the water supply for another compatible rinsing operation.
- Counter-current rinsing with multiple tanks method uses up to 90% less rinse water than a conventional single-stage rinse system. In a multistage counter-current rinse system work piece flow moves in a direction opposite to the rinse water flow. Three or more rinse tanks are operated in series with the water flowing from the tank farthest away from the plating tank toward the tank closest to the plating tank by gravity or pumping. The work piece is sequentially immersed in each of the rinse tanks, from the least pure rinse tank to the cleanest rinse tank. This system allows greater contact time between the work piece and the rinse water and greater diffusion of process chemicals into the rinse solution.

## **II. MATERIAL/CHEMICAL SUBSTITUTION**

This is the second alternative, after reduction, when pursuing a program of pollution prevention.

The increasing complexity of pollution control regulations has provided incentive for using less toxic process chemicals. Material and chemical substitutes are now being gradually introduced into the marketplace by chemical manufacturers and suppliers.

- a. When evaluating and selecting chemical substitutes for a particular application, some factors should be considered, such as:
  - If substitutes are available and practical.
  - If substitution solves one problem but create another.
  - If tighter chemical controls are required of the bath.
  - If product quality or production rate are affected.
  - If the change involves cost increases or decreases.
- b. Beware of the disadvantages of some attractive ideas:



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- Use of deionized water instead of tap water to reduce sludge generation. However, when deionization units are regenerated, they also generate a waste stream.
- Use of nonchelated process chemicals for some processes (e.g., alkaline cleaning and etching) in which metals can be allowed to precipitate. If chelating compounds enter the waste stream, additional treatment chemicals are required, which contribute to the volume of sludge and hazardous wastes. However, nonchelated process cleaning baths usually require continuous filtration to remove the solids that form, which involves filter element replacement, disposal, and maintenance.
- Use hot alkaline cleaner baths instead of chlorinated and nonchlorinated solvents. However, some alkaline cleaners can be treated on site and disposed of in the sanitary sewer only with the permission of the local authority.
- Biodegradable cleaners may be acceptable for discharge to public sewers. However, the oxygen demand created by the cleaners during treatment may increase sewer fees.
- Nonphosphate cleaners may help reduce waste by eliminating the generation of phosphate sludges during wastewater treatment, but may not clean as well. These and other alternative cleaners should be tested to determine their effectiveness.

c. Some commonly used material and chemical substitutes in electroplating operations are summarized below:

PROCESS	CHEMICAL SUBSTITUTE OR ALTERNATIVE
Cyanide Zinc	<ul style="list-style-type: none"> <li>• Ammonium or potassium chloride for complexing zinc</li> <li>• Acid sulfate, chloride, and fluoroborate baths.</li> </ul>
Cyanide Cadmium	<ul style="list-style-type: none"> <li>• Acid bath with sulfuric acid and cadmium oxide.</li> <li>• Cadmium chloride.</li> <li>• Zinc alloy for enhanced corrosion resistance.</li> </ul>
Cyanide Copper	<ul style="list-style-type: none"> <li>• Copper sulfate.</li> <li>• Alkaline non-cyanide copper with cupric ions.</li> <li>• High pH nickel for copper strike on zinc.</li> </ul>
Cyanide Tin	<ul style="list-style-type: none"> <li>• Acid tin chloride.</li> </ul>
Hexavalent	<ul style="list-style-type: none"> <li>• Trivalent chromium chloride based chemistry.</li> </ul>

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Chromium	<ul style="list-style-type: none"> <li>• Trivalent chromium sulfate based process.</li> <li>• Nickel-tungsten alloy with silicon carbide for hard chromium.</li> </ul>
Pickling, Bright	<ul style="list-style-type: none"> <li>• Sulfuric acid and hydrogen peroxide can be used as substitutes for chromic acid.</li> </ul>
Copper etchants	<ul style="list-style-type: none"> <li>• Sulfuric peroxide as substitute for persulfate.</li> <li>• Acid "salts" (sulfate aka sodium bisulfate) for replacing hydrochloric acid.</li> </ul>
Cyanide cleaners	<ul style="list-style-type: none"> <li>• Trisodium phosphate.</li> <li>• Ammonia.</li> </ul>
Solvents CFCs, 1,1,1 Trichloroethane Carbon tetrachloride Halons	<ul style="list-style-type: none"> <li>• Alkaline cleaners.</li> <li>• High pressure hot water washing.</li> <li>• Steam cleaning.</li> <li>• Mechanical blasting in place of chemical strippers to remove paints or rust.</li> <li>• Non volatile organic compounds.</li> <li>• Non-stratospheric ozone depleting compounds.</li> </ul>

### III. RECYCLING AND RESOURCE RECOVERY

Many companies discovered that the cost of installing on-site recycling equipment can be quickly recovered and future profits gained by savings in waste management and raw material cost. In addition, there are off-site recyclers who will take a company's waste, recycle it, and sell the refined product back to the company at a lesser price than the cost of the virgin material, or return spent plating solution to manufacturer, who will reclaim the waste.

Recycling and resource recovery approaches use waste from one process as raw material for another process or recover valuable materials from a waste stream before disposed. Therefore, recycling and resource recovery technologies require waste streams segregation.

**a. Reusing waste material.**

- Multiple-use rinse water is a common option, in which the rinse water from one process, after it becomes too contaminated, may be useful for other rinse processes, such as:

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- Acid cleaning rinse water effluent can be used as influent to an alkaline rinse system.
  - Acid cleaning rinse water from a critical or final rinse operation (usually less contaminated) can be used as rinse water for work pieces that have gone through a mild acid etch process or other processes that not require high rinse efficiency.
  - Using the same rinse tank to rinse parts after both acid and alkaline baths.
- Spent acid or alkaline solutions may be used as pH adjusters for diverse processes, exempt for final wastewater pH adjustment due to high concentrations of metals, such as:
    - Acid solutions can be used for pH adjustment in chromium reduction treatment.
    - Alkaline solutions can be used for pH adjustment in a precipitation tank.

### **b. Recycling rinse water and process baths.**

- Closed loop system: the effluent, treated in chemical recovery processes, is returned to the rinse system. This system can significantly reduce water use and water discharged to the wastewater treatment plant. However, a small amount of waste is still discharged.
- Open loop system: the effluent, treated in chemical recovery processes is returned to the rinse system, but the final rinse is fed by fresh water to ensure high quality rinsing.

### **c. Chemical recovery processes.**

Discharge of treated wastewaters to a POTW is much more common than recycle or reuse. A high volume of rinse water dilutes the contaminants dragged from the metal finishing baths and results in a low concentration of contaminants. "Dilution is the solution for pollution" has been the easy answer for this problem, encouraged by concentration-based wastewater discharge limits. Unfortunately, dilution is not a solution for pollution because it does nothing to minimize the impact of discharged wastewater contaminants that accumulate in sediment or enter the food chain. In addition, conventional treatment technologies used to lower contaminant concentrations in the wastewater from the metal finishing processes can be affected by some current regulatory issues, such as:

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- Sewage Sludge Regulations, finalized by EPA in November 25, 1992, provide the maximum concentrations of heavy metals that municipal sewage sludge may contain, if it is to be used for land application. These can replace the concentration-based discharge standards with mass-based standards, that would encourage water conservation and pollution prevention. Until then, POTW can lower allowable concentrations of heavy metals in the metal finishing facilities effluent, especially for lead, chromium, cadmium, and molybdenum.
- The safe drinking water standard of 0.1 mg/l for nickel finalized by EPA has an indirect impact on metal finishers because standards in clean-up regulations under RCRA and CERCLA are based on a factor multiplied by the drinking water standard.
- The elimination of the 10,000 gal/day exemption expected to be proposed in the near future will affect the small jobshop platers, which will need to meet the standards required by Section 413, 40 CFR.
- The elimination of current beneficial exemption of "elementary treatment systems" is expected with RCRA reauthorization in 1994. In this situation, each metal finisher shall apply for a Part B permit under RCRA, which is very expensive, time-consuming, and typically requires analytical monitoring on a scheduled basis.
- Chromium emission standards promulgated by EPA Office of Air Quality Planning Standards by November 23, 1994, will affect chromium anodizing, decorative and hard chromium electroplating.

In this regulatory climate, the electroplaters should consider and evaluate the available chemical recovery processes for metals and metals salts from spent process baths and rinse water. Recovered process solutions can be returned to baths as makeup, recovered metals can be sold or returned to suppliers, and elemental metal can be sold to a reclaimer or reused on site as plating metal anode materials.

The chemical recovery processes available to concentrate plating solution from rinse water for reuse and to purify spent process solutions include:

- Evaporation:
  - In this process, rinse water is boiled to concentrate the plating solution. Steam from the process is condensed and reused for rinsing. The plating solution is return to the plating bath. The process can be

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performed at low temperature under vacuum, which will prevent degradation of plating additives.

- This process can be applied for drag-out recovery of rinse water, such as from hot chromium baths, ambient temperature nickel baths, and metal cyanide baths.
- Reverse osmosis:
  - In this process water is separated from dissolved metal salts by forcing the water through a semipermeable membrane at high pressure. A concentrated solution containing the plating metals is produced and returned to the plating bath. The purified water is reused for rinse.
  - This process can be applied for drag-out recovery of rinse water on lines with heated plating baths (evaporation is high enough to allow the concentrate to be fed directly to the plating bath), such as: acidic, sulfamate and fluoroborate nickel; sulfate, pyrophosphate and fluoroborate copper; chloride and sulfate zinc; cyanide baths for copper, zinc, and cadmium.
- Ion exchange:
  - In this process the chemical solution is passed through a series of resin beds that selectively remove cations and anions. The metals and anions are recovered by cleaning the resins with an acid or alkaline solution.
  - This process can be applied for recovery of plating chemicals from rinsewater, purification of plating solutions, and wastewater treatment.
- Electrolytic recovery/Electrowinning:
  - In this process a cathode and an anode are placed in the rinse solution tank, obtaining a solid metallic deposit on the cathode, that can be reclaimed or used as an anode in an electroplating tank.
  - This process can be applied to recover the metallic content of rinse water and of spent process bath prior to bath treatment in the wastewater treatment system.

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- **Electrodialysis:**
  - In this process, water is separated from dissolved salts using alternately-spaced anion-permeable and cation-permeable membranes. An electric potential is applied across the membranes to provide the driving force.
  - This process can be applied for regeneration of chromic acid etchant and drag-out recovery of rinse waters from chromium, nickel, gold, silver, tin and zinc baths.
  
- **Ultrafiltration:**
  - In this process, a solution is filtered through an extremely fine filter to remove solids, emulsions, and high molecular weight organics.
  - This process can be applied for regeneration of alkaline cleaners, coolants, or process baths requiring removal of particles and emulsified oils.

When evaluating a recovery process for a particular plating operation, general and site-specific factors must be considered.

These factors include the advantages and disadvantages of the recovery system, the metal being plated, drag-out rates, concentration of metals in the rinse water, rinse water flow-rates, space requirements, personnel requirements, energy requirements, and cost and payback period of the recovery system.

### **d. Sludge reduction.**

Sludges produced in process baths and as a result of wastewater treatment processes, such as hydroxide sludges from precipitation processes, are the greatest environmental burden created by the electroplating industry. These sludges are hazardous wastes that must be appropriately managed. Frequent management problems include the high volume that must be handled, cost for disposal and liability.

Several waste management alternatives are available to help alleviate these problems:

- Mechanical dewatering devices that reduce sludge volumes, such as:
  - Centrifuges.
  - Filter presses.

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- Vacuum filters.
- Sludge dryers.
  
- Chemical treatments for precipitating dissolved metals out of solution. Some chemicals produce less sludge when compared to other chemicals of comparable removal efficiency, such as:
  - Use of caustic soda instead of calcium hydroxide (lime).
  - Use of magnesium hydroxide instead of calcium hydroxide.
  - Use of polymers instead of ferrous sulfate and alum.

Therefore, the selection of a chemical treatment for a particular application is important for reasons of efficiency and sludge volume production.

### **e. Solvent reduction.**

Organic solvents are widely used in electroplating facilities for cleaning and degreasing. The management and disposal of spent organic solvents are becoming increasingly more difficult and expensive.

Some reuse and recovery spent solvents include:

- Cascade reuse, using a spent solvent from a precision cleaning operation as a cleaner for another process that does not require a high purity solvent.
- On-site distillation systems.
- Off-site recycling.

In general, waste management is becoming increasingly more burdensome in terms of time, resources, and costs. Of particular concern to electroplating are such issues as:

- Strict limits for discharging wastewaters to the sewer.
- Costs of wastewater treatment to meet those limits.
- Evolving discharge restrictions are replacing with lower ion concentration limits, mass-load limits, and lower pretreatment concentration requirements.
- Regulatory requirements for hazardous waste management.

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- Costs of managing and disposing of hazardous wastes and associated liabilities.

Waste reduction and recycling can address these problems.

The company shall consider pollution prevention and waste minimization opportunities and implement the cost-effective options not only for law requirements, but also for its own benefits, such as:

- Reduced costs, liability, and risks associated with the management of hazardous waste.
- Reduced water, energy and raw material/chemical requirements.
- Increased production rates and improved product quality.
- Created a safer workplace by reducing exposures to hazardous wastes.

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