SOURCE REDUCTION POTENTIAL IN THE ELECTROPLATING INDUSTRY SIC-3471

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ABSTRACT

The goal of this manual is to describe Source Reduction Techniques available to the Electroplating Industries.

Source Reduction (SR) is defined as on-site activities that reduce the production of hazardous waste at the point of generation. Source Reduction includes good housekeeping practices, process modification, product substitution, waste segregation, reuse and recycling.

Federal, state and local governments are reinforcing legislation restricting the disposal of heavy metals from the plating industry into POTW's, surface waters and landfills. These regulations are limiting the availability of disposal options and increasing the costs of handling hazardous waste. Source Reduction is a waste management option that can help you comply or avoid costs associated with these regulations.

INTRODUCTION

The Massachusetts Hazardous Waste Source Reduction Program conducted by the Department of Environmental Management (DEM), Bureau of Solid Waste Disposal (BSWD), encourages an alternative plan to conventional hazardous waste management.

DEM's efforts to encourage Source Reduction include the following elements:

* Source Reduction Advisory Committee - provides DEM with technical assistance in the planning and implementation of the Source Reduction Program.

* Statewide survey- conducted by GCA Technology Division (consultants) to provide data on hazardous waste generation and source reduction practices in Massachusetts.

* Two source reduction conferences and exhibitions (October 1983 and 1984) and two wastestream-specific seminars on Metallic Wastes in May 1984, the second in June 1984 on Solvent Wastes.

* Coalitions- (The Mass. Coalition for Safe Waste Management Program) funding provided to local, citizen, environmental and industry interest groups to promote public participation and education of the State's Source Reduction program.

* Industry-specific technical assistance manuals such as this one, provide information on available source reduction techniques.

WHY SOURCE REDUCTION

Does Source Reduction (SR) reduce treatment and disposal needs? The answer to this question is a resounding YES. Source Reduction processes offer benefits in the following areas:

* Under the reauthorization of the Resource Conservation and Recovery Act (RCRA, PL98-616, Nov.8, 1984), the EPA will be restricting land disposal of specific waste and liquids and encouraging "waste minimization" processes.

* Decreases the Commonwealth's shortfall capacity for land disposal and the variety of technologies required to handle its hazardous waste stream.

* Decreases dependency on land disposal, associated costs and liabilities. According to EPA, the cost of cleaning up improperly disposed waste is approximately $2,000/ton, while the cost of disposing waste in accordance with RCRA is only $90/ton.

* Minimizes generator liability under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), better known as Superfund. A generator is liable for the disposal of his hazardous waste to a licensed disposal facility. (Public Law 96-510, Sec.107, Liability).

* Decreases dependency on raw materials through reuse and recycling. For example, a company purchases oils at a cost of $2.00 to $4.00 per gallon. Disposal costs for used oil are approximately $1.00 per gallon. An on-site waste oil reclamation system recovers 95% of the oil at an average cost of .$30 per gallon. Using the oil recovery system, the generator saves a net $2.70 to $4.70 per gallon.

* Minimize the impact of "Right to Know" legislation through substitution with less toxic raw materials.

WHAT IS SOURCE REDUCTION

Source Reduction is a preventive waste management strategy requiring a commitment on behalf of corporate management.

Source reduction techniques include:

* Good housekeeping practices resulting in the reduction of wastes produced and raw materials consumed. Examples: adequate preventative maintanence program; eliminating excessive water usage; minimize leaking and spillage of tanks, valves and pumps.

* Product Substitution involving the replacement of hazardous waste-intensive products by a new product that eliminates or reduces the generation of hazardous waste. Examples: replacing chromic acid cleaners with sulphuric acid and hydrogen peroxide cleaners.

* Waste Segregation separating hazardous from nonhazardous waste streams. Examples: separation of process and noncontact cooling waters; avoid mixing a recoverable solvent with a nonrecoverable waste.

* Process Modification requiring altering a waste producing industrial process to minimize the amount of waste being generated. Examples: eliminate acid pickling operation with mechanical descaling system, eliminating hazardous waste generation of spent acid.

* Reuse and Recycling include the use of a waste without prior treatment (reuse) and use of a waste after some form of treatment (recycling). Example: Reuse- solvents used in the electronics industry for cleaning are slightly

without prior treatment. Recycling- reclaiming waste oil for use as a fuel supplement.

* Waste Exchanges (technically not Source Reduction) promote the reuse and recycling of hazardous waste by matching generators with companies that can use their waste in their production process. Examples: The Northeast Industrial Waste Exchange and the California Waste Exchange.

MASSACHUSETTS WASTE STREAM

According to the Directory of Massachusetts Manufacturers, 73 facilities are listed as Electroplating, plating, polishing, anodizing and coloring-- SIC code 3371.

Wastes inherent to these operations include:

* D001- solid wastes that exhibit the characteristic of ignitability.

* D002- solid wastes that exhibit the characteristic of corrosivity.

* D007- Chromium.

* F001- spent halogenated solvents used in degreasing; tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, chlorinated fluorocarbons.

* F002- spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenene, 1,1,2-trichloro-1,2,2-trichloro-1,1,2-trifluoroethane, ortho dichlorobenzene, trichlorofluoromethane.

* F003- spent nonhalogenated solvents: xylene, acetone,ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, methanol, still bottoms from the recovery of these solvents.

* F005- spent nonhalogenated solvents: toluene, methylethyl ketone, carbon disulfide, isobutanol,pyridine, still bottoms from the recovery of these solvents.

* F006- cadmium, hexavalent chromium, nickel cyanide.

* F007- spent cyanide plating solutions from electroplating operations (except precious metal electroplating spent cyanide bath solutions).

* F008- plating bath sludges from the bottom of plating baths from electroplating where cyanides are used (except precious metal electroplating bath solutions).

* F009- spent stripping and cleaning solutions from electroplatingoperations where cyanides are used(except for precious metals electroplating of spent stripping and cleaning solutions).

SOURCE REDUCTION TECHNIQUES

METALS RECOVERY

The electroplating industry pours millions of dollars of valuable metals "down the drain" annually. Operations designed as closed-looped systems, reduce rinse water volumes and facilitate separation processes such as evaporation, ion exchange, reverse osmosis, electrolysis and electrodialysis for the recover of metal cyanides for reuse in plating baths.

The goals of source reduction for the electroplating industry are as follows:

* recover metals in the rinsewater in a form that is reuseable
* reduce the amount of wastewater to be treated, thereby reducing treatment costs
* reduce the amount and degree of toxicity of resultant sludges produced by final treatment, thereby reducing the liability and cost of disposal to the generator.

An industry consultant estimates that it would be technically possible to recover 80-90% of copper, 30-40% of zinc, 90-95% of nickel and 70-75% of chromium presently being trucked as sludge to landfill sites.

Water conservation techniques become an intergal component of the metals recovery process. The "Providence" and "Kushner" rinsing techniques reduce water use as much as 95%, decreasing the hydraulic loading to recovery units. These techniques concentrate dragout from plating tanks by utilizing the dirtiest (most contaminated) rinse tank as a source for metals recovery.

Once these prerecovery techinques are implemented, valuable resources from your hazardous waste stream can be recovered by utilizing the following waste reclamation technologies:

* Evaporation- an evaporator distills rinsewaters from plating lines until the chemicals remaining are concentrated enough to allow reuse in the plating bath. Countercurrent rinse systems are used to concentrate plating chemicals to the point where evaporators can be used to good effect. [Figure1]

In one case of a chrome plating line, the use of sodium metabisulphite for the reduction and precipitation of hexavalent chromium was cut 90% by using a countercurrent rinse and metals recovery system.

The major expense is cooling water and energy costs. Approxmimately 1.1 lbs. of steam is needed to evaporate one pound of wastewater.

The advantages to evaporation include:

* energy source (steam) usually available
* rinse concentrated to plating bath composition
* return distilled water condensate to rinse tanks
* applicable to a large variety of solutions

* Ion-exchange-- a process where certain resins act on a metallic ion solution, selectively replacing their own ions with the ions of the solution. The solution passes through the resin column until it is exhausted. The resin is regenerated by another chemical that replaces the ions given up by the ion-exchange process, converting the resin back into its original state.

Nitric acid, an etchant and stripper, used by electroplaters, become contaminated after use and eventually has to be discarded. Use of ion-exchange/acid purification reclaims the spent acid which is returned to the bath.

The advantages of ion-exchange include:

* no return of organics
* feed stream can be very dilute
* energy consumption minimal
* rugged and suitable for a wide range of uses

* Reverse osmosis- process based on the principle of flow from a greater to a lesser concentration through a semipermeable membrane until an equilibrium is reached. [Figure2]

Reverse osmosis has been successfully used on rinsewaters from a number of electroplating baths including: Watts nickel, copper sulfamate, copper pyrophophate, nickel fluoroborate, zinc chloride, copper cyanide, cadmium cyanide and zinc cyanide.

The advantages of reverse osmosis include:

* unit relatively small requiring minimal installation space
* energy consumption very low
* product waters usually contain less than 10% of dissolved solids, therefore, waters can be directly returned to rinse

* Electrolysis- a process used to plate out dissolved metals, oxidize cyanides or convert trivalent chromium to hexavalent chromium by application of a direct current passed through a metal bearing solution by means of cathode plates and insoluble anodes. As the current flows from the anode to the cathode, the positive metallic ions are attracted to the cathode plate and deposited there. Deposition continues as long as the current is present and sufficient electrolyte exists. Accumulated metal on the cathode is removed as a slab for resale.

New cell designs have brought about drastic improvements, allowing the efficient and economical recovery of metals. These electrolytic techniques include:

* Extended Surface Electrolysis (ESE)

* Fluidized Bed Electrolysis

* Carbon fiber reactor

* System to recycle spent chromic acid by oxidizing trivalent chromium to the hexavalent form

The advantages of electrolysis include:

* established process in the metal finishing industry

* highly efficient energy source (direct current) readily available

* metals recovered are saleable

* Electrodialysis- a membrane process used for the separation, removal or concentration of ionized species in water solution. These operations are accomplished by the selective transport of ions through ion-exchange membranes under the influence of an electrical potential applied across the membrane. Two differing membranes-- an anion-permeable (AP) membrane allows passage of anions only, while the cation-permeable (CP) membrane allows only cations to pass through.

Feedwater travels through compartments formed by spaces between the CP and AP membranes. At each end of the stack, an electrode having the same area as the membrane has a direct current potential applied across the stack causing the positive and negative ions to migrate in opposite directions. [Figure3]

Electrodialysis is an effective method for concentrating rinse waters to a high percentage of their original bath strength. Nickel, copper, chromic acid, iron and zinc can be removed from process waters by electrodialysis. It has also been used to treat spent chromic acid, copper and other solutions.

The advantages of electrodialysis include:

* low energy consumption

* compact equipment

* low capital and operating costs

SOLVENT RECOVERY

There is a change in direction for users of solvents. No longer content to pay money to bury or burn spent solvents, a growing body of solvent users are employing established ways to reclaim these contaminated liquids.

Recent developments in the production of solvent recycling equipment have yielded commercially available units small enough for businesses generating low volumes of waste solvents.

Solvents loss can occur at many phases of the recovery process because solvents are very volitale, even at room temperature. Good housekeeping techniques such as the following can reduce volatile solvent loss (fugitive emissions):

* Increasing the height of the freeboard on a degreaser tank can reduce solvent loss by 25%.

* Insuring covers for an open tank systems are closed when the system is at rest or shut down will result in a 25-50% reduction of solvent loss.

* By retrofitting an open-top vapor degreaser with a second set of condensing coils, a cold blanket of air is created above the vapor zone, preventing the escape of solvent vapors.

Off the shelf units are commercially available for small and medium sized companies that generate solvent wastes. These units have proven to be an economically attractive alternative to recycling or disposal.

* An engineering company in Erie,Penn. manufactures on-site solvent recovery equipment in a variety of sizes. Solvents such as methylene chloride, acetone, MEK, toluene, xylene and many others can be recovered for reuse. The contaminated solvents are heated, causing the vapors to rise, pass through a water condenser and exit as clean liquid flowing to a storage tank. Recovery levels range from 80-95%.

* Another company in San Jose, California, offers simple batch stills with solvent recovery capacities of 10 gallons per

eight hour shift to over 25 gallons per hour and priced from $5,000 to $20,000. Typical solvents handled by these include: halogenated hydrocarbons, hydrocarbons, ketones, alcohols and esters.
Example: Companies are paying, on an average, $2-$5 a gallon for solvents. Add the cost of disposal- let's say $1 per gallon- and you can see the benefits of solvent recovery. An on-site unit recovers at least 90% of the solvent and nets the generator a savings of $2.70-$4.50 per gallon. [5]

On-site recovery of spent solvents offer substantial benefits to the generator by:

* drastically reducing the amount of solvent waste requiring off-site disposal or incineration.

* companies find the machines pay for themselves in 6 months.

* reducing generators liability under CERCLA (Superfund).

* generators need no treatment permit to operate on-site stills according to DEQE.

* decreasing dependency on virgin material and their escalating costs.

CONCLUSION

Given the potential for significant and wide spread damages resulting from inappropriate or accidental waste management practices, source reduction programs are being actively pursued by many hazardous waste generators. Current reduction activities along with those in the planning stages will reduce overall waste generation requiring off-site treatment and disposal and long term liability.

Waste abatement, reuse and recycling technologies offer substantial benefits:

* decreases dependency on TSDF's
* conserves resources
* reduces the cost of pretreatment
* minimizes regulatory and financial costs
* decreases water and sewer-user fees
* minimizes employee, public and environmental exposure to hazardous waste
* reduces the generation of hazardous waste

HAZARDOUS WASTE CAN BE A VALUABLE RESOURCE TO THE GENERATOR WHO ADOPTS SOURCE REDUCTION AS A KEY ELEMENT OF A HAZARDOUS WASTE MANAGEMENT PROGRAM !!!

BIBLIOGRAPHY

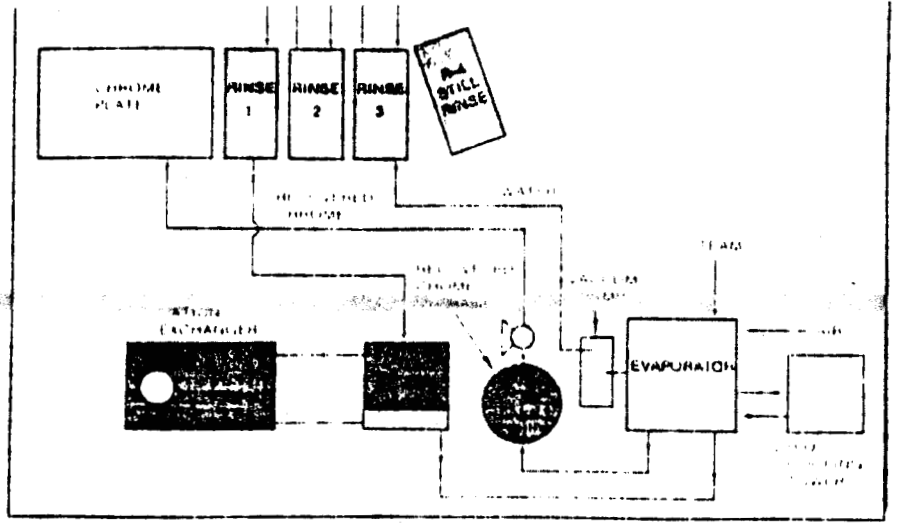

FIGURE 1 CHROMIC ACID EVAPORATIVE RECOVERY UNIT
Source EPA Technology Transfer 625-5/79-016

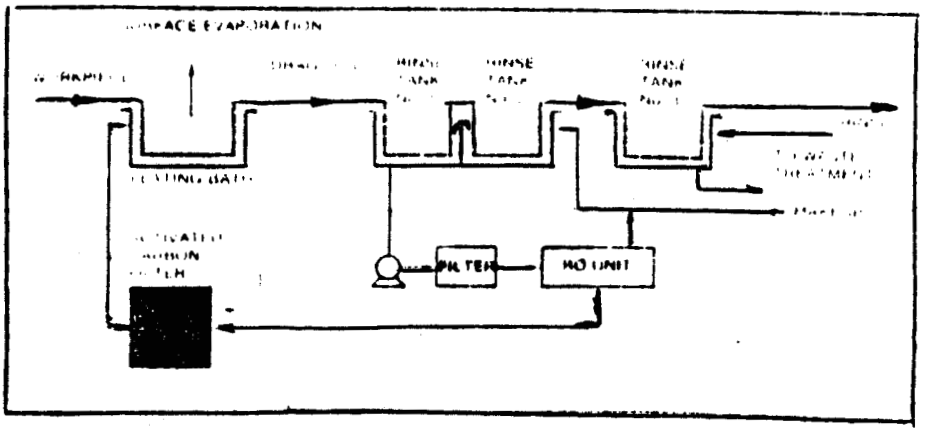

FIGURE 2 REVERSE OSMOSIS FOR NICKEL PLATING DRAG-OUT RECOVERY
Source EPA Technology Transfer 625-5/79-016

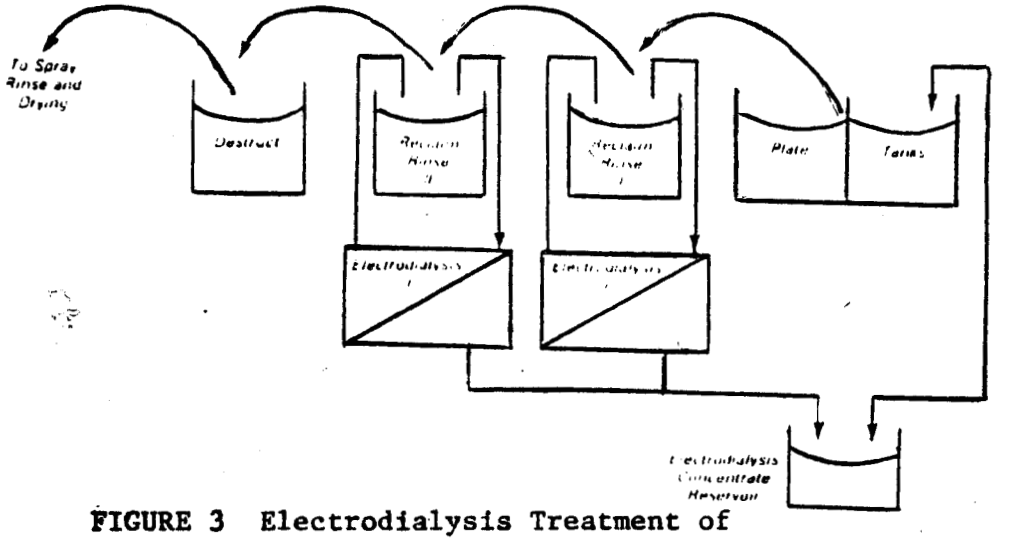

FIGURE 3 Electrodialysis Treatment of Nickel plating line
Source EPA Technology Transfer 600/S2-81-130

BIBLIOGRAPHY

1) Campbell and Glenn; Profit From Pollution Prevention; Toronto, Canada, 1982.

2) Massachusetts Hazardous Waste Source Reduction Conference Proceedings; Bureau of Solid Waste Disposal, Oct. 17, 1984.

3) Generic Process Technologies Studies; Ontario Waste Management Corporation, August 1982.

4) Directory of Massachusetts Manufacturers, 1983-1984 Edition; George D. Hall Company, 1983.

5) F.A. Steward, ERC/Lancy;Conservation and Recovery of Materials and Treatment of Wastes, 1981.

6) Laughlin, Forrestall and McKim; Primary Metals Industry Technical Manual Waste Abatement, Reuse, Recycling ande Reduction Opportunities in Industry; November 1984.

7) Alternates to the Land Disposal of Hazardous Wastes; prepared by the Toxic Waste Assessment Group; State of California, 1981

8) Pollution to Profit: Reducing Industrial Waste in Illinois, Proceedings of the Waste Reduction Conference, April 16-17, 1984; Document No. HW 84/02; Illinois Department of Energy and Natural Resources, June 1984.

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