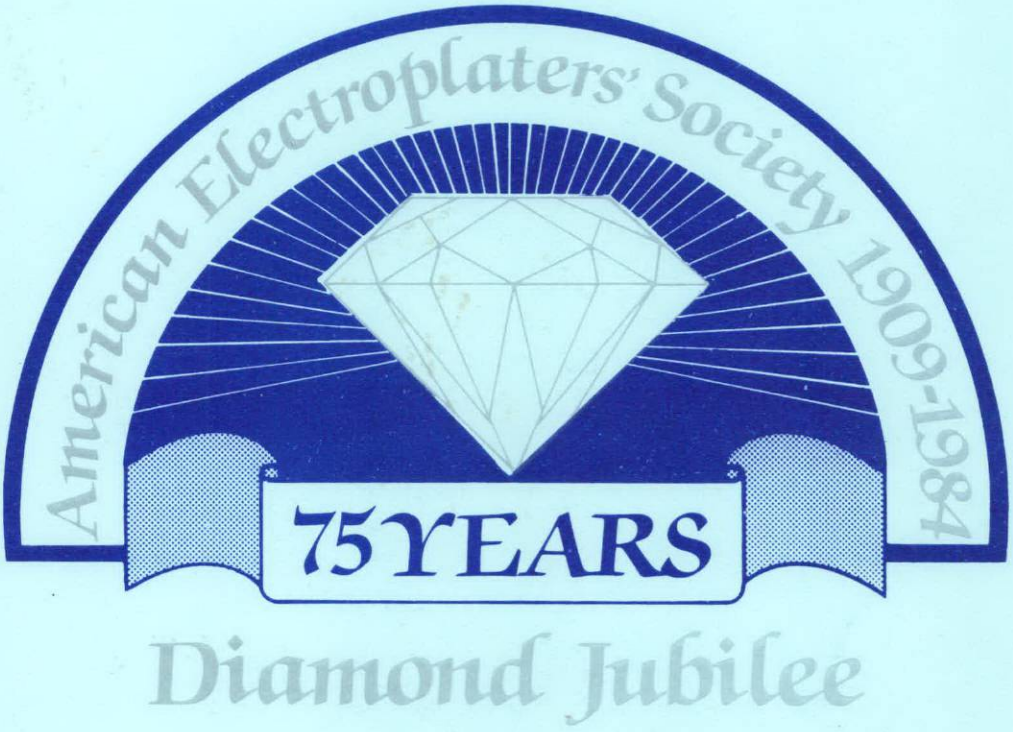
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SUR/FIN

American Electroplaters' Society

SUR/FIN '84

71st Annual Technical Conference



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Session L - Environmental II

AMERICAN ELECTROPLATERS' SOCIETY, INC.

71ST ANNUAL TECHNICAL CONFERENCE - NEW YORK CITY

ENVIRONMENTAL II

SESSION L

Page No.

Toxic & Hazardous Waste Management for Metal Finishers.....L-1

Ted T. Topolski and Robert F. Skach, ETI of North America, Inc., Overland Park, KS

Industrial Hygiene Considerations In The Electroplating/Metal Finishing Industry.....L-2

Barbara N. Mabbett, Mabbett, Capaccio & Associates, Inc., Cambridge, MA

Contingency Planning.....L-3

Jack Henderson, Jack Henderson Co., Falconer, NY

Recent Studies and Applications of Radiation Grafted Structures...L-4

Vincent D'Agostino and George Schore, RAI Research Corp., Hauppauge, NY

L-1

Environmental II
Session L

Toxic & Hazardous Waste Management For Metal Finishers

Ted T. Topolski and Robert F. Skach
ETI of North America, Inc.
Overland Park, KS

TOXIC & HAZARDOUS WASTE MANAGEMENT FOR METAL FINISHERS

By

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ABSTRACT

Review the statutory and regulatory programs for management of toxic and hazardous wastes, including PCB's, asbestos and toxic organics at facilities and in their discharges. Record keeping, and the current impact of OSHA's new Hazardous Chemical Communication and Labeling Regulations for metal finishers. Guidance will be given on PCB reporting requirements, RCRA requirements and contingency plans, concluding with a checklist to aid in the development of comprehensive programs.

Introduction

This paper will review some of the recent and lesser known regulatory programs dealing with management of toxic and hazardous waste in the Metal Finishing Industry. Some of these wastes will not be present in every plating shop, but are very common in the larger captive metal finishing facilities, ranging from the small jeweler and independent printed circuit board manufacturer, up to the automotive, aircraft and steel manufacturing operations. The purpose will be to highlight these regulations, using them as a guide to industry in the proper management techniques and proceddures for safeguarding their employees, the community and the environment. This will be an over simplification, due to the broad coverage and limited time, but references to the regulations and laws will be presented where appropriate to provide more comprehensive information.

Let's first review the statutory elements which form the basis for the regulations as we know them. Each law has its specific target area of responsibility. There are some overlaps between each regulation and there are regulations and laws beyond the scope of this paper also having control over these wastes. Nevertheless, this will provide a basic check list to help in these mangement programs.

The Toxic Substances Control Act (TSCA) controls the use of toxic materials in the work place and environment. It has broad coverage, but our focus will be on management of toxic wastes as defined by this law and the ensuing regulations. The William-Steiger Occupational Safety and Health Act (OSHA) is generally concerned with employee health and safety, but our emphasis will be on some new regulations regarding Communication and Labeling for Hazardous Chemicals.

The next law is one we are all familiar with, the Clean Water Act, (CWA) and its control of effluents discharged to publicly owned treatment works (POTW) and directly to the environment. Again, our emphasis will be on toxics management, particularly the new regulations on Total Toxic Organics, (TTO's), and how they are regulated and controlled. This paper will not address the management of the other toxics familiar to you all, which include cyanides and heavy metals, as they are thoroughly addressed by other authors.

Another law familiar to us is the Resource Conservation and Recovery Act (RCRA) and its voluminous ever-changing regulations. These will be reviewed to focus on current activities and programs to keep the environment safe and encourage recovery.

Finally, the most recent environmental legislation is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which is better known as the Superfund Act. This legislation gives the EPA the authority to clean up hazardous

spills and has unique funding provisions that have a significant impact on all metal finishing operations.

There are numerous other legislative vehicles that touch on our methods of management of toxic and hazardous waste beyond the scope of this paper, but will be mentioned here in this introduction. They include the Hazardous Materials Transportation Act; the Safe Drinking Water Act; the Marine Protection, Research and Sanctuary Act; the Clean Air Act; the Administrative Procedures; the Small Business Act and the Tax Reform Act. Each of these have features that control and assist industry in management of these wastes.

You are probably wondering why a representative from EPA is not presenting this paper. The explanation is simple. Since each law and subsequent regulation is promulgated, administered, permitted, enforced, funded and litigated by separate government agencies and departments within each agency and by different levels of government,e.g., federal, state, and local. There experts are certainly more knowledgeable about their respective area of responsibility, but as a consultant, we have developed a broad knowledge to assist our clients in development and administration of efficient, comprehensive management programs. As our service to this fine educational society, it is our responsibility to share this knowledge and clarify the programs to assist in this monumental management effort. We all have a common goal to protect the environment while still maintaining a reasonable profit margin to sustain our businesses.

TSCA

Some examples of TSCA regulations impacting your facilities include control of Polychlorinated Bipheyls (PCB's). These dielectric fluids, having excellent heat conductance and stability, made them the preferred liquid in electrical transformers and capacitors, heat transfer systems and many hydraulic fluid applications. They were manufactured principally by Monsanto Corporation under the generic name of Askerel as a non-flammable insulating liquid until 1977. Due to the suspected ecological problems, and the fact that they continually accumulate in man, EPA has developed a series of regulations governing their use and disposal,(44CFR, Part 761, May 31, 1979, and August 25, 1982). The fact of their common presence in industry, without the knowledge of the users, coupled with the potential for catastrophic production of dioxins through incomplete combustion during accidental or intended burning, has produced alarming situations warranting a strict control procedure for their usage. This includes extensive inventory requirements, routine inspections and record keeping procedures, diligent repair, with prompt and secure disposal. Figure 1 and 2 provide samples of two of the annual reporting requirements needed for all users of PCB equipment.

SUMMARY PAGE

PCB ANNUAL REPORT - PCBs REMOVED FROM SERVICE

Period Beginning _____ Period Ending _____

NAME _____

ADDRESS _____

1. Total Weight (Kilograms) of any PCBs and PCB Items in PCB Containers: _____Kg

   a. Identification of Container Contents

      PCB Liquids _____ PCB Capacitors _____

2. Total Number of PCB Transformers _____

   a. Total weight of PCB fluid contained in the transformers _____Kg

3. Total number of PCB large high voltage capacitors _____

Submitted by: Name: _____

Title: _____

Date: _____

SUMMARY PAGE

PCB ANNUAL REPORT - PCBs REMAINING IN SERVICE

Period Beginning_____Period Ending_____

NAME _____

ADDRESS_____

1. Total Weight (Kilograms) of any PCB's and PCB Items in PCB Containers:_____kg

   a. Identification of Container Contents

      PCB Liquids _____PCB Capacitors_____

2. Total Number of PCB Transformers_____

   a. Total Weight of PCB Fluids contained in the Transformers_____kg

3. Total Number of PCB large high voltage capacitors

   _____

Submitted by: Name:_____

Title:_____

Date:_____

For PCB transformers, additional records of the inspection and maintenance history are to be maintained and kept on file for at least three years after disposing of a transformer. The records to be maintained are:

(1) The location of the PCB transformer.

(2) The date of each visual inspection, and the date that a leak was discovered if the date is different from the scheduled inspection date.

(3) The person performing the inspection.

(4) The location of any leaks.

(5) An estimate of the amount dielectric fluid released from any leak.

(6) The date of any cleanup, containment, or repair performed.

(7) The results of any containment and daily inspection required for uncorrected active leaks.

The following PCB use prohibitions have been instituted:

(a) Hydraulic and heat transfer systems after July 1, 1984.

(b) Transformers posing an exposure risk to food or feed after October 1, 1985.

(c) Large capacitors after October 1, 1988.

There are only a few disposal sites and destruction processes available for the waste liquids and contaminated equipment. Table No. 1 gives a guide for the various disposal options for PCBs. Many firms are unaware of the problem and are now faced with severe legal penalties and untimely remedial action programs when they can least afford them.

Another toxic substance of concern is asbestos. This common insulation material is prevalent in industry for freeze protection, maintaining high termal efficiencies and even for ceiling and wall insulations in offices and manufacturing areas. EPA's regulations governing asbestos are published in 40CFR, Part 61, April 6, 1973, titled National Emission Standards for Hazardous Air Pollutants. Improper handling and disposal can be damaging to plant personnel and neighbors, in addition to the fines incurred. It would be wise to inspect your facility for any suspected asbestos materials and

Table 1

DISPOSAL OPTIONS

ITEM	INCIN-ERATE	EPA APPROVED LANDFILL	HIGH EFFICIENCY BOILER	MUNICIPAL LANDFILL	SALVAGE	EPA APPVD ALT.TO INCINERATE
PCB Transformers (≥500 PPM PCB)	Yes	[1]Yes	No	No	No	No
PCB-Contaminated Transf. (>50<500 PPM PCB)	N/R	N/R	No	[1]Yes	[1]Yes	[3]Yes
Large PCB Capacitors (≥3 pounds PCB)	Yes	No	No	No	No	[3]Yes
Small Capacitors (<3 pounds PCB)	Yes	Yes	No	[2]Yes	No	No
PCB hydraulic Devices	N/R	N/R	No	[1]Yes	[1]Yes	Yes
Other PCB Articles	Yes	Yes	No	No	No	Yes
PCB Containers (≥500 PPM PCB)	[1]Yes	[1]Yes	No	No	No	[3]Yes
PCB Contaminated Containers (>50<500 PPM PCB)	N/R	N/R	No	[1]Yes	No	Yes
Properly Decontaminated PCB Containers	N/R	N/R	No	[1]Yes	[1]Yes	Yes
PCB Liquid (≥500 PPM)	Yes	No	No	No	No	[4]Yes
PCB Contaminated Liquid (>50<500 PPM PCB)	Yes	[5]No	Yes	No	No	[3,4]Yes
Non-PCB Liquids (≤50 PPM PCB)	Dispose of as waste oil; only restriction is that it cannot be used as dust control sealant or coating.					
Solid PCB Wastes: dredge spoils, sewage treatment sludges.	Yes	Yes	No	No	No	No
Materials contaminated from PCB spills; soil, sand, gravel, rags, wood, etc.	Yes	Yes	No	No	No	Yes

1. Requires proper draining and flushing as specified in Regulations.
2. Symbols used: (<) Less than, (>) Greater than, (=)equals to
3. ENVIRONMENTAL INTERNATIONAL OF N.C. (913) 321-3155 is approved by the EPA as an Alternative to Incineration for Reclamation and Recovery at their facility.
4. Contaminated Oil is treated by some companies, Regional EPA Approval required for Chemical Treatment.
5. Some landfills will accept solidified, contaminated Oils.
6. ETI of North America, Inc., 1-800-255-0530, is approved by the EPA to handle PCB wastes.

retain professional assistance to appraise the problem and develop an efficient and safe decontamination program. These regulations are actually under the authority of the Clean Air Act and there are other regulations under OSHA, all governing handling of friable asbestos.

OSHA

A new facet of OSHA that should be brought to your attention is the upcoming requirement to educate your employees in proper handling of hazardous chemicals. Although these regulations specificially exclude hazardous waste as defined under RCRA, a brief introduction appears to be appropriate. Chemical manufacturers are charged with the responsibility of properly labeling their products and providing materials to train the users in their hazards (29 CFR, Part 1910, November 25, 1983). By November 25, 1985, chemical manufacturers, importers and distributors, shall label containers of hazardous chemicals leaving their work places, and provide material safety data sheets with initial shipments. These regulations will directly impact metal finishers by May 25, 1986, when all employers using these chemicals shall be in compliance with all provisions of this section, including initial training for all current employees. Some of the training features of this regulation include:

1) Methods and observations that may be used to detect the presence or release of hazardous chemicals in the work area.

2) Physical and health hazards of the chemicals in the work area.

3) The measures employees can take to protect themselves from these hazards.

4) The details of the hazard communication program developed by the employer.

Note that this applies to all hazardous chemicals, with the exception of hazardous wastes, but it would be wise to include the handling of hazardous wastes in your training programs to provide a comprehensive coverage that would protect your employees and also comply with the training requirements in accordance with the RCRA regulations.

CWA

The CWA's primary emphasis has been on the control of toxic liquid discharges. Recent attention has focused on the toxic organics prevalent in industry, especially in the Metal Finishing Industry. The EPA is concerned about discharge to the POTW system as well as directly into streams. There are two options provided for in the

recent Electroplating and Metal Finishing Regulations (40 CFR, Parts 413 and 433, July 15, 1983): Solvent management practices and/or precipitation/clarification of the toxics from wastewaters. The first level of treatment establishes a total Toxic Organic (TTO) concentration limitation of 4.57 milligrams per liter by June 30th using solvent management, and 2.13 milligrams per liter by February 15, 1986, using the precipitation/clarification controls in addition to the solvent management program. One important feature of the TTO regulation is the ability to waive or at least reduce the expensive monitoring requirements to show compliance. This can be done by certifying the implementation of a solvent management plan, which includes a list of any toxic organic compounds used, the method of disposal and procedures for assuring that these organics do not routinely spill or leak into the wastewater.

Also note that there are certain industrial categories that have special regulations or clauses in these regulations establishing different compliance dates. As an example, plants also covered by the Iron and Steel industrial category, (Part 420), must be in compliance by July 10, 1985, in lieu of the June 30th date.

Another concern for this part of the regulations is the actual monitorying. Special sampling techniques and apparatus are required in addition to the need for GCMS analytical capabilities. Since there are over 100 organic compounds listed, and the limitation is a summation of all quantifiable values greater than 0.01 milligrams per liter, accuracy is of the utmost importance. A summation of .01 milligrams per liter for each compound would amount to over 1.0 milligram per liter by itself, not allowing for any significant concentration from any single compound. Therefore, development of a professionsl monitoring and control program is normally the cheapest in the long run. It can point to the source of the problem more effectively and ensure that unnecessary costs are not incurred in treatment of wastes from non-polluted sources.

RCRA

As we all know, this is the primary regulatory vehicle for "cradle to grave" handling of hazardous wastes. This regulatory program requires proper identification listing, tracking, management, and transportation of hazardous wastes. Some of the features that metal finishers should be aware of are:

(1) Obtain proper permits for the use of impoundments for hazardous wastes, e.g., a polishing pond receiving effluent from a waste treatment facility would be considered a hazardous waste impoundment and must be designed, operated and permitted as such.

(2) Develop contingency plans and the proper facilities

and training for areas where hazardous wastes are generated and temporarily stored.

(3) Test wastes for hazardous characteristics, even though they are not listed.

(4) Storage of hazardous wastes longer than 90 days requires a storage permit.

(5) Complete and file biennial reports for treatment, storage or disposal facilities by March 1st.

(6) Properly manage and complete manifests.

(7) Develop spill control and countermeasure plans for storage of waste oils.

We have learned that the temporary delisting program has been discontinued and this will greatly increase the difficulties in successfully petitioning your case. We have also learned that all temporarily delisted wastes will now be required to obtain permanent delisting through a new petition within 12 to 18 months.

The permanent program will require more comprehensive evaluation of the waste, including review of all possible reasons for characterizing it as hazardous waste, plus public hearings. As an example, plating wastewater treatment plant sludge (F006) was originally listed because of toxicity due to the presence of cadmium, chromium, nickel and complexed cyanide. The temporary delisting petition was mainly responsible for showing that it was not toxic based on these constituents. The new regulations are expected to require complete evaluation of all the listed toxics plus the other characteristics for which wastes can be defined as hazardous; e.g., ignitability, reactivity and corrosivity. In addition, all the other evaluation factors must be more thoroughly addressed to determine whether a waste is capable of posing a substantial present or potential hazard to human health when <u>improperly</u> treated, stored, transported, disposed, or otherwise managed. It is uncertain whether this relisting of previously "delisted" wastes will introduce new liabilities for the landfill operators and the generators if they were disposed of in non-hazardous landfills. It would be wise to use manifest controls with secure disposal of all industrial wastes regardless of the current status of your temporarily delisted wastes.

An effective management program we have used involves the segregating of waste streams in metal finishing shops to minimize the quantity of actual hazardous waste generated. Only a certain volume of the metal finishing shop wastewater produces hazardous waste sludges, e.g., certain plating wastewater rinses and dumps (F006, 7, 8 & 9). It has been economical to isolate these wastewaters, which produce hazardous waste sludges, into separate treatment and sludge handling systems. Then the other industrial wastewaters, including many metal finishing operations, can be

treated and their sludge handled as non-hazardous materials. This is a goal of of the EPA as well as good fiscal sense, because it reduced the volume of waste requiring specialized disposal in the limited hazardous waste landfills.

On the legislative front, Congress is proposing changes to RCRA that would reduce the small generator values to as little as 25 kilograms per month. Another feature is phased prohibition of land disposal of certain wastes.

CERCLA

Superfund means BIG BUCKS, which are funded by every metal finisher. 87.5% of this $1.6 billion fund is financed by taxes on manufacturing or import of certain chemicals and petroleum. The rest comes from the general revenue, e.g., from all taxpayers. There is also a Post Closure Liability Fund (financed by a tax on waste disposed in RCRA-permitted facilities), to assure that financial obligations of these facilities can be met, even after closure. We all pay, but metal finishers, as consumers of large quantities of chemicals, are picking up much of the tab. But that's not all. This is merely seed money to get spills and abandoned or illegal disposal operations corrected as quickly as possible. Then the EPA goes back to the parties "responsible" and sues to recover their costs, including treble the actual cost for punitive fines if the ordered actions are not undertaken by the responsible parties.

This program involves Emergency Response Teams, staffed, equipped and available nearby, and at all times, to respond to emergency spills. We all know how expensive this can be; but, of course, it is necessary to protect the environment. A determination of the "responsible" parties can bring in seemingly unrelated companies into this massive legal nightmare.

A review of some examples of actual projects we have encountered will help illustrate this point. The names and actual circumstances have been modified slightly to maintain confidentiality and combine several projects into this single example.

The Smith Plating Shop is located in a small town, discharging into a small stream. Mr. Smith has had a simple treatment lagoon for 20 years. He periodically excavated sludge from this lagoon and disposed of half of it on-site in his landfill and had the rest hauled to a local dump by a private hauler. Five years ago, Jack Jones bought the shop and has improved the waste treatment in compliance with his NPDES permit, but still uses the pond to provide effluent polishing before discharging into the stream. All of the sludges removed from the main treatment facility are dewatered and hauled to a permitted, hazardous waste disposal facility.

Last year, Bill Farmer drilled two wells for watering his livestock

on property adjacent to the abandoned dump that received Smith's sludge. His livestock became sick and died. He complained to the EPA.

After months of investigations, they identified this as a "CERCLA Site" and authorized emergency cleanup action at the highly inflated ERT contract rate. Mr. Smith is deceased. EPA joins Mr. Jones and the hauler in litigation and finds them responsible for reimbursement for the cleanup. While investigating this problem, they notice "vegetative stress" from aerial photos of Jones' property and discover the landfill of heavy metal and cyanide sludges, again, unknown to Mr. Jones. Due to their continued investigation, they also fine Mr. Jones for operating his polishing pond as a hazardous waste impoundment without a RCRA permit and require immediate closure of this pond by emergency operations. An intensive soil and groundwater monitoring program is required to track pollution and mitigate further environmental damage. New polishing treatment systems are required and the total monitary cost for this emergency cleanup operation is $500,000.00. In addition, there are still potential fines and legal and engineering professional fees for defense and development of closure plans. Another cost that is harder to define is the disruption of plant production by diversion of plant management and operations personnel during this entire program.

This sounds like a horror story, but it occurs routinely around the country. All parties involved were acting in good faith, but Jones was left holding the bag, because he had some income.

SUMMARY

Toxic and hazardous waste management is a specialized profession requiring constant attention. Care must be taken during the entire cycle of manufacturing from plant acquisition or design through all phases of production and concluding with final closure. Some of the key items to include in your toxic and hazardous waste management program are as follows:

1. Develop toxic and hazardous waste management programs at the corporate level and at each profit or manufacturing center, with adequate funding and authority for control.

2. Training of management and operations personnel, with respect to environmental regulations, liabilities and responsibilities.

3. Training of operations and management personnel in safety and spill control for toxic and hazardous waste.

4. Development of required spill prevention control and countermeasure plans and hazardous waste contingency plans for all regulated operations.

5. Develop recordkeeping and inspection programs in compliance with regulations.

6. Analytical monitoring of all regulated materials and wastewaters with proper sampling procedures, statistical validity tests and chain-of-custody protocols.

7. Development of storage and handling facilities and procedures to minimize spillage and discharges.

8. Procurement of safety equipment and facilities.

9. Routinely contract for independent professional environmental audits of facilities to monitor compliance with regulations and prevent surprises when EPA makes their official compliance inspections.

10. Continual training and education of staff through environmental courses, attendance at environmental conferences and certification programs.

11. Professional engineering of facilities and analytical monitoring programs.

12. Diligent selection of waste hauling and disposal contractors and control of all manifests.

13. Development of a close rapport with regulatory agencies at all levels of government.

14. Prompt and professional response to any violation.

15. Efficient and thorough housekeeping, waste segregation and waste reduction programs.

16. Comprehensive inventory and purchasing control to monitor products coming into facility and tracking them through the production cycles.

If you successfully complete this checklist, you should be adequately prepared when an official inspection occurs. Each federal agency and their different departments, plus the various state and local agencies, are continually engaged in inspections. They select candidates randomly, and in response to the historical record for violations in certain industrial classifications. Previous citations generally trigger repeat inspections by the same agency, so you can generally be assured that "lightening <u>will</u> strike twice." Citizen complaints also trigger inspections, so good neighbor policies usually pay valuable dividends.

Another device used is referrals from other agencies. A special agency titled the Interagency Regulatory Liaison Group has been formed representing the Consumer Product Safety Commission (CPSC);

the Environmental Protection Agency (EPA); the Food and Drug Administration, Department of Health, Education and Welfare (FDA); and the Food Safety and Quality Service, Department of Agriculture (FSQS).

The following are some visual signs listed in their published Referral Guide, which generally connote potential violations. (Federal Register 3/28/80, pp. 20639-20641)

Water (EPA)

1. Presence of the following in the vicinity of waste discharge; foam, scum, dead aquatic life, oil solids, algae.

2. Evidence of: oil/chemical spills/leaks, improperly maintained spill containment dikes, uncontrolled pipe discharge.

Air (EPA)

1. Stack emissions other than steam; white, black, other.

2. Fugitive emissions other than steam from: doors, windows, equipment.

3. Fugitive dust fall-out.

4. Open burning: trash piles, disposal area, other.

This information would be referred to EPA by federal inspectors from the other agencies if any of the above signs are observed.

The inspector, whether from EPA or another agency, will often not alert you of any potential violations. In fact, the first knowledge of some of our clients' violations came in the newspaper six months later. Requesting confidentiality can help prevent the newspaper from learning first, but it won't speed up your notification. It is best to keep in contact with the inspector, get his reports and conduct an internal audit to ensure that you have no violations before a legal citation is made. And, if you are cleared by one branch of EPA, such as TSCA, it doesn't mean they won't return comments about your facility to another agency such as RCRA, or a state agency that has jurisdiction.

This isn't meant to develop paranoia or an adversary relationship with the regulatory agencies, it is just good business sense, similar to proper accounting practices to keep the IRS auditors satisfied. Environmental laws are much more complex than tax laws; and the consequences for failure to comply are infinitely more severe when you consider environmental and health hazards that could result, plus the fines and remedial action expenses.

Each agency's enforcement groups have standard guidance for their inspectors. Attached to this paper is a reprint of EPA's "Generators Checklist" from the RCRA Inspection Manual to assist in your internal audits. There are similar checklists for hazardous waste treatment, storage and disposal facilities and other RCRA regulated activities in this manual. For more information, contact the authors at 1-800-255-0530.

GENERATORS CHECKLIST

Section A - EPA Identification No.

1. Does Generator have EPA I.D. No.? ___Yes___No

   a. If yes, EPA I.D. No. _ _ _ _ _ _ _ _ _ _ _ _

Section B - Manifest

1. Does generator ship waste off-site? ___Yes___No

   a. If no, do not fill out Sections B and D

   b. If yes, identify primary off-site facility(s) Use narrative explanations sheet.

2. Does generator use Manifest? ___Yes___No

   a. If no, is generator a small quantity generator: ___Yes___No

      1. If yes, does generator indicate this when sending waste to a T/S/D facility ___Yes___No

   b. If yes, does manifest include the following information?

      1. Manifest Document No. ___Yes___No

      2. Generators Name, Mailing Address, Telephone No. ___Yes___No

      3. Generator EPA I.D. No. ___Yes___No

      4. Transporter(s) Name and EPA I.D. No. ___Yes___No

      5. a. Facility Name, Address and EPA I.D. No. ___Yes___No
         b. Alternate Facility Name, Address and EPA I.D. No. ___Yes___No
         c. Instructions to return to generator if undeliverable? ___Yes___No

      6. Waste information required by DOT - Shipping name, quantity, (weight, or vol.) containers (type and number.) ___Yes___No

      7. Emergency Information (optional) (special handling instructions, phone no.) ___Yes___No

8. Is the following certification on each manifest form? ___Yes___No

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the EPA.

9. Does Generator retain copies of Manifests? ___Yes___No

If yes, complete a through e.

a. (1) Did generator sign and date all manifests? ___Yes___No
(2) Who signed for generator?

Name_____ Title_____

b. (1) Did generator obtain handwritten signature and date of acceptance from initial transporter? ___Yes___No
(2) Who signed and dated for transporter

Name_____Title_____

c, Does generator retain one copy of manifest signed by generator and transporter? ___Yes___No

d. Do returned copies of manifest include facility owner/operator signature and date of acceptance? ___Yes___No

e. Does generator retain copies for 3 years? ___Yes___No

Section C - Hazardous Waste Determination

1. Does generator generate solid waste(s) listed in Subpart D (List of Hazardous Waste)? ___Yes___No

a. If yes, list waste and quantities_____ (include EPA Hazardous Waste No.)

2. Does generator generator solid waste(s) listed in Subpart C that exhibit hazardous characteristics? (corrosivity, ignitability, reactivity, EP toxicity) ___Yes___No

a. If yes, list wastes and quantities_____ (include EPA Hazardous Waste No.)

b. Does generator determine characteristics by testing or by applying knowledge of processes? _____

1. If determined by testing, did generator use test methods in Part 261, Subpart C (or Equivalent)? ___Yes___No

a. If equivalent test methods used, attach copy of equivalent methods used.

3. Are there any other solid wastes generator by generators? ___Yes___No

a. If yes, did generator test all wastes to determine non-hazardous characteristics? ___Yes___No

1. If no, list wastes and quantities deemed non-hazardous or processes from which non-hazardous waste was produced? (Use additional sheet if necessary.)

_____

_____

_____

Section D - Pre-Transport Requirements

1. Does Generator package waste in accordance with 49 CFR 173, 178, and 179? (DOT requirements) ___Yes___No

2. a. Are containers to be shipped leaking or corroding? ___Yes___No
   b. Use sheet to describe containers and condition. ___Yes___No
   c. Is there evidence of heat generation from incompatible wastes in the containers? ___Yes___No

3. Does the genertor use DOT labeling requirements in accordance with 49 CFR 172? ___Yes___No

4. Does the generator mark each package in accordance with 49 CFR 172? ___Yes___No

5. Is each container of 110 gallons or less marked with the following label? ___Yes___No

Label saying: HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal. If found, contact the nearest policy or public safety authority or the U.S. Environmental Protection Agency.

Generator/s Name and Address_____

_____

Manifest Document Number_____ _____

6. Does generator have placards to offer to transporters? ___Yes___No

7. Accumulation Time

a. Are containers used to temporarily store waste before transport? ___Yes___No

1. If yes, is each container clearly dated? Also, fill out rest of No. 7 (Accum. Time) ___Yes___No

b. 1. Does generator inspect containers for leakage or corrosion? (265.174 - Inspections) ___Yes___No

2. If yes, with what frequency? _____

c. Does generator locate containers holding ignitable or reactive waste at least 15 meters (50 feet) from the facility's property line? (265.176 - Special Requirements for Ignitable or Reactive Wastes) ___Yes___No

NOTE: If tanks used, fill out checklist for tanks.

d. Are the containers labeled and marked in accordance with Section D 3, 4, & 5 of this form? ___Yes___No

NOTE: If generator accumulates waste on-site fill out checklist for General Facilities, Subparts C and D

e. Does generator comply with requirements for personnel training? (attach checklist for 265.16 - Personnel Training). ___Yes___No

8. Describe storage area. Use photos and narrative explanation sheet.

Section E - Recordkeeping and Records

1. Does generator keep the following reports for 3 years?

a. Manifests and signed copies from designated facilities? ___Yes___No
b. Annual reports ___Yes___No
c. Exception Reports ___Yes___No
d. Test results ___Yes___No

2. Where are the records kept (at facility or elsewhere)?_____

3. Who is in charge of keeping the records?

Name_____ Title_____

Section F - Special Conditions

1. Has generator received from or transported to a foreign source any hazardous waste? ___Yes___No

   a. If yes, has he filed a notice with the Regional Administrator? ___Yes___No
   b. Is this waste manifested and signed by Foreign consignee? ___Yes___No
   c. If generator transported wastes out of the country has he received confirmation of delivered shipment? ___Yes___No

L-2

Environmental II
Session L

Industrial Hygiene Considerations In The Electroplating/Metal Finishing Industry

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INDUSTRIAL HYGIENE CONSIDERATIONS IN THE ELECTROPLATING/METAL FINISHING INDUSTRY

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I. Introduction

Industrial hygiene considerations play an important part in helping to provide a safe and healthy workplace. Productivity is often directly related to workplace conditions and employee health. The employer must ensure that adequate environmental controls are provided to reduce and/or eliminate adverse occupational exposures. Such considerations are of particular concern in the electroplating/metal finishing industry where a myriad of potential chemical and ergonomic exposures routinely exist. The use of local exhaust ventilation, personal protective equipment, and the establishment of employee training programs are critical areas of concern. Continued emphasis by federal, state and local agencies including recent Occupational Safety and Health Administration regulations regarding hazard communication and individual State Right-to-Know Acts will require increased employer activity. Employee exposures common to the electroplating/metal finishing industry will be discussed. Administrative and engineering control recommendations to control potential exposures will also be presented.

II. The Occupational Safety & Health Act

The Williams-Steiger Occupational Safety and Health Act of 1970 (P.L. 91-596) was enacted to improve the health, safety and welfare of working individuals. The Act "assures as far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources". This assurance is accomplished through the promulgation and implementation of codes, standards and regulations by the Secretary of Labor, which apply to general manufacturing industry in the United States including the electroplating/metal finishing industry.

The health standards promulgated and established by the Secretary of Labor are those that are required to be utilized by the employer to protect employees against potential health hazards and harmful materials and contaminants in the workplace. Standards applicable to the

electroplating/metal finishing industry are found in OSHA Title 29 Code of Federal Regulations Part 1910 General Industry Standards. In many cases, these standards are national consensus standards which have been adopted by the Federal government.

III. Permissible Exposure Limit

The Occupational Safety and Health Administration (OSHA) has the regulatory authority to protect employees from toxic and hazardous chemical substances. In the early 1970's, OSHA adopted as federal permissible exposure limits (PEL) the recommended American Conference of Governmental Industrial Hygienists (ACGIH) 1968 threshold limits values (TLV) for industrial chemical exposures. The PEL is defined as the time-weighted average concentration for an 8.0 hour day, 5 day work week, to which a majority of workers may be repeatedly exposed without detrimental effects. OSHA standards require legislation to adopt or amend; a lengthy administrative process.[1,2]

Since adoption of the 1968 Edition of ACGIH TLV's by OSHA, more recent toxicological information has indicated a need to reduce several TLV's to assure the health and safety of the worker. Therefore, although the TLV's are not legal standards, it is good engineering practice to consult them when reducing workplace chemical exposures to acceptable levels. The ACGIH TLV's are updated annually and should not be confused with the OSHA PELs which are not updated annually.

If industry can maintain chemical exposures to within acceptable limits established by OSHA and/or recommended by the ACGIH then the hazard potential to employees will be greatly reduced, if not eliminated. It is the employer's responsibility to comply with applicable workplace standards; if the employer does not comply, he can be issued a citation by OSHA and ordered to abate the hazard. If the employer fails or refuses to abate the hazard he will face a penalty of a fine, imprisonment, or both. In addition, employers must make workers aware of the Occupational Safety & Health Act and a copy of the Act along with the General Industry Standards must be made available to them upon request.

Employers can achieve compliance with the standards by the recognition and evaluation of potential hazards and the ultimate control of such hazards.

IV. Recognition and Evaluation

The industrial environment must be evaluated on a routine basis in order to recognize potential hazards. The evaluation assesses process operations completed, employee work practices, chemicals stored, handled and used, and ergonomic impact (i.e. cold, heat, noise, stress, etc.). The evaluation must be completed by persons trained to recognize potential industrial hygiene problems. In most instances, an industrial hygienist will complete the evaluation, and will consult with engineers, medical personnel, chemists and other personnel familiar with plant operations and procedures. They must work together to recognize environmental stress in the workplace and to further evaluate the level and extent of environmental stress imposed on the employees.

In order to recognize and evaluate chemical and ergonomic impacts responsible for imposing worker stress, an industrial hygiene survey/audit should be conducted. The industrial hygiene survey/audit assesses process operations and equipment and evaluates methods currently being used for the control of environmental stress. The survey must obtain a list of all chemicals used, including reaction intermediates and by-products of the process. Observation of job activities i.e., plating by the worker, must be done to ensure the proper handling of chemical agents, and to assess employee adherence to established company policies and procedures. Obtaining Material Safety Data Sheets (OSHA Form 20) from the chemical suppliers is another means of obtaining information on the chemical agents utilized in the workplace.[3] Table I is a list of chemicals commonly used in the electroplating/metal finishing industry and their hazards.

Environmental sampling/monitoring, i.e. personnel or area, is a major component of the industrial hygiene survey. The degree of hazard is directly dependent on the length of exposure, contaminant concentration levels, and the nature of the agent. The results of field sampling are compared to the PEL/TLV to determine compliance status. If unacceptable levels are noted, the industrial hygienist along with associated support personnel will design and implement control methods to reduce the exposure to acceptable levels.

V. Methods of Control

Once the environmental stress has been recognized and properly evaluated the best control method must be

determined. The type of control utilized depends on the toxicity of a substance, frequency and degree of exposure, the equipment being utilized, and the processes involved. For example, inhalation hazards from plating operations are best controlled by the use of local exhaust ventilation. Exhaust volumes for each tank will vary depending on the hazard potential as determined by the hygienic standard, and contaminant evolution-emission rate determined by the liquid temperature of the bath. Chrome electroplating baths have a high hazard potential and rate of gassing and require more exhaust volume per square foot of tank area than an acid copper electroplating bath which has a lower hazard potential and rate of gassing.

Three basic methods of control must be evaluated when providing for hazard reduction or elimination. They are: engineering; administrative; or the provision and use of personal protective equipment. Within each method of control there are several alternatives choices that may be applied alone or in conjunction with others.[3,4,5]

1. Engineering Controls

A. Substitution

A useful and common method of engineering control is substitution of one toxic chemical substance with another less toxic substance, or the substitution of one process for another. For example, Perchloroethylene, a common degreasing agent and a suspected carcinogen and highly toxic agent can often be replaced with 1,1,1-trichloroethane. 1,1,1-Trichloroethane is the least toxic of the chlorinated solvents and has failed to demonstrate carcinogenic properties in laboratory experiments.[3, 6] Unfortunately, in the electroplating/metal finishing industry, there are very few chemicals and/or processes that can be economically substituted or changed. In most instances, if a process can be changed it is done to provide a better quality product and/or increased production.

Equipment substitution can be employed in the electroplating/metal finishing industry as a means of control. Substitution of equipment is usually very costly and many considerations must be examined. The use of automated plating lines can greatly reduce worker exposure to harmful con-

taminants such as formaldehyde in electroless copper baths, acid and cyanide mists. When operated and maintained properly, automated, conveyorized etching, solvent metal cleaning, and stripping machines can help to eliminate worker exposure to harmful ammoniacal etchants, solvent strippers, and cleaners. Production requirements must be great enough however, to justify the purchase of such equipment.

B. Isolation

Isolation can be achieved via the use of a physical barrier or by locating control panels away from the equipment, process, and exposure. Automated plating lines usually have remote control panels. Etching and stripping machines have barriers at the inlet and outlet ports to reduce the escape of harmful contaminants. Both methods of isolation help to prevent hazardous physical contact with chemical substances, as well as inhalation of toxic vapors, gases, and mists.

Chemicals must be stored and used properly. Chemicals contained in drums, cans and/or bottles must be stored in areas specifically designed for chemical storage i.e., cabinets, vaults or rooms. Specially designed storage tanks are often used for bulk storage inside buildings, as well as outside above ground or underground storage tanks. Chemicals from such tanks will often be pumped automatically through pipes into plating tanks, etchers or other equipment thus eliminating operator handling. A closed and isolated system is created thereby reducing potential employee exposure hazards. Waste or spent chemicals may be handled the same way. If flammable or combustible materials are utilized, federal OSHA, state, and local agency storage requirements must be identified and incorporated into the design and utilization of flammable and combustible storage areas. Insurance underwriter requirements must also be met.[7,8]

C. Miscellaneous

Other types of engineering controls required by the OSHA General Industry Standards include the use of dikes to prevent intermixing of cyanides and acids and the construction of floors so as to prevent slipping and tripping when wet.[1]

D. Ventilation

Ventilation at or within process operations is the most common method of engineering control. Section 1910.94 of the OSHA General Industry Standards discusses control via ventilation methods. Open surface tank ventilation as employed in electroplating/ metal finishing operations must meet the requirements of 1910.94(d).

The use of local exhaust ventilation (i.e., LEV) captures contaminants from the source and draws them away from the workers breathing zone. The LEV system combines the use of a hood or enclosure, ductwork, an air cleaner, and an exhaust fan. When properly designed and installed, LEV can be an excellent control method because it helps prevent contaminants from entering the workplace.

The ACGIH publishes a manual entitled, Industrial Ventilation A Manual of Recommended Practice that is revised every other year. This manual is an excellent source of information for the proper selection, design and operation of industrial ventilation systems in the electroplating/metal finishing industry.[9]

Control of contaminants via LEV does not stop after installation. Systems must be periodically checked and preventive maintenance conducted to help ensure performance. Filters, fan speeds, and system balance must be properly maintained.

General area exhaust ventilation systems do not eliminate a contaminant from the source, instead they may keep contaminant concentrations below hazardous levels by dilution. General exhaust ventilation systems make less efficient use of exhaust capacity relative to LEV systems. These systems should only be utilized when the toxicity of a contaminant is low or when trace amounts of contaminants are entering the work area.

Care must be taken when designing exhaust systems. Specifically, exhaust outlets and make-up air supply inlets should not be located so as to cause the recirculation of contaminated air. In addition, the recirculation of exhausted

fumes from air pollution control equipment, i.e., scrubbers, is not recommended for the purpose of saving heat.

When properly used, both LEV and general ventilation can help provide for a safe work area atmosphere.

2. Administrative Controls

Administrative controls are only applicable when engineering controls are not feasible or when engineering controls alone cannot maintain a healthful work area. Administrative controls can be applied in the form of job reorganization. An example is reducing the length of exposure to one man by shifting an operator to another job when his duration of exposure has reached that allowed by OSHA standards.

The use of several short rest periods can also prove helpful in reducing exposure. Such a work practice is especially useful for solvent degreasing operations. Solvents such as 1,1,1-trichloroethane or perchloroethylene can be very irritating and have the potential to cause dizziness and nausea in low concentrations. Susceptability to such impacts varies individually. Such practices are often employed even though PEL's are not being exceeded.[3,4]

3. Personal Protective Equipment (PPE)

Wherever chemical hazards exist that cannot be totally reduced/eliminated by engineering and/or administrative controls, and are capable of causing physical impairment through absorption, inhalation or physical contact, protective equipment for eyes, face, head, and extremities should be provided. PPE takes the form of protective clothing, respiratory devices, safety eyewear, protective shields, safety shoes, and barriers. This equipment must be used and maintained in sanitary and reliable condition.

Section 1910.94 and Subpart I of the OSHA General Industry Standards details the requirements of personal protection.[1,6,10]

A. Eye Protection

To protect the eyes and face from acids, alkalis, cyanides, and solvent solutions found in the electroplating/metal finishing industry, safety

glasses, goggles and/or faceshields should be supplied to all operators and their use made mandatory. Whether the chemical operations are automatic or manual a potential threat of exposure exists from splashing of corrosive and irritating solutions. When additions of corrosive or toxic chemicals are manually made to open surface tanks, or when waste or spent chemicals are removed from the tanks, or when maintenance is required, employees should be required to wear either tight fitting chemical goggles or an effective faceshield.

B. Skin Protection

Protective clothing should also be supplied and its use made mandatory where the potential to get cloths and skin wet from acids, caustics, solvents or other harmful agents exists. Protective clothing takes the form of impervious gloves, aprons, and boots made of rubber, neoprene or other substances resistant to the specific chemical(s) being used. In some instances, the use of clothing completely resistant to corrosive action can be supplied. When selected and appropriately used, the threat of skin exposure to acids, alkalis, cyanides, and other corrosive and irritating chemicals found in the electroplating/metal finishing industry can be virtually eliminated.

C. Respiratory Protection

Respiratory protective equipment (RPE) should be made available for use as necessary but should never be used in place of engineering controls. If process operations are properly ventilated, RPE should not have to be utilized by employees during normal operations. In many older plating facilities, however, the presence of local exhaust ventilation (LEV) does not exist and harmful vapors, gases and mists are released into the worker's breathing zone. In this case, RPE should be worn on an interim basis, if PEL's are being exceeded and until a LEV is designed and installed.

RPE should be worn where manual dumping and dispensing of chemical solutions is completed and adequate ventilation is not provided. During such operations, harmful vapors, gases, and mists can be released from the agitation of fluids and RPE will help prevent contaminant inhalation by the

worker. The employer is responsible for the establishment and maintenance of a respiratory protection program. Section 1910.134 of the General Industry Standards covers the requirements for the use of RPE and outlines the details of a respiratory protection program.

During maintenance operations or tank entry, if tests indicate that PEL's are exceeded or that oxygen concentration is less than 19.5 percent, suitable respirators should be donned prior to entry or initiation of such operations.

D. Emergency Protection

The need for emergency washing facilities i.e., eye wash fountains and deluge showers in the area of open surface tanks is outlined in Section 1910.94 (d)(9)(VIII) of the General Industry Standards. In an area where tanks containing liquids that may burn, irritate, or cause harm to the skin or eyes from splashing, deluge showers or eye wash fountains must be installed. These installations must be tested on a routine basis to assure that they will properly operate in the event of an emergency.

E. Miscellaneous Protection

Other types of protective equipment required by the OSHA General Industry Standards include sufficient washing facilities, first aid treatment, and locker space to prevent the contamination of street clothes.

Control however, does not end with the use of engineering, administrative, and/or PPE. Other supplemental control methods play a key role in providing for protection of the worker when used in conjunction with the three basic control methods.

4. Educational Training

Worker education and training play a major role in the safe operation and maintenance of an industrial facility. It is a key component of a good safety and health program. Education and training involves all levels of the workforce, from management down to the line worker.[3] Supervisory personnel have the responsibility of enforcing safe practices in the work area. The supervisor should, after proper education

and training, be able to recognize the existence of a health hazard, and when to request aid to abate such a hazard, and how to respond in the event of an emergency. In addition, the supervisor must ensure that all required methods of environmental control such as LEV, gloves, safety glasses are being used and properly maintained.

The worker has the responsibility of performing his job so as not to endanger himself or his coworkers. Both the supervisor and IH must train and educate the worker in the correct operation of equipment, handling of process materials and chemicals, and maintenance procedures. Most worker accidents result from the lack of knowledge about specific process operations, chemicals, and/or the use of installed engineering controls.

Management must establish a safety and health program by preparing a manual applicable to each individual job operation, posting signs on job safety and health in obvious places, and by conducting frequent meetings and seminars pertaining to job safety and health. Frequent unannounced plant inspections can prove helpful in determining whether or not employees are achieving to established policies or if control systems are being properly utilized/maintained.

In areas where the potential for workers to become exposed to contaminants exists, as in plating and etching operations workers must be given special training. These sessions should detail the form and nature of the hazard, the consequences of the exposure, the application of PPE both on a routine basis, if applicable and in emergency situations, procedures to be followed in an emergency situation, medical surveillance and requirements of applicable OSHA standards. A training manual should be prepared including Material Safety Data Sheets, that can be used as a reference source in future training. A copy of this manual should also be provided to the local hospital so that medical personnel are knowledgeable of potential exposures/hazards in the event of an emergency.

Good housekeeping is an important factor that must be stressed to the worker on a continuing basis. The necessity of a daily cleanup period and the immediate cleanup of spills is of vital importance. Keeping the work area neat and clean will help to prevent unnecessary accidents and hazards from occurring.

Although management rarely becomes involved in the direct control of hazard protection, they assume the responsibility of safety and health for all employees. They must express and display a positive attitude toward a hazard free work environment.

Management must support the Occupational Safety & Health Act and OSHA standards and work continuously to see that department supervisors are implementing established policy. As the National Safety Council states, "Safety is the responsibility in management. Without question it is the number one responsibility of management, taking precedence over everything else".

VI. Conclusions

Potential safety and health hazards common to the electroplating/metal finishing industry can be controlled if the work environment is thoroughly evaluated and the potential hazards recognized. Once this is accomplished, the most appropriate control technology can be applied to reduce and/or eliminate the hazard(s). The use and maintenance of engineering, administrative and/or personal protective equipment controls must be made mandatory and become a part of routine process operating procedures. Reducing and/or eliminating potential health hazards in the workplace can improve employee job dedication, motivation, and productivity. A safe and healthful work environment helps create the conditions necessary for a successful and profitable electroplating/metal finishing facility.

Hazardous Chemicals Commonly Used in the
Electroplating/Metal Finishing Industry
TABLE I

Chemical	Source	Atmospheric Contaminant	Hazards	Control[1]
ACIDS				
Boric Acid	• Sulfamate Nickel	Boric Acid Dust	• Eye and Nose Irritant	• Ventilation • Dust Mask • Safety Glasses
Chromic Acid	• Etching • Chrome Electro-plating • Pickling • Acid Dipping • Stripping	Chromic Acid Mist	• Eye and Respiratory Tract Irritant • Tissue Burns and Ulcerations	• Ventilation • Foaming Agents to Reduce Fuming • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Hydrochloric Acid	• Activation • Pickling • Acid Dipping • Plating • Stripping	Hydrochloric Acid Mist	• Eye and Respiratory Tract Irritant • Dental Erosion • Tissue Burns	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Nitric Acid	• Stripping • Pickling • Acid Dipping	Nitric Acid Acid Mist	• Eye and Respiratory Tract Irritant • Pulmonary Edema • Tissue Burns and Ulcerations • Discolor Skin - A Yellowish-Brown	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles

TABLE I

Chemical	Source	Atmospheric Contaminant	Hazards	Control[1]
ACIDS				
Sulfuric Acid	• Etching • Plating • Acid Dipping • Stripping • Pickling	Sulfuric Acid Mist	• Eye and Respiratory Tract Irritant • Dental Erosion • Oral Ulcerations • Pulmonary Edema • Tissue Burns and/or Dermititis	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Sulfamic Acid	• Nickel Plating	Sulfamate Mist	• Mild Skin, Eye and Respiratory Irritant	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Hydrogen Peroxide	• Etching	Hydrogen Peroxide Mist	• Eye and Respiratory Irritant • Skin Irritant	• Ventilation • Butyl Rubber Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
CAUSTICS				
Ammonia and Ammonia Hydroxide	• Etching • Plating • Stripping	Ammonia Gas	• Eye and Respiratory Irritant • Pulmonary Edema • Tissue Burns and/or Blistering	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles

TABLE I

Chemical	Source	Atmospheric Contaminant	Hazards	Control[1]
CAUSTICS				
Cyanides	• Plating • Gold Stripping	Cyanide	• Chemical Asphyxiation • Headache • Nasal Ulcerations • Dermititis • Corneal Burns	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles • Isolation of Cyanide and Acid Solutions • Dikes to Prevent Mixing of Cyanide and Acids
Potassium/Sodium Hydroxide	• Plating • Stripping • Metal Cleaning	Alkaline Mist	• Eye and Respiratory Irritant • Nasal Lesions • Tissue Irritant	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
ALDEHYDES				
Formaldehyde Polyvinyl	• Electroless Copper Plating	Formaldehyde	• Suspected Carcinogen • Eye and Respiratory Irritant and Sensitizer • Headache • Dermititis • Discolor Nails	• Ventilation • Neoprene or Chloride Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles

TABLE I

Chemical	Source	Atmospheric Contaminant	Hazards	Control[1]
HALOGENS				
Chlorine Gas	• Etching	Chlorine Gas	• Eye and Respiratory Irritant • Highly Toxic • Tissue Blistering and Discoloration • Dental Corrosion	• Leak Detection Equipment • Ventilation • Respirators • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Fluoboric Acid Lead Fluoborate	• Plating	Fluoborate Mist	• Eye and Respiratory Irritant • Mild Skin Irritant	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
Hydrofluoric Acid	• Stripping • Pickling • Plating	Hydrogen Fluoride Gas	• Severe Eye and Respiratory Irritant • Pulmonary Edema • Coughing • Increased Bone Densities	• Ventilation • Neoprene Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles
SOLVENTS				
Methylene Chloride	• Screen Resist Stripping	Solvent Vapors	• Anesthetic, Narcotic • Headache, Dizziness, Nausea • Dermititis	• Ventilation • Polyalcohol Gloves • Impervious Boots and Clothing

TABLE I

Chemical	Source	Atmospheric Contaminant	Hazards	Control[1]
SOLVENTS				
			• Eye Irritant	• Faceshield/Safety Goggles
Trichloroethylene Perchloroethylene	• Screen Resist Stripping • Metal Cleaning	Solvent Vapors	• Suspected Carcinogens • Eye Irritant • Nose and Throat Irritants • Central Nervous System Depressant • Dizziness • Headache • Nausea • Incoordination • Respiratory Impairment • Dermititis	• Ventilation • Polyvinyl Alcohol Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles • Preclude from Exposure Persons with Respiratory Disfunction • Preplacement/Annual Physical Exams
1,1,1-Trichloroethane	• Metal Cleaning	Vapors	• Narcotic • Eye Irritant • Headache • Dizziness • Drowsiness • Dermititis	• Ventilation • Polyvinyl Alcohol Gloves • Impervious Boots and Clothing • Faceshield/Safety Goggles • Preclude from Exposure Persons with Respiratory Disfunction • Preplacement/Annual Physical Exams

TABLE I

NOTES:

1 Good industrial hygiene practices recommend that engineering controls be applied to reduce environmental concentrations to the permissible exposure level. Respirators should only be used when engineering and work practice controls are not technically feasible, when such controls are being installed or when they fail or an emergency occurs.

References: National Institute for Occupational Safety and Health/Occupational Safety and Health Administration. Occupational Health Guidelines for Chemical Hazards, NIOSH No. 81-123; Washington, D.C.: Government Printing Office, 1980.

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration. Pocket Guide to Chemical Hazards. NIOSH No. 78-210; Washington, D.C.: Government Printing Office, 1980.

NOTE: This table is summary in nature and should only be used for general reference purposes. Consult reference texts for additional detailed information.

Reference Sources

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L-3

Environmental II
Session L

Contingency Planning

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CONTINGENCY PLANNING

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In recent years, metal finishers have grown accustomed to visits by inspectors from one agency or another. The next inspector to visit your plant may ask to see your Spill Prevention, Control and Counter Measure Plan or your Contingency Plan. This is particularly true if he is from an agency that is responsible for any phase of employee health or the environment. With all the laws that metal finishers are required to meet, having a Contingency Plan is often overlooked until the inspector arrives. On a Federal level, the Clean Water Act, the Resource Conservation and Recovery Act (RCRA) and OSHA, all have requirements for some type of Contingency Plan for leaks, spills, fires or explosions involving hazardous materials and hazardous waste. In addition, many State and Local ordinances also call for a Contingency Plan. Depending where you are located in the country you may or may not have been pressured into preparing a plan. Due to a shortage of trained inspectors, many State and Federal agencies have not done too much inspecting and enforcing of these laws as yet. This is changing as more and more trained inspectors are being assigned and getting out into the field. Failure to be prepared for their visit can be very expensive to your company. My personal experience with these inspectors has been good. Most appear to be willing to work with industry toward complying with the new regulation providing the company shows good faith that they are attempting to meet the provisions required of them. My presentation will deal with preparing and implementing a Contingency Plan that should meet the basic requirements of most Federal, State and Local ordinances and they all have one common goal - to protect people, property, animals and the environment in the event of an emergency involving hazardous material or hazardous waste. Most metal finishers are finding that they are covered by RCRA. In Part 265, subpart C & D "Standards for Owners & Operators of Treatment, Storage, Disposal facilities", subpart C outlines the requirements for preparedness and prevention. This involves outlining where hazardous material/waste is being stored prior to treatment, storage and disposal. It covers the emergency and communication equipment required to be maintained and details the arrangements made with local emergency response agencies and hospitals. Subpart D covers contingency plans and emergency procedures. The Contingency Plan must include the following information:

- Arrangements agreed to by the local fire and police departments, hospitals, clean up contractors and state and local response personnel.
- The Plan must list the Emergency Coordinator and alternate Emergency Coordinators and their phone numbers.
- The Plan must include a list of all emergency and communi-

cation equipment at the facility, where it is located and an outline of its capabilities.

- An evacuation plan for plant personnel must be included.
- A topographical map of the area is often required.
- Copies of the Material Safety Data Sheet on all products used at the facility should be included.
- A floor plan of the plant showing the location of all emergency equipment, process lines, waste storage, chemical storage, drain lines, service connections (e.g. fuse panels) etc., floor sumps.
- Anything else that might be of use to emergency response personnel.

One of the first steps that management should take in preparing a Contingency Plan is to designate an Emergency Coordinator to help prepare the plan and then to supervise its implementation. The Emergency Coordinator has complete responsibility for the Contingency Plan and all of its requirements. He must be thoroughly familiar with all aspects of the plan, all plant operations, location of all records within the facility, and most importantly, be authorized to commit the resources of the company as he sees fit in order to carry out the plan. He should be selected also on his ability to make quick decisions and operate under a high degree of stress. If at all possible, management should select an Emergency Coordinator who does not have direct responsibility for production. In addition, a secondary coordinator should be appointed to work with and back up the Emergency Coordinator and then a shift coordinator to be in charge of each shift the plant is in operation when the Emergency Coordinator is absent from the premise.

After a Plan is prepared and implemented, the Emergency Coordinator must, whenever there is an imminent or actual emergency:

1. Activate the internal alarm to notify all plant personnel of the emergency and order an evacuation of the plant if necessary.
2. Notify appropriate State or Local agencies with designated response roles, if needed.
3. Notify the National Response Center, if applicable.
4. Supervise the control and clean-up of the situation.
5. Prepare and file all required reports after the incident.
6. Be sure all emergency equipment is repaired and replaced promptly.

I can't emphasize enough the importance of strong management support for the preparation and implementation of a plan. It does require a substantial outlay of money and hopefully will never be needed. However, if an emergency does arise and an inadequate plan fails to work, the initial cost of the plan will seem small in comparison to the clean-up costs, to say nothing of potential fines.

In preparing the Contingency Plan, the Emergency Coordinator should first meet with all of the Local, State, and Federal agencies who have any jurisdiction over his operation. If approached with the right attitude, they can be most helpful in giving guidance to preparing a plan that will meet their approval. Next I would suggest you meet with the local emergency response agencies in your

community to see what resources they might have that you can include in your plan. For instance, many fire departments in the country have formed hazardous material response teams of various degree. Some are only prepared to assist if an emergency affects people or property outside your facility. Others, however, such as the one I am in charge of, will assist at emergencies inside your plant as well. Many are equipped with equipment to repair leaks, neutralize spills, fight hazardous material fires and assist in medical problems that occur. Local police agencies can assist with evacuation procedures when necessary as well as traffic control. If local hospitals are aware of the potential type injuries that might result from the materials used in your operation, they will train in the proper procedures they should use in treatment and in decontamination of victims.

I would suggest that you contract with an emergency clean-up contractor in your area and make him a part of your plan. They are usually quite knowledgeable in preparing plans and will assist in the event of an actual emergency.

You have a responsibility by law to be prepared to handle any emergency involving hazardous material or waste at your facility. In order to do this, I suggest you create a spill control team comprised of your own employees. The team could be comprised of a half dozen or so employees on each shift who will work during an emergency under the direct supervision of the Emergency Coordinator. In selecting the team, they should be employees who have good work habits, follow instructions, are in good health and are willing to serve on the team. They should receive professional training in spill control, firefighting, use of protective equipment and breathing apparatus, emergency procedures, etc. Such training is available at several locations around the country. Regular training with local emergency response agencies should be maintained. In the event of the emergency, the team may be able to contain, control and clean-up the spill if it is small or be able to at least contain the spill or fire until outside resources arrive. On a routine basis they can assist the Emergency Coordinator with maintaining the emergency equipment and supplies that they may need such as neutralizing material, absorbent material, fire extinguishers, breathing apparatus, etc.

Speaking from some personal experiences, there are several things that should be considered in a Contingency Plan from a firefighter's viewpoint. First, invite your local fire department in for plant visits and familiarity with the layout. If you have valuable equipment on hand such as process controllers, testing instruments, etc., let them know what it is and where so in the event of an emergency they can take extra caution to see that the equipment is removed or protected. Next,lable everything, particularly tanks and pipelines. You and I may be able to look at a plating line and know that the first tank is probably an alkaline cleaner, and the tank with blue solution is an acid copper bath and so on but the average firefighter has no knowledge of what you have or how dangerous it is. I experienced an incident where an

evacuation was ordered because of a leaky five gallon container of zinc purifier on a loading dock because no one knew what it was, but they knew it was a chemical so it must be dangerous.

Your Contingency Plan should include a layout of all your process lines and what is in each tank. Also include the various chemicals that are stored in the building and where they most likely will be located. Your fire department would like to see you use the NFPA (National Fire Protection Association) Code 704M placards on your building. Many localities now require this in their local ordinances.

Many companies, particularly those with plant fire brigades are reluctant to call their local fire department. We generally would like to be notified immediately of a problem. Fire apparatus is all radio equipped and can always be sent back to quarters if not needed, so please, don't hesitate in calling.

When an emergency occurs, the decision to evacuate is a very serious one and can be costly in terms of lost production, damaged goods left in the process tanks and so forth. A lot of attention must be given to this part of the plan even though it will seldom be used. A distinct alarm must be established and be able to be heard in every area of the plant no matter how noisy. This includes maintenance shops, restrooms, lab, etc. There can be no hesitation on the employees part when the alarm goes off, no going for personal belongings or anything like that. Arrangements should be made with the spill control team to turn off plant utilities, close all doors, and windows if it can be done safely, perhaps while wearing breathing apparatus and see that local emergency response agencies are contacted. I heartily suggest a central meeting point be established outside the plant where all employees are to report so a head count can be taken to be sure all employees are accounted for. If not, determine where the person missing was last seen so properly equipped rescuers can attempt to locate the person. If you are in a part of the country that has severe weather, you might want to line up a building where your employees can go to stay warm and out of the weather until the emergency is over.

Another suggestion I would make to you is that you designate someone in your company to handle public relations. Whether your company is large or small, if you have an emergency the media people will be there and in most cases will try to make the incident more sensational than it really is. Only one person should speak with the press and he should be factual and honest. Don't withold information about the situation that the public should know for their own safety. Training Seminars in dealing with the news media are also available for your company PR man.

In conclusion, having a well prepared and workable Contingency Plan is good business for you, your employees and your community in addition to complying with the law. Preparing and implementing such a plan will take time and money but can make a bad situation into one that goes smoothly providing management gives 100% support to its preparation and implementation and the Emergency Coordinator sees that it is maintained and updated on a regular basis.

L-4

Environmental II
Session L

Recent Studies and Applications of Radiation Grafted Structures

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RECENT STUDIES AND APPLICATIONS OF RADIATION GRAFTED STRUCTURES

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Introduction

An introduction and application of radiation grafted structures have been reviewed in previous publications. (1,2,3)

The chemical and physical aspects of preparing radiation grafted structures have been discussed by S. Zapisek. However, we will again cover the chemical and physical aspects of radiation grafted structures as applied to ion exchange and membrane technology. These technologies are included so that references to their applications may be more clearly understood.

Radiation Grafting - Graft polymerization refers to the process whereby a base polymer is modified by the attachment of side chains onto the polymer backbone. The attached species in a standard polymerization or copolymerization reaction could lead to formation of block copolymers in the backbone with the addition of grafted homopolymer or copolymer side chains. Using the radiation grafting process as generally practiced, only pure grafted chains are attached to preformed polymer structures. Further the application of ionizing to 60 gamma radiation permits the attachment of various chemical moieties onto a multiplicity of different backbone polymers. The specific polymer backbones can have any form, i.e. film, sheeting, fibers, tubes, nonwoven composites or reinforced combinations. Table One indicates the type polymers to which the various monomers noted can be grafted.

TABLE I. Base Polymer Grafted at RAI

Polymer Types

1. High density polyethylene
2. Low density polyethylene
3. Polypropylene
4. FEP (polyhexafluoropropylene-ethylene)
5. TFF (polytetrafluoroethylene)
6. Polyvinylidene fluoride
7. Polyvinylchloride
8. Silicones
9. Cellulosics
10. Others

The grafting of the above polymers follows the general kinetics and mechanisms as described in Flory's Principles of Polymer Chemistry. The singlular difference between radiation grafting and standard grafting is due to the use of ionizing radiation to iniate a free radical site on the polymers noted above. The subsequent reaction then involves the reaction of the radicals onto an olefinic monomer and propagation of the resulting chain. With ionizing radiation as an initiator in place of peroxides, the initial reaction to the backbone is a carbon-carbon bond structure. The type graft is readily tailored by designing certain conditions of the reaction as follows:

1. Ion exchange type can be determined by preselecting the monomer in situs with the base polymer:
   a. Weak acid --- acrylic
   b. Weak acid --- pyridine

c. Strong acid --- sulfonatic styrene
d. Strong base --- quaternized vinylbenzyl chloride
e. Non-ionic (hydrophylic) --- grafted vinylacetate, subsequently hydrolyzed.
f. Internal salt --- graft acrylic acid/vinylpyridine

2. Chain length of the grafted chain can be controlled by:
   a. Dose rate - higher dose rates increase the number of sites and thereby reduce the chain length
   b. Solvent selection -
      1. carbon tetrachloride can be used to effect chain transfer reaction
      2. methylene chloride can act as a solvent and chain transfer medium
      3. water will give very short chain length grafts due to formation of peroxides and subsequent chain transfer reaction and increased rates of termination.
   c. Monomer concentration: dilute concentrations of monomer give decreased chain lengths.
   d. Solvent insolubilization: long chains can be fostered by addition of solvents which decrease chain "solubilization." This could lead to Tromsdorff effects and very long chains.

3. Ion exchange capacity or percent grafts: are readily controlled by:
   a. Monomer concentration
   b. Grafting time
   c. Temperature of reaction

All the above variations can be used along with procedures to precrosslink the base polymer or post crosslink the grafted structure by application of Beta radiation. This additional tool, i.e., crosslinking permits enhancement of:

1. Chemical stability
2. Lower diffusion rates
3. Decreased swelling

Judicious combination of the above variables can lead to preparation of tailored membranes and non woven structures for:

1. Ion exchange filters for metals
2. Membranes for ED and dialysis
3. Tubular membranes for Donnan dialysis
4. Substructures for enzyme coupling
5. Others

More recently radiation grafted structures, as has previously been cited, are prepared for selective ion or specific ion separation and recovery. Industrial applications will include:

PROPERTIES	APPLICATION
1. Hydrolytic Flow	1. Dialysis
2. Physical Strength	2. Electrodialysis
3. Transfer t^+, t^-	3. Donnan Dialysis
4. Ion Selectivity	4. Electrochemical Reactor
5. Chemical Resistance	5. Redox Batteries
6. Electrolytic Resistance	6. Batteries
7. Temperature 40-100°C	

A review of the advantages of radiation grafted structures has been stated: (4)

1. The density of crosslinked polymers may be varied before grafting.
2. Selective ion exchange monomers may be imparted to preformed structures.
3. The grafting process may control the specific ion exchange media and concentration of media.
4. The polymer base (substrate) may be varied to produce specific chemical/physical properties.
5. Membranes can be pre-determined by controlling the parameters of fabrication.

Radiation grafted structures can be prepared in various forms:

1. Polymer base (polypropylene polyethylene, Teflon, etc.)
2. Fibers - with a high incalculable area.
3. Film - up to 20 mils.
4. Tubing - approximately 10 mils.
5. Powder
6. Mesh
7. Microporous structures
8. Difunctional monomers for crosslinking before radiation
9. Control of Mc (distance between crosslinks.)
10. Post linking with Gamma or Beta radiation.

Industrial Applications of Radiation Grafted Structures (Membranes)

1. Electrodialysis - As cited above, electrodialysis membranes have transport of ions, (t^+,t^-) as prime requisite. The recovery of gold from plating rinse waters has been reviewed.(5) Electrodialysis is generally applied to concentrate chemicals, e.g. nickel after a drag-out rinse; recovery of sodium hydroxide and sulfuric acid from concentrated sodium sulfate solution.(6)

   Later, in this paper, we will discuss demineralization and metal recovery using electrodialysis in combination with ion exchange beads.

2. Donnan Dialysis - The membranes used for Donnan Dialysis applications are selective. Therefore, only the anions or cations may diffuse through the membrane at one time. Analytical use of tubular membrane is practised to concentrate small volumes of solution.

   In Donnan Dialysis, the feed solution is passed through the membrane in one direction, while the strip solution is passed outside the tubular membrane in the opposite direction.

   Conversion of Fluorborate tin-lead solutions into organic solutions has been successfully completed. The fluoborate solutions is passed through the membrane while the organic acid is passed in the opposite direction outside the membrane. Virtually complete transfer of the cations into the organic acid stripping solution can be made within a reasonable time period.

   Nickel has been recovered from spent electroless nickel solutions using sulfuric acid as stripping agent.

   Other applications include palladium from palladium chloride and nickel from nickel sulfamate dilute and concentrated solutions.

   The economic advantage of Donnan Dialysis over other recovery systems is their small energy requirement. Only two pumps are necessary in addition to the membrane to design a Donnan Dialysis recovery system.

Dialysis Membranes

Dialysis membranes are similar in fabrication to acid/alkali battery separators.

Dialysis membranes may be used to diffuse acid or alkali from pickle and cleaning solutions thereby prolonging their useful life before requiring "dumping".

Electrochemical Reactors

Anionic and cationic membranes have been used to separate anolyte and catholyte of the chemical reactor. Which ion exchange membrane is used is dictated by the operating parameters of the process. An added feature of such a reactor is the potential for recovering metal in the catholyte and at the same time have a chemical reaction progressing at the anode. Such a process has been reviewed in the literature describing recovery from chromic acid etchants.(7)

A method for treating alkaline etchants by separating anolyte and catholyte has been in operation for three years. The alkaline etchant is catholyte; anolyte is prepared using the same formulation as the etchant without copper. The membrane is cationic. The anolyte is used to rinse the printed circuit board exiting from the spray chamber. The copper in the anolyte will transfer through the membrane to the catholyte. The copper concentration in the etchant is maintained at 75 to 90 grams per liter. Pure copper sheet is produced on a stainless steel cathode. Automatic pH systems are included in the plant; chloride determination is made twice weekly. Wetting agents are added to the etch chamber as necessary.

A method for treating the sulfuric peroxide etchant is now in the final stages of prototype. Originally, the etchant was separated from the anolyte and catholyte by cationic and anionic membranes. The catholyte and anolyte were sulfuric acid. The difficulties of water transfer and copper transfer made the equipment exceedingly large.

The more recent prototype processes use the etchant as catholyte and an anionic membrane with a combination of acid and salt as anolyte. This system can maintain the copper concentration so that it does not exceed 20-25 grams per liter and will not affect the etching operation. The entire process is operated at the operating temperature of the etchant.

Spent electroless copper solutions have been treated for copper recovery in a membrane separated cell. The spent solution is catholyte; sodium hydroxide is anolyte; the membrane is cationic. The solution is plated at 25 amperes per square foot. It is possible to treat an approximate 4 grams per liter solution so that the copper concentration is less than 2 parts per million in approximately 3 hours. Additionally, the EDTA and/or quadrol will not be affected by the process.

In the same type of reactor cell, spent electroless nickel solutions may be processed for nickel recovery. The final 100 parts per million may be treated by ion exchange, as will be described later in this paper, to reduce the nickel concentration to 2 parts per million.

The above are mentioned as feasible systems. Recovery of silver, palladium and other metals is feasible using the chemical reactor cell.

Ion Exchange Systems for Metal Recovery

Systems for recovering gold, copper silver, nickel, and palladium by an

ion exchange prepared by radiation grafting are available.(8) Moreover, each of the systems, including gold, can be regenerated. The ion exchange cartridge used in the system is prepared by radiation grafting of a monomer to a polymer base.

The ion exchange cartridges can be regenerated by simple chemical treatment; the cartridges are reuseable. In each system, a polymer which is compatible to the process is processed by gamma radiation. A monomer which is selective to ion complex is grafted to the surface of the polymer. In this manner, ion exchange media which are selective to metal cyanide and to metal ammonia complexes have been prepared. The gold ion complex is captured by the ion exchange cartridge with influent of 800 to 1000 parts per million giving an effluent of no greater than 1 part per million. Copper ammonia complex is captured in the same manner with effluent never greater than 1 part per million. The system is continuous since two sets of cartridges are provided allowing one set for capture while the second set is regenerating. Potassium hydroxide is the regenerating agent for gold; sulfuric acid is used for the ammonia ion complex systems. The metal is recovered by a rotating stainless steel cathode as previously described in the literature.(9) The metal foil produced is 99.9+% pure. It is possible to use the ammoniacal etchant concentrate replenisher solution for regeneration. The regenerant can then be used for rinsing the boards and finally to the etch chamber.

The ammonia ion complex system may be used for recovering nickel from electroless rinse waters by adjusting the pH 8.0-8.2 with ammonium hydroxide. Similarly, nickel sulfate and nickel sulfamate rinse waters can be used to reduce the nickel concentration to no greater than 2 parts per million.

Palladium in the ammonia solutions may be recovered in the same manner as the copper and nickel. The regnerating chemical may be nitric or hydrochloric acid.

THERE ARE NO SLUDGES OR PRECIPITATES RESULTING FROM THE RECOVERY SYSTEMS. ONLY PURE METAL OR PURE CHEMICALS ARE END PRODUCTS.

Electrodialysis/Ion Exchange Demineralization/Decationization System

Demineralization by ion exchange has been practised. Cationic exchangers attract cations; anionic exchangers attract anions. Generally, these exchangers are operated in series to produce demineralized water. Both cocurrent and counter current ion exchange systems are used to produce more efficient and more economical operating systems.

When the capacity of the exchangers is reached, they must be regenerated. The cation exchanger is generally regenerated with sulfuric or hydrochloric acid; the anion exchanger with sodium hydroxide. Unfortunately, after these chemicals are used for regeneration, the exchangers must be rinsed. Both these procedures produce waste quantity.

The advantages of ion exchange are its capacity for removing ions; its potential for adaptation to operating conditions; and its ability against fouling by organic contamination.

The disadvantages to the systems may be summarized as follows:

1. Regenerating chemicals required.
2. Times for regeneration.
3. Neutralization equipment necessary because of regeneration.
4. Increase in total dissolved solids because of the use of chemicals.

A German system has been developed to remove the disadvantages of ion exchangers. The system combines electrodialysis and ion exchange.

The system incorporates both cation and anion areas separated into individual cells. The cation cell consists of a membrane chamber filled with strong acid cation resin; the anion cell operating in series with the cation consists of a membrane chamber filled with strong basic anion resin. The final brine cell is situated between the two cells.

The anode of the electrodialysis is situated next to the cation cell; the cation cathode is placed next to the anion cell. A DC voltage, varying with the inlet water conditions, is applied between the anode and cathode. The water to be treated is first directed through the cation exchange cell so that the cations may be removed; it is then directed by series piping to pass through the anion resin cell which removes the anions. The procedure produces an almost salt free solution, the conductivity of which will be at least equivalent and in most cases better than that resulting from a mixed bed process.

A low concentration sulfuric acid is used for anolyte to produce H^+ ions. Sodium hydroxide is used as anolyte to produce OH^- ions. The applied DC voltage will force the transport of H^+ ions through the cation cell; the OH^- will pass through the anion cell.

During the process, a balance is reached at the ion exchanger surface so that the attracted cations are displaced by the stronger H^+ ions and are transported through the membrane to the brine cell. The ions are prevented from transporting further by the anionic membranes in the anion cell.

The OH^- ions are transported similarly through the anion cell and the anionic membrane to the brine cell. The OH^- ions are prevented from further transport by the cationic membrane at the cation cell. Thus, a concentrated salt will be formed in the brine cell. The salt is removed intermittently by dosing with the demineralized water.

Between 10 to 15 watts of electrical energy is necessary to remove 1 gram TDS. Increasing operating temperatures and other parameters of the system will substantially reduce the energy requirements.

Tests are being carried out to remove cations cheaply and efficiently using the combined technologies in combination with a rotating cathode to produce pure metal.

There is no requirement for additional chemicals using the technologies involved. No sludges or precipitates result from the recovery and/or treatment systems. The membranes have long life and will neither clog nor foul since only ions, not salts, are transported.

The advantages to the system are obvious and may be summarized as follows:

1. No pre-treatment of inlet water is necessary.
2. The chemicals used for regeneration are of low concentration.
3. Only electrical energy is necessary for decationization or demineralization.
4. No neutralization system is required.
5. Low operating pump requirements, i.e. 30-50 PSI.
6. Since membranes do not contaminate or foul, there will not be any loss of capacity.
7. The entire system is not complex; no large investment is necessary for extension or enlarging the plant.
8. The system can be stopped and started at any time without affecting the operation of the plant.

9. The system is non-polluting. It will not create any toxic or hazardous waste.

To summarize, recent developments in radiation grafted structures provide a new tool for water treatment and recovery systems. The systems are not only economically feasible but in many cases will provide and return an investment in real time. Moreover, properly designed systems will not produce toxic or hazardous end products. The paper has been prepared to present a new tool for metal recovery. Radiation grafted structures, alone or in combination with other technologies will provide economically feasible systems for metal and chemical recovery. Moreover, there will be no sludge or precipitates resulting from the recovery systems.

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Biography

Vincent D'Agostino, Vice President - Membrane Division

Received B.S. and M.S. in chemistry from Polytechnic Institute of Brooklyn in 1951 and 1957. Completed all course work for Ph.D., Polytechnic Institute of Brooklyn.

Mr. D'Agostino has been employed as an analytical chemist for Van Iderstein Company, product development chemist for Airkem Inc., and research chemist at American Cyanamid Company working on polymerization reactions, coatings alkyds, epoxides, melamines and various crosslinking agents.

In 1962 he was employed by Republic Aviation as a senior radiation/organic chemist and studied the effect of radiation and vacuum on plastic degradation and outgassing. Studies were also conducted on soft graft polymerization of Teflon to improve adhesion and study membrane properties.

He joined RAI Research in 1964 and has worked on various government projects involved in the study and/or development of microporous structured membranes via grafting and crosslinking, studied dialysis, electrodialysis, Donnan dialysis and developed membranes for various battery systems and chemical processes.

George Schore, Manager RAICOUP Division

Received his B.S. in chemical engineering at the College of the City of

New York. He did post graduate work in metallurgy at Stevens Institute. Mr. Schore has been superintendant of Metal Finishing at Broil-Quick Corp. and International Telephone and Telegraph Company. He has also been in charge of the plating departments of firms in the New York area. As sales manager for Abbey Automations, he designed and engineered integrated automatic plating machines. He was President of Schore Automations, which designed and engineered automatic and semi-automatic hoist lines. For the past twenty years he has been very actively involved in waste water treatment systems. He has been very actively involved in advanced technology stressing the economic recovery potentials from waste streams and concentrated solutions. He was president of Closed Loop Enviornmental and Recovery Corp. (CLEAR Systems), a wholly owned subsidiary of Park Electrochemical Corp. Presently, Mr. Schore is the manager of the RAICOUP Division of RAI Research Corporation.


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