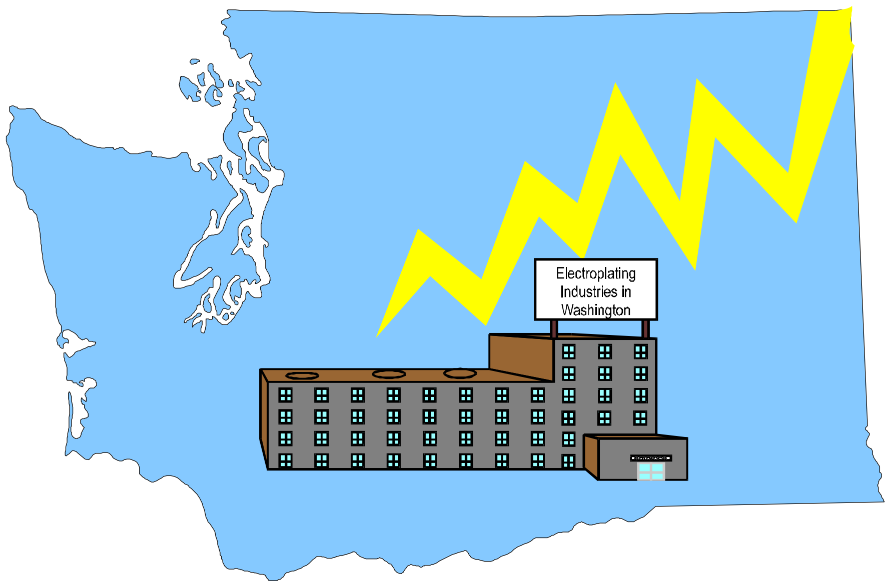


# Pollution Prevention Progress for 23 Washington Electroplating Facilities: An Industry Sector Report

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

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August 1996

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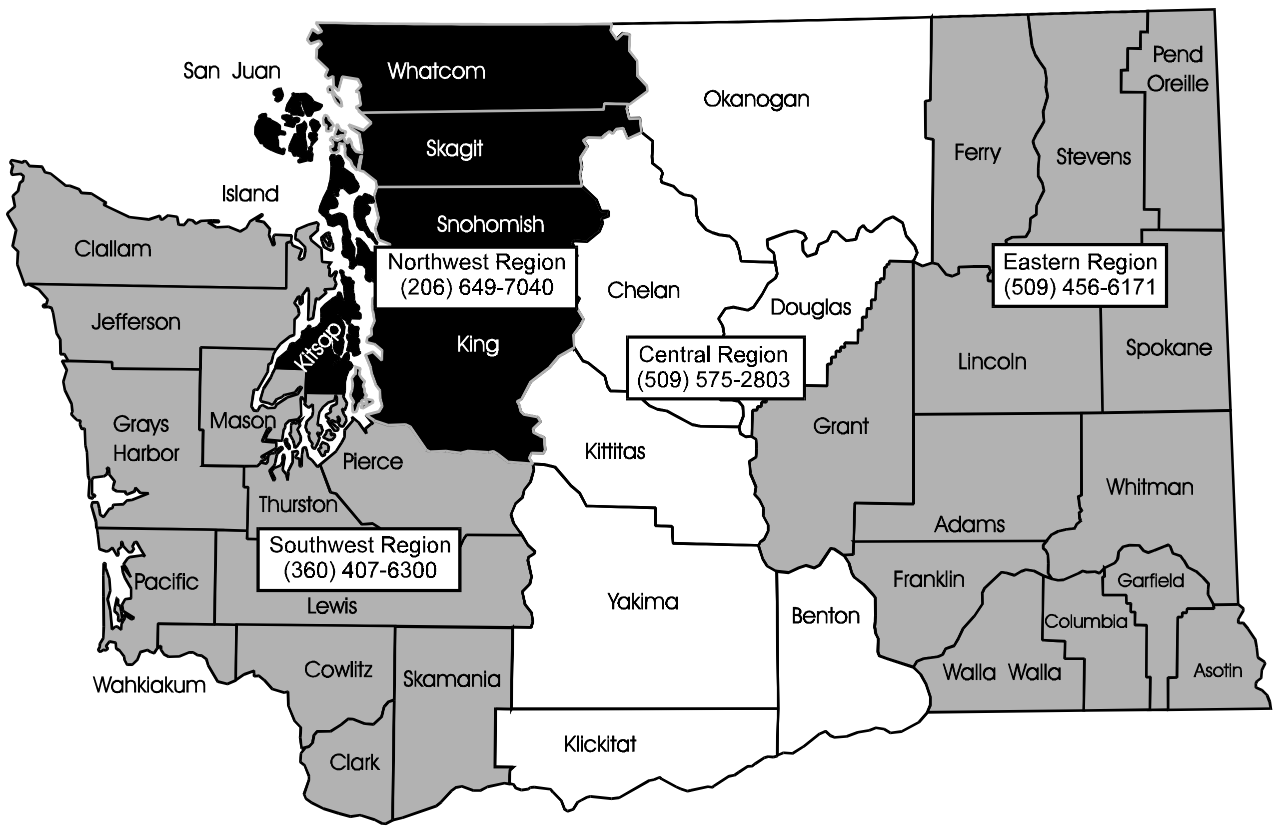


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# Pollution Prevention Progress for 23 Washington Electroplating Facilities: An Industry Sector Report

Prepared by:

Washington State Department of Ecology
Hazardous Waste and Toxics Reduction Program

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# Executive Summary

## Purpose

In 1995, the Washington State Department of Ecology (Ecology) began to evaluate the implementation status of hazardous waste and hazardous substance pollution prevention planning efforts for three distinct industry classes or sectors. This report describes the evaluation, summarizes the findings, and provides conclusions and recommendations for the electroplating sector.

This report provides information on the progress being made in reducing hazardous waste generation and hazardous substance use for 23 electroplating facilities in Washington. The report is intended to promote further implementation of pollution prevention by sharing what has been accomplished at facilities in the electroplating sector, help facilities benchmark their progress against like businesses in the sector, document the progress being made in reducing hazardous wastes and help Ecology to better assist all electroplating facilities in their pollution prevention efforts.

## Overview

In 1990 Washington's Legislature passed the Hazardous Waste Reduction Act to promote the reduction of hazardous waste through voluntary reductions of hazardous substance use and hazardous waste generation. The Legislature also set a statewide policy goal of reducing the amount of hazardous waste generated by fifty percent by 1995. The law requires certain facilities to prepare and submit Pollution Prevention Plans to Ecology. The plans identify and evaluate opportunities for preventing pollution. Facilities submit Annual Progress Reports indicating the progress being made toward implementing their plans.

Eighty percent of the electroplating sector facilities are located in western Washington. The industry is closely tied to manufacturing sectors, particularly the Boeing company. Business is very competitive, especially for shops that process high volumes of parts with low profit margins. Three important issues for platers are low price, delivery time and product quality.

## Methodology

To analyze the 23 facility Pollution Prevention (P2) Plans, information for certain data fields was extracted from those plans and Annual Progress Reports, placed into a relational database and queried to identify:

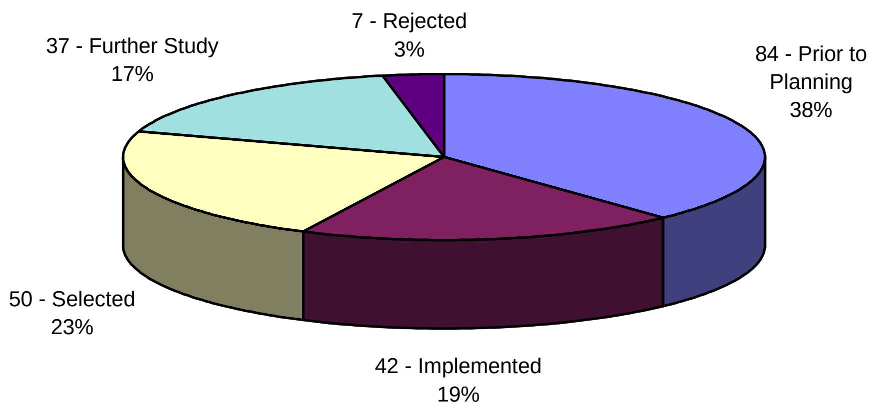
- Implemented P2 opportunities
- Hazardous substances and wastes associated with those opportunities
- Opportunities still under investigation or which were rejected

Where possible, comparisons are made between the 23 Washington facilities and the results of a national survey done on P2 for plating operations.

## Findings

The sector facilities identified 220 pollution prevention opportunities. Figure ES-1 illustrates the distribution of P2 opportunities by implementation status.

**Figure ES-1: P2 Opportunity Distribution by Implementation Status**




The majority (57%) of the P2 opportunities identified by the sector facilities have been implemented. Opportunities implemented for hazardous substance use reduction prior to or following planning emphasized chlorinated and non-chlorinated solvent use reduction, rinse water reduction and improved operating practices. Reducing wastewater treatment sludge was the principal focus of hazardous waste reduction efforts. Substituting alkaline-zinc in place of zinc-cyanide plating has been the most successful cyanide use reduction measure with three sector facilities having successfully made the change. Nationally, more than ninety percent of those shops attempting this conversion have been able to do so.

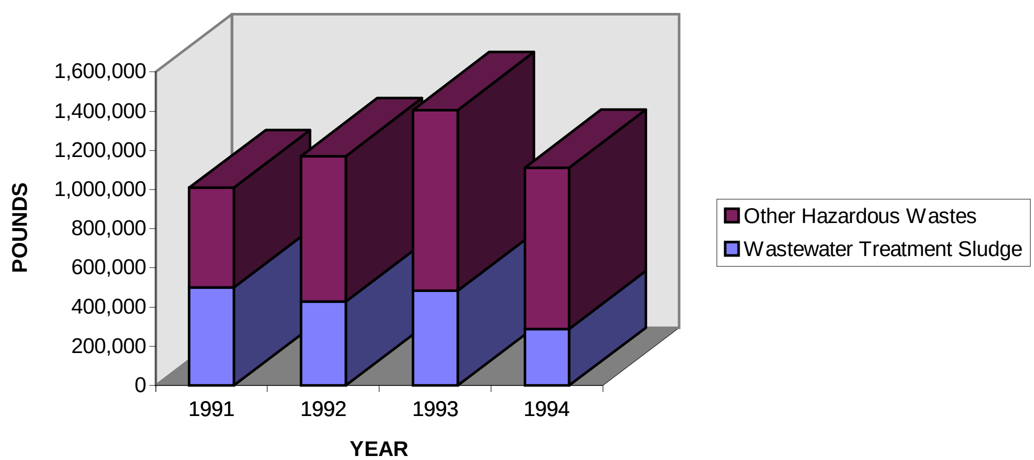
Solvent use reduction and the move to aqueous cleaning is the single most intensive area of pollution prevention activity with 37 opportunities identified for implementation. Solvents targeted for reductions included 1,1,1 trichloroethane (TCA), trichloroethylene (TCE) and methyl ethyl ketone (MEK). The biggest incentive for reducing the use of solvents in Washington has been the 1992 regulation adopted by the Puget Sound Air Pollution Control Authority (PSAPCA) that strongly discouraged the use of vapor degreasers.

Those P2 opportunities under further study or which were rejected include methods for solvent use reduction or elimination, chromium use reduction, further rinse water reduction and electrowinning for metal recovery. The 44 opportunities in these areas have been more challenging for facilities to implement. This is an area where Ecology should focus future assistance.  Five operating practices related to bath maintenance that were not mentioned in the sector P2 Plans appear overlooked and may represent opportunities for preventing pollution.

## Pollution Prevention Progress

Progress in hazardous waste reduction was estimated using hazardous waste generation as reported on Annual Dangerous Waste Reports.  The data is for the period from 1991 to 1994 and it has been normalized for changes in production.  Results show that total hazardous waste, excluding wastewater, increased approximately ten percent.  In contrast, sludge from wastewater treatment has decreased approximately forty-two percent over the same period.  The generation of hazardous wastes, other than wastewater treatment sludge, increased sixty-one percent. Wastewater designating as hazardous waste decreased by over eight percent over the same period.  Figure ES-2 illustrates the trend in hazardous waste generation between 1991 and 1994. Wastewater is not included.

**Figure ES-2:  Hazardous Waste Generation 1991-1994**
**(excluding wastewater)**




The reason for the increase in overall hazardous waste generation is, in part, due to production priorities.  Meeting the demand for increasing production and satisfying customers has tended to be a greater priority at many facilities than has pollution prevention.  Also, the adoption of many environmentally preferable technologies and practices often has a perceived negative impact on production rates which has tended to impede progress in pollution prevention.

Although there are data accuracy issues with Annual Dangerous Waste Reports, this information is generally assumed to more accurately portray waste generation trends than Annual Progress Report information.  Annual Progress Reports are intended to indicate the progress facilities are making against reduction goals set in their P2 Plans.  Using “pounds reduced” from Annual Progress Reports as a measure of pollution prevention progress does not fully capture the nature or extent of progress made.

Reported hazardous waste reductions from Annual Progress Reports covering the period from 1991 to 1994 total 84,000 pounds. This indicates that approximately seventeen percent of the combined hazardous waste reduction goals set in these facilities' P2 Plans have been achieved. Excluding wastewater, this quantity equals approximately nine percent of total base year generation for the sector.

Annual Progress Reports show a hazardous substance use reduction of approximately 194,000 pounds over the same period, thus indicating that fifty-two percent of the goal identified by the sector in P2 Plans has been achieved. The reduction represents approximately a twelve percent reduction in the amount of hazardous substances used in the base year. Analysis of trends for hazardous substance use is not possible using Annual Progress Report data because annual totals are not tracked for specific hazardous chemicals used, only the annual quantities reduced are tracked.

Annual Dangerous Waste Reports indicate that the generation of sludge from wastewater treatment decreased approximately forty-two percent between 1991 and 1994. This is principally due to increased use of sludge drying equipment.

By weight, wastewater represents nearly all (99%) of the hazardous waste generated by the sector facilities. Trends in generation were difficult to establish largely due to one facility discharging 396 million pounds in 1991, the base year. Many instances of misreported or unreported wastewater information were noted on the Annual Dangerous Waste Reports.

There have been significant declines in the release of Toxic Release Inventory (TRI) chemicals to the environment. Particularly notable is the dramatic decline (73%) in releases of the chlorinated solvents TCA, TCE, and the solvent MEK. In 1992, these three chemicals were ranked the top three substances released by volume to the environment by electroplating facilities. Regulatory pressure has been the biggest catalyst for change. The number of sector facilities that are required to file TRI reports has declined significantly from 14 in 1991 to 8 in 1994. In some cases this was due to pollution prevention activities.

## Conclusions

1. Significant reduction efforts were made by sector facilities prior to being required to develop P2 Plans (38% of the P2 opportunities identified were implemented prior to planning).

2. Reductions have occurred for hazardous wastes and hazardous substances targeted for reductions by the sector facilities.

3. Few pollution prevention opportunities have been rejected (only 3%).

4. There is still considerable opportunity for further reductions in rinse water. Excessive use of rinse water is notable. Many P2 opportunities have been identified for implementation by

only a small number of sector facilities. Sector facilities were still generating 42 million pounds of wastewater annually in 1994.

5. In addition, there appears to be several overlooked or underutilized P2 opportunities for bath maintenance and drag-out reduction. Fewer drag-out reduction opportunities have been implemented by the sector facilities than have been implemented nationally. Many P2 opportunities have been considered by only few sector facilities.

6. Finding alternatives for cyanide use is the biggest need for technology transfer nationally.

## Recommendations

**Sector Facilities are encouraged to:**

1. Evaluate the potentially overlooked or underutilized P2 opportunities for bath maintenance, rinse water reduction and drag-out reduction discussed in this report.

2. Investigate P2 opportunities implemented by other facilities for which technology transfer might apply, in particular the opportunities identified by only a few facilities (see Appendix A for a complete list). Contact Ecology's technical staff for more information if the application of these opportunities is of interest. [Rob Reuter (206) 649-7086 or Michael Johnson (360) 407-6338]

3. Obtain copies of the national survey on pollution prevention conducted by the National Center for Manufacturing Sciences (NCMS) in cooperation with the National Association of Metal Finishers (NAMF). This report and the accompanying database provide a wealth of information on pollution prevention for electroplaters.

4. Become involved in the Metal Finishing Roundtable, either through the Pacific Northwest Pollution Prevention Research Center (PPRC) or the Puget Sound chapter of the NAMF.

**Ecology is encouraged to:**

1. Focus technical assistance efforts on the 87 P2 opportunities that have either been selected for future implementation, or are under evaluation. The potentially overlooked or underutilized opportunities discussed in the report should also be examined for the feasibility of technology transfer.

2. Develop a strategy to better assist facilities to correctly designate wastewater as a hazardous waste when appropriate.

3. Make better use of the capabilities of the Toxics Reduction technical staff by encouraging cross-regional interaction with facilities.

4. Obtain and disseminate information on cyanide use reduction/elimination.

5. Discontinue looking for substitutes for chromium in hard chrome plating.

6. Continue participation in the Metal Finishing Roundtable efforts of the PPRC.

# Chapter 1
# Introduction

## Background

Washington's 1990 Hazardous Waste Reduction Act (Chapter 70.95C RCW) was intended to promote the reduction of hazardous waste through voluntary reductions of hazardous substance use and waste generation. The law requires certain facilities to prepare and submit Pollution Prevention (P2) Plans or summaries of those plans to the Department of Ecology. The Legislature also set a policy goal of reducing hazardous waste generation by fifty percent by 1995. P2 Plans cover a five year period and Annual Progress Reports update progress in implementing P2 Plans. It was anticipated that the benefits discovered through the planning would compel companies to move forward to implement pollution prevention. By 1995, nearly all facilities required to complete plans had completed adequate plans.

In March 1995, Ecology's Hazardous Waste and Toxics Reduction Program initiated a pilot study to make use of the information in P2 Plans and Annual Progress Reports received from industry. Three industries were selected for the study: fiberglass reinforced plastics, printed circuit board fabrication and electroplating. Electroplating was selected as one of three initial sector studies because of the chemically intensive nature of the industry, its impact on the environment, its high regulatory profile, and an assumption that considerable opportunities remain for further reductions in hazardous substance use and hazardous waste generation.

## Purpose

There are four primary purposes for conducting the sector studies:

1. Promote implementation of pollution prevention by compiling information in P2 Plans and Annual Progress Reports and sharing the information with businesses comprising the sector.

2. Help facilities benchmark their pollution prevention progress against others in their sector.

3. Document progress the sector has made toward the fifty percent hazardous waste reduction policy goal.

4. Assist Ecology to better target future technical assistance efforts.

The information obtained will be shared with members of the industry sector through workshops or other means. Members of each sector who are not required to do P2 Plans could also benefit from receiving copies of any final reports or participating in other outreach efforts.

## Scope

This report analyzes data from P2 Plans and Annual Progress Reports prepared by 23 Washington electroplating facilities under the Standard Industrial Classification (SIC) code 3471 and 3479. Painting and coating processes are not included. Electroplating facility representatives were not contacted directly as part of this study because of the number of contacts and requests for information that electroplaters receive from government regulators.

The study only includes "job shops," facilities that contract with other manufacturers for their finishing needs. "Captive shops," those that manufacture products rather than specialize in electroplating, were not included in this study because electroplating represents only a small portion of those businesses. Captive facilities do considerable electroplating in Washington, but they are more appropriately placed under other SIC codes such as those associated with aerospace.

Ecology is working with the Pacific Northwest Pollution Prevention Research Center (PPRC) on pollution prevention initiatives through the Metal Finishing Roundtable in the Puget Sound region. Information in this report will be shared with Roundtable participants and electroplaters including planners and non-planners.

This report begins with a discussion of the methodology used to study the P2 Plans and Annual Progress Reports. A profile of the industry gathered from various sources is presented in Chapter 2. Pollution prevention progress that the sector has made toward meeting the statewide 50 percent hazardous waste reduction goal is examined in Chapter 3 using Annual Progress Reports and Annual Dangerous Waste Reports. Chapter 4 displays and discusses P2 opportunities that the plating sector facilities have undertaken or are working to implement. The appendices list the P2 opportunities identified by the sector, the computer data fields used to analyze the P2 Plans and Annual Progress Reports, and a list of 523 references for plating operations.

Where possible, comparisons of pollution prevention progress are made between the 23 Washington plating facilities and the results of a national survey[1] on pollution prevention conducted by the National Center for Manufacturing Sciences (NCMS) in cooperation with the National Association of Metal Finishers (Ref. 1). This exhaustive study, entitled "Pollution Prevention and Control Technology for Plating Operations," captures the collective experience of 318 individual plating companies (294 job shops) nationwide. The 400-page report describes the results of the survey, the track record of currently available pollution prevention technologies, and it allows users to match their shop requirements and capabilities with the experiences of

[1] This highly recommended publication provides detailed descriptions of all commonly used pollution prevention options, and includes a literature search of 523 references that are included in the Appendix (C) at the back of this report. The publication may be obtained for $43 from CAI Engineering, 3433 Valewood Drive, Oakton, VA 22124, or George Cushnie at (703) 264-0039.

comparable survey respondents.  The report also discusses which treatment, recovery and bath maintenance technologies have been most successful for different plating processes and the costs for purchasing and operating these technologies.[2]

## Methodology

Five sources of data were used to develop this report:

- P2 Plans and Annual Progress Reports submitted by the 23 electroplating facilities
- Annual Dangerous Waste Reports
- Toxic Release Inventory (TRI) Reports submitted under the Superfund Amendments Reauthorization Act (SARA) Title III Section 313
- Information from the NCMS sponsored national survey
- The report “Profile of the Metal Finishing Industry,” written by the Waste Reduction Institute for Training and Applications Research

To aid analysis, information for certain data fields was extracted from P2 Plans and Annual Progress Reports, placed into a relational database (Microsoft Access) and queried.  A list of the data fields is included in Appendix B.  The type of information and depth of inquiry are constrained by the information contained in the P2 Plans and Annual Progress Reports.  To facilitate comparison with national trends, the P2 opportunities identified by the 23 sector facilities are grouped under categories similar to the NCMS Report.

[2] A list of 523 references for plating operations compiled by the National Center for Manufacturing Sciences is available from Ecology.  To obtain a copy, call the Ecology regional office located near you or a Sector Team member listed on the inside front cover of this report.

# Chapter 2
# Industry Profile

## Industry Characteristics

There are approximately 31 facilities listed under SIC code 3471 (electroplating, plating, polishing and anodizing) and SIC code 3479 (etching, engraving, and painting and powder coating) that file Annual Dangerous Waste Reports. Twenty-three of these facilities are "job shops" that have been required to prepare P2 Plans. The majority (80%) of these facilities are located in western Washington (see Table 1).

There are many other businesses, "captive shops," that conduct plating as a portion of their manufacturing process under a variety of other SIC codes. Nationally, the Office of Technology Assessment reports that job shops only represent 10-15 percent of the number of companies that perform surface finishing operations (Ref. 2). No figures were available for the number of "captive" shops that perform electroplating in Washington, however, many larger operations exist at Boeing's aircraft and aerospace facilities.

The economic health of job shops discussed in this report is closely tied to manufacturing sectors. Washington's electroplating industry is closely tied to the Boeing company and thus sales for these plating companies is heavily influenced by the aerospace industry (Ref.2). Nine of the 23 job shops included in this report are principally Boeing subcontractors. The decline in factory orders at Boeing for new airplanes in 1993 and 1994 slowed the demand for plated parts in western Washington.

**Table 1: Geographic Distribution and Type of Plating for the 23 Sector Facilities**

| | Facility Name[3] | Site City | Ecology Region | Type of Plating |
|---|---|---|---|---|
| 1 | Asko Processing | Seattle | NWRO | Anodizing, chrome plating, copper plating |
| 2 | Skills Inc. | Seattle | NWRO | Anodizing |
| 3 | Protective Coatings Inc. | Kent | NWRO | Cadmium plating, copper plating, anodizing, conversion coating |
| 4 | Hytek Finishes Co. | Kent | NWRO | Anodizing, cadmium plating, chrome conversion, copper plating |
| 5 | Surftech Finishes Co. Inc. | Kent | NWRO | Anodizing, chrome conversion |

[3] The first 9 facilities are principally Boeing subcontractors.

| | | | | |
|---|---|---|---|---|
| 6 | Production Plating Corp. | Mukilteo | NWRO | Chrome conversion, develop-etch-strip, galvanizing |
| 7 | Industrial Plating Corp. | Seattle | NWRO | Anodizing, cadmium plating, copper plating |
| 8 | TC Systems Inc. | Everett | NWRO | Anodizing |
| 9 | All American Metal Finishing | Kent | NWRO | Galvanizing |
| 10 | Acu-line Corp. | Seattle | NWRO | Develop-etch-strip |
| 11 | Seattle Technical Finishings | Seattle | NWRO | Nickel plating |
| 12 | Scott Galvanizing | Seattle | NWRO | Galvanizing |
| 13 | Ace Galvanizing | Seattle | NWRO | Galvanizing |
| 14 | Art Brass Plating Inc. | Seattle | NWRO | Chrome plating, nickel plating |
| 15 | Artisan Finishing Systems Inc. | Marysville | NWRO | Chrome plating |
| 16 | Blue Streak Finishers Ltd. | Everett | NWRO | Anodizing, chrome conversion |
| 17 | Northwest Etch Technology | Tacoma | SWRO | Develop-etch-strip, imaging |
| 18 | Boomsnub Corp. | Vancouver | SWRO | Hard chrome plating |
| 19 | Middco & Inland Empire Plating | Spokane | ERO | Alkaline zinc, cadmium plating, copper plating |
| 20 | Accra Fab | Spokane | ERO | Chrome conversion |
| 21 | Spokane Galvanizing | Spokane | ERO | Galvanizing |
| 22 | Schwerin Concaves Inc. | Walla Walla | ERO | Hard chrome plating |
| 23 | Multi Manufacturing Inc. | Yakima | CRO | Cyanide zinc plating |

Electroplating facilities tend to be small businesses. In 1992, a majority (over 70%) of all plating companies had fewer than 20 employees (Ref.2). Interestingly, the number of job shops is on the increase while the number of all facilities engaged in electroplating has decreased (about 6%) between 1982 and 1992. This is, in part, because many manufacturers have chosen to avoid the heavy regulatory burden associated with using the chemicals necessary to perform plating operations.

Electroplating is a very competitive industry, especially for shops that process large volumes of parts with low profit margins. Three important issues are low price, delivery time and product quality. The availability of capital, an ongoing issue for platers, is often dependent on the economy and business conditions from year to year. Because of these factors, many platers are reluctant to adopt new technologies unless they can first be demonstrated (Ref.3).

## Overview of Processes

Electroplating is done to impart desirable physical, chemical qualities to a metal surface. Often, corrosion resistance or decorative function is the goal. Electroplating involves a series of three basic processes: surface cleaning or preparation; the actual changing of the surface of the part; and rinsing. The national NCMS study of 318 platers reported 167 different types of processes. The 23 facilities in this study reported 19 general process areas. Table 2 lists the processes and indicates the number of facilities that addressed each process area in their P2 Plans. Table 3 indicates which processes were targeted in P2 Plans for each of the 23 sector facilities. Painting, although present in many facilities that perform electroplating, is not examined in this study because it is also commonly found in many other industries.

**Table 2: List of Processes and Number of Facilities Addressing Each Process in Pollution Prevention Plans**

| Process Used | No. of Facilities Addressing Each Process in P2 Plans |
|---|---|
| Acid Regeneration/Reclamation | 3 |
| Anodizing | 7 |
| Cadmium Plating | 3 |
| Chrome Conversion | 5 |
| Chrome Plating | 5 |
| Cleaning | 17 |
| Copper Plating | 4 |
| Develop-Etch-Strip | 3 |
| Etching | 1 |
| Galvanizing | 4 |
| Imaging | 1 |
| Improved Operating Practices (housekeeping) | 11 |
| Nickel Plating | 2 |
| Oxide Removal | 2 |
| Painting | 7 |
| Preparation | 2 |
| Rinsing | 12 |
| Wastewater Treatment | 18 |
| Zinc Plating | 2 |

## Table 3: Processes Addressed in Pollution Prevention Plans by Facility

| Facility Name4 | Improved Operating Practices | Cleaning | Anodizing | Cadmium Plating | Chrome Plating | Chrome Conversion | Copper Plating | Galvanizing | Nickel Plating | Zinc Plating | Rinsing | Wastewater treatment | Acid Regen./ Reclaim | Develop-Etch-Strip |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Asko Processing | X | X | X | | | | X | | | | X | X | | |
| *Skills Inc. | | X | X | | | | | | | | X | X | | |
| *Protective Coatings Inc. | | X | | | | | | | | | X | X | | |
| *Hytek Finishes Co. | X | X | X | X | | X | X | | | | X | X | | |
| *Surftech Finishes Co. | X | X | X | | | X | | | | | X | | | |
| *Production Plating Corp. | | X | | | | X | | X | | | X | X | | X |
| *Industrial Plating Corp. | X | X | X | X | | | X | | | | X | X | | |
| *TC Systems Inc. | | X | X | | | | | | | | | | | |
| *All American Metal Finishing | X | X | | | | | | X | | | X | | | |
| Acu-line Corp. | | | | | | | | | | | | X | | X |
| Seattle Technical Finishings | | X | | | | | | | X | | | X | | |
| Scott Galvanizing | X | | | | | | | | | | | | | |
| Ace Galvanizing | X | X | | | | | | X | | | | X | X | |
| Art Brass Plating Inc. | X | X | | | X | | | | X | | X | X | X | |
| Artisan Finishing Systems | | X | | | X | | | | | | | | | |
| Blue Streak Finishers | | X | X | | | X | | | | | | X | | |
| Northwest Etch Technology | | | | | | | | | | | | X | | X |
| Boomsnub Corp. | | | | | X | | | | | | | X | | |
| Middco & Inland Empire Plating | | X | | X | X | | X | | | X | X | | | |
| Accra Fab | | | | | | X | | | | | | X | | |
| Spokane Galvanizing | X | X | | | | | | X | | | | X | X | |
| Schwerin Concaves | | | | | X | | | | | | X | X | | |
| Multi Manufacturing Inc. | X | | | | | | | | | X | X | X | | |

[4] The first 9 facilities are principally Boeing subcontractors, and are marked with an asterisk.

## Hazardous Substances & Wastes

The major sources of waste in plating operations can be subdivided into three areas: cleaning/ surface preparation, drag-out and bath dumps. Cleaning includes both alkaline and solvent cleaning. Drag-out is the bath solution that is carried on the work piece as it moves from tank to tank during the plating process. Bath dumps occur periodically because the chemicals in the baths no longer function due principally to exhaustion and/or contamination (Ref.2).

Table 4 lists the hazardous substances and hazardous wastes addressed in the 23 sector facilities' P2 Plans and associated processes. Nationally, the most problematic metal waste streams are: nickel, zinc, chromium (total), copper, cyanide, cadmium and lead, in approximate order of priority (Ref.1).

**Cleaning/Surface Preparation**
The most significant trend in the plating industry in recent years has been the dramatic movement away from chlorinated solvents and toward aqueous cleaning chemicals and other non-chlorinated solvents in the parts cleaning process. Environmental issues differ depending on whether solvent based cleaning or aqueous systems are used. The Puget Sound Air Pollution Control Authority (PSAPCA) banned the use of solvent based vapor degreasers unless a facility owner could demonstrate that there were no other cleaning alternatives.

Solvent based systems include vapor degreasing and or dip or wipe cold cleaning. Air toxics concerns are now generally reduced because of the movement over the past 5 years away from solvents, such as 1,1,1 trichloroethane (TCA), trichloroethylene (TCE) and methyl ethyl ketone (MEK). Nationally, nearly every facility still using vapor degreasing has modified their units to minimize emissions (Ref.2). Many facilities still using solvent cleaning have turned to non-listed, high-flash petroleum naphtha, or to the distillation of spent solvents to reduce materials consumption. Chapters 3 and 4 of this report provide more detail on the decline in solvent cleaning.

Alkaline cleaners are now the most common means to clean parts before plating. The cleaners themselves usually contain no SARA Title III listed constituents, and consist of dilute solutions of alkaline salts with emulsifiers and surfactants. Wastes from alkaline cleaning systems are usually not a major environmental concern. Often, the sludges are non-hazardous solid waste. Other outputs are pretreated or directly sewered under permit. These waste streams are regulated for metals, oils, greases and pH before releasing them to be sure the wastes meet local discharge limits (Ref.2).

Dilute acids are used in nearly every plating process to remove surface oxidation and prepare the surface for plating. Spent acids with metals usually are the resulting waste streams. These waste streams are generally sent to a pretreatment system or directly discharged to the sewer if their pH and metal content meet local discharge limits. The useful life of these acids often can be extended through purification methods such as filtration or electrolytic regeneration (Ref.2).

Occupational health concerns are major issues for certain acids used in spraying applications or for acidic plating baths such as chromic, nitric and hydrochloric acids. In the case of chromic acid, tiny aerosol droplets of highly toxic hexavalent chrome are released into the air when hydrogen gas bubbles reach the surface of the plating bath (Ref.2).

**Electroplating Bath Dumps**

Process inputs typically include anodes as metallic salts dissolved in either an alkaline or acidic solution. Process outputs are typically the same input chemicals that have degraded or become contaminated over time and no longer serve their function. Bath dumps can be reduced in frequency by continuously filtering bath solutions. Filtration sludge and spent filters are the resulting hazardous waste streams. Spent solution from bath dumps and tank bottom sludges are also listed hazardous wastes.

**Drag-out**

The drag-out of process solutions from plating tanks and the resulting contamination of rinse waters is the major pollution control problem for plating facilities. Process chemicals that have been “dragged out” of the plating tanks as residuals on the parts being plated are removed at the point of generation or by end-of-pipe pretreatment processes, either by: precipitation using hydroxide precipitation methods; reduction or oxidation of certain materials, such as chromium; and/or the dewatering of sludge to reduce the volume of the resulting waste (Ref.1).

Usually these waste streams are combined with other waste streams prior to treatment. This fact makes identifying sources and quantities of specific waste streams difficult. Measurement of the effects of a specific pollution prevention measure can be problematic. Fortunately, there are a number of successful, low cost techniques available to reduce drag-out. Chapter 4 of this report identifies drag-out reduction techniques implemented by the 23 sector facilities.

**Table 4: List of Hazardous Substances & Hazardous Wastes Addressed in the 23 Facility Pollution Prevention Plans**

| Process Area | Hazardous Wastes | Hazardous Substances[5] |
|---|---|---|
| Cleaning/surface prep. | Spent 1,1,1 TCA | 1,1,1 TCA |
| | Spent TCE | TCE |
| | Spent MEK | MEK |
| | Spent sodium hydroxide | |
| | Spent cyanide compounds | |
| | F006 wastewater treatment sludge | |
| | Rinse water (hazardous waste) | |
| | Spent solvents | |
| | Spent resins | |
| | Spent blast media | |
| Anodizing | Spent chromic acid | Chromic acid |
| | F006 wastewater treatment sludge | |
| Cadmium Plating | Spent cyanide compounds | |
| | Spent cadmium compounds | Cadmium |
| Chrome Plating | F006 wastewater treatment sludge | (Sulfuric acid)[6] |
| | Filters | |
| Chrome conversion | Rinse water | Chromic acid |
| Copper Plating | Spent cyanide compounds | |
| | F006 wastewater treatment sludge | Copper |
| Nickel Plating | F006 wastewater treatment sludge | Nickel, Nickel compounds |
| Zinc Plating | F006 wastewater treatment sludge | |
| Develop/Etch/Strip | F006 wastewater treatment sludge | |
| | Spent sodium hydroxide | |
| Galvanizing | Spent lime with zinc | Hydrochloric acid |
| | Spent cyanide compounds | Ammonia |
| | Spent MEK | MEK |
| Rinsing | Spent cyanide compounds | Nitric acid |
| | F006 wastewater treatment sludge | Hydrochloric acid |
| | | Chromic acid |
| Wastewater Treatment | Spent sodium hydroxide | |
| | F006 wastewater treatment sludge | Chromic acid, & compounds |
| | | Hydrochloric acid |
| | | Nitric acid |

[5] Hazardous substances are those substances with constituents listed under Section 313 of SARA Title III and the Montreal Protocol listed chemicals.

[6] Sulfuric acid is no longer a SARA Title III listed substance, but it is shown on this list as a substance identified and targeted for reduction in many of the sector facilities' P2 Plans.

| | | |
|---|---|---|
| | | (Sulfuric acid) |
| Acid Regeneration/Reclamation | Spent sulfuric acid | (Sulfuric acid) |
| Housekeeping | Floor sweepings with zinc | Hydrochloric acid |
| | F006 Wastewater treatment sludge | |

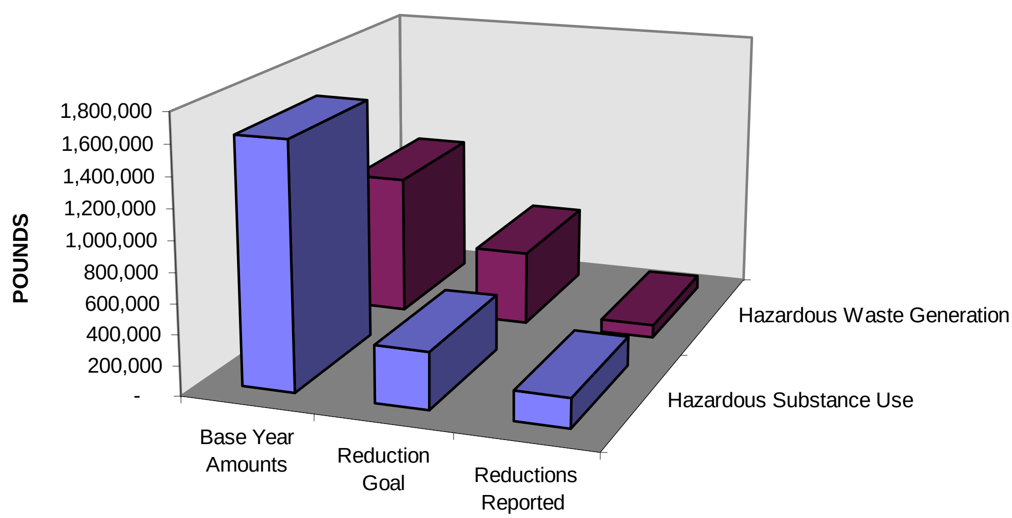
# Chapter 3
# Progress In Preventing Pollution

## Progress Toward the 50% Hazardous Waste Reduction Goal

Washington's 1990 Hazardous Waste Reduction Act established a statewide policy goal of reducing hazardous waste generation by fifty percent by 1995. While the goal was not intended for individual facilities or a given industry, individual facilities were asked to establish five year goals for reducing hazardous waste generation and the use of hazardous chemicals. The goals are based on the anticipated results of implementing their P2 Plans. Numeric goals were established by 15 of the 23 sector facilities, and 12 facilities set both hazardous substance use and hazardous waste reduction goals. The amount of effort expended to establish numeric goals and the accuracy with which those goals were estimated vary widely from facility to facility.

The 23 electroplating facilities in the sector study set a combined hazardous waste reduction goal of 496,000 pounds. This goal is approximately one-half (53%) of their combined base year hazardous waste generation (933,000 lbs.), excluding wastewater. They also set a goal of reducing hazardous substance use by 375,000 pounds, which would approximate a twenty-three percent reduction from the base year use of 1,617,000 pounds (see Figure 1).

**Figure 1: Progress Toward Hazardous Waste and Substance Use Reduction Goals**




**Reported Hazardous Waste Reductions**

Annual Progress Reports prepared by facilities each year contain information on the amounts and types of substances or wastes that are being avoided. An indication of progress is gained by comparing annual reductions reported in "pounds reduced" against the goals that facilities set in their P2 Plans. Reported hazardous waste reductions from three years of Annual Progress

Reports total 84,000 pounds. This indicates that approximately seventeen percent of the combined hazardous waste reduction goals set in the sector facilities' P2 Plans had been achieved between 1991 and 1994. This quantity, excluding wastewater, equals approximately nine percent of total base year generation of hazardous waste for the 23 electroplating facilities. This apparent reduction contrasts with the increase in overall hazardous waste generation discussed later in this chapter. Some possible reasons for this discrepancy are discussed below. It should be noted that hazardous waste reductions were reported by only four of the 23 facilities as shown on Table 5.

Total hazardous substance use and hazardous waste reductions through 1994 are also listed in Table 5. The base year for facilities varies depending on which year they were required to develop a P2 Plan. Most facilities in this study use either 1991 or 1992 as their base year. The quantities shown on Table 5 are not normalized for changes in production and do not include reductions resulting from P2 opportunities implemented prior to planning.

**Reported Hazardous Substance Use Reductions**

Annual Progress Reports indicate a hazardous substance use reduction of approximately 194,000 pounds between 1991 and 1994. Thus, approximately one-half (52%) of the goals established in the P2 Plans have been achieved. This represents about a twelve percent reduction in the amount of hazardous substances used by the sector facilities in the base year of P2 planning. A substantial total reduction of approximately 137,000 pounds occurred for the three principal cleaning solvents used in the industry: 1,1,1 trichloroethane (TCA), trichloroethylene (TCE) and methyl ethyl ketone (MEK). The combined reported reductions for each chemical are as follows:

- TCA 74,800 pounds
- TCE 38,400 pounds
- MEK 24,200 pounds

Sulfuric acid is no longer a SARA Title III listed substance. Removal of this acid from SARA Title III listing has caused measurement problems for tracking the use of hazardous substances because some facilities reported progress in reductions for sulfuric acid while others did not. This is significant because sulfuric acid constitutes one-third (33%) of hazardous substances used by weight for the 23 sector facilities.

**Data Issues for Reported Reductions**

Reported reductions from Annual Progress Reports may not accurately depict P2 progress for several reasons. It is often difficult to link implementation of an opportunity with a measurable reduction. Typically, waste streams from many sources are combined into a single waste stream that feeds directly into a wastewater treatment plant for batch treatment. This often results in a facility not reporting, or under-reporting the amount of hazardous waste reduced for each individual waste stream. Conversely, when the contributing waste streams can be measured, reductions are sometimes double counted. The following are reasons why using "pounds reduced" from Annual Progress Reports as a measure of P2 progress does not fully capture the nature or extent of progress made by implementing P2 strategies:

- Reductions may result from changes in production, as well as pollution prevention.

- Impact from processes added or dropped since the base year of the plan are often not addressed.
- Increases in either hazardous waste generation or the use of hazardous substances are often not reported.
- Annual totals for waste generation or hazardous substance use are not required.
- Reporting errors, for example reporting the amount of a particular hazardous substance used during the year rather than the amount reduced.

**Table 5: Reported Hazardous Substance Use & Hazardous Waste Reductions**

| Facility | Hazardous Substance | Reported Reductions (lbs.) |
|---|---|---|
| TC Systems | Eliminate vapor degreaser (TCA) | 28,900 |
| TC Systems | Substitute for MEK | 24,200 |
| Art Brass Plating Inc. | Eliminate vapor degreaser (TCE) | 23,000 |
| Production Plating | CH90-P | 22,500 |
| Ace Galvanizing Inc. | Reduce ammonia use for neutralization | 17,000 |
| Protective Coatings Inc. | Reduce operation time of degreaser (TCA) | 15,400 |
| Protective Coatings Inc. | Use HVLP paint guns (solvents, paint) | 14,200 |
| Middco Tool & Equipment | Eliminate vapor degreaser (TCE) | 11,800 |
| Blue Streak | Substitute for TCA | 8,800 |
| Skills Inc. | Alternative for vapor degreasing (TCA) | 7,800 |
| Surftech Finishes Co. Inc. | Substitute for TCA | 7,500 |
| Seattle Technical Finishes | Substitute for TCA | 6,500 |
| Asko Processing Inc. | Substitute for TCE | 3,600 |
| Schwerin Concaves Inc. | Chromic acid | 2,700 |
| **TOTAL** | | **193,900** |

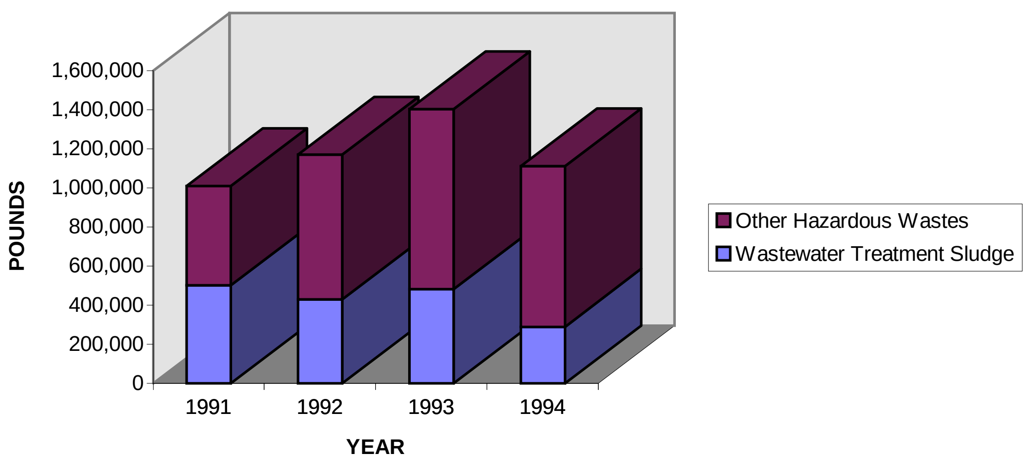
| Facility | Hazardous Waste | Reported Reductions (lbs.) |
|---|---|---|
| Schwerin Concaves Inc. | Wastewater treatment sludge (F006) | 40,800 |
| Scott Galvanizing | Zinc contaminated floor sweepings | 28,300 |
| Protective Coatings Inc. | Reuse spent nitric acid baths in wastewater treatment plant | 13,000 |
| Art Brass Plating Inc. | Spent TCE | 2,000 |
| **TOTAL** | | **84,100** |

**Form 4 Data Trends**
Another approach to examining progress for hazardous waste generation is to use Annual Dangerous Waste Reports (Form 4 data). Ideally, Form 4 data should capture the total hazardous waste routinely generated by a facility during a calendar year. The Form 4 data used for this study is for the period from 1991 to 1994. Results show that total hazardous waste generation,

excluding wastewater increased approximately ten percent during this period while wastewater designating as hazardous waste decreased by eight percent.  In contrast, sludge from wastewater treatment has decreased significantly (approximately 42%) over the same period.  The overall increase in waste generation is due to the large increase (61%) in wastes other than wastewater treatment sludge.  Figure 2 illustrates the trend in hazardous waste generation between 1991 and 1994.  Wastewater is not included.  The data has been normalized (or adjusted) to reflect changes in production as discussed below.

Although there have been increases in the quantities of many waste types generated by the sector facilities, the average rate of production has also increased.  To more accurately view pollution prevention progress, the Form 4 data has been normalized to account for these changes in production levels using a "weighted production factor."  This factor was calculated for each year by multiplying the individual facility production factor by the percentage of total waste generated by that facility.  In this way facilities that generate more waste (hopefully by virtue of greater production) would also have greater influence on the value of the "weighted production factor."  The same weighting method was also used to indicate normalized trends for individual waste types.

**Figure 2:  Hazardous Waste Generation 1991-1994**
**(excluding wastewater)**




Despite a sixteen percent increase in the rate of production from 1991 to 1994, quantities of most waste types have increased faster than increases in production.  The reason for the increases in overall hazardous waste generation is, in part, due to production priorities.  Meeting the demand for increasing production and satisfying customers has tended to be a greater priority at many facilities than has pollution prevention.  Also, the adoption of many environmentally preferable technologies and practices often have a perceived negative impact on production rates which has tended to impede progress in pollution prevention.

To report changes in the rate of production, each facility is required to choose its own "unit of measure."  Table 6 indicates the number of sector facilities that selected each unit of measure.

**Table 6: Units of Measure for the 23 Sector Facilities**

| Units of Measure | Number of Facilities |
|---|---|
| Labor hours/Production hours/Total hours of work | 7 |
| Pounds of metal processed | 5 |
| Gross sales | 4 |
| Production levels | 2 |
| Chromic acid used or purchased | 2 |
| Square feet processed | 1 |
| Annual operating cost | 1 |
| Gallons of paint sprayed | 1 |

In contrast to the trend in overall waste generation, sludge from wastewater treatment has decreased approximately forty-two percent between 1991 and 1994. Over the same period, the quantity of sludges designating as extremely hazardous waste decreased by nearly one-third (31%) while sludges designating as dangerous waste declined by nearly one-half (47%). The dramatic overall decrease in wastewater treatment sludge is probably due, at least in part, to the increased use of sludge drying equipment.

Wastewater designating as a hazardous waste is required to be included on Form 4's. Wastewater represents the vast majority (98.9%) of all hazardous waste by weight released by the 23 facilities between 1991 and 1994. As result, the sheer volume of wastewater tends to occlude data trends for other waste categories, so it is considered separately. A decrease in wastewater generation of thirty-seven percent was noted between 1991-1994 using data unadjusted for production. However, this decrease was largely due to one facility discharging 396 million gallons in 1991. This considerably raised the base year amount, thus making wastewater quantities for the following years appear to be reduced. Omitting this facility, and normalizing the data for changes in the rate of production, the release of hazardous wastewaters generated by sector facilities decreased by eight percent from 1991-1994. Despite the modest reduction, 42 million gallons are still released annually, suggesting that opportunities probably remain for further reductions.

Although there are data accuracy issues with the annual Form 4 data, it is generally assumed to more accurately portray waste generation trends than Annual Progress Report information. This is because of the very incomplete picture that the "pounds reduced" measure provides, as well as the other data integrity issues discussed in the previous section.

The increase in hazardous waste generation based on Form 4 data contrasts with the nine percent decrease suggested by the reductions in the Annual Progress Reports. That the two reporting systems show differing results is not surprising recognizing that the two systems are really quite different. There are several differences in what data is included in each report and the way that information is reported. For example, Form 4 reports include reductions from previously implemented P2 opportunities, while Annual Progress Reports do not. Also, Annual Progress Reports measure pounds of waste avoided while Form 4 reports the generated waste totals for specific waste streams.

## Trends In Chemical Usage & Releases to the Environment

Progress toward pollution prevention should not only address waste reduction, but should also include reductions in the release of hazardous substances to the environment. Although there is no universal data system in place to report progress for all media, the Toxic Release Inventory (TRI) data does provide some insight into trends in chemical releases. Actual releases from all facilities that perform electroplating is greater than TRI data indicates because the data includes neither "captive" shops nor small shops that are exempt from reporting. Shops are exempt if they employ less than 10 employees, or are under the TRI reporting thresholds.

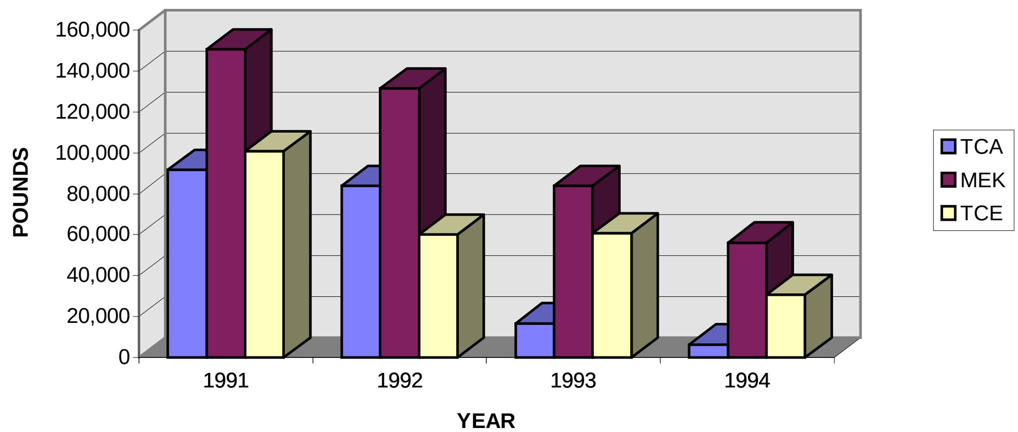
The number of sector facilities that are required to file TRI reports has declined significantly from 14 in 1991 to only 8 in 1994. This has occurred because some facilities are using less chemicals and as a result they no longer exceed the reporting thresholds for TRI. In some cases this was due to pollution prevention activities. In other cases it is because companies are no longer are required to report certain TRI chemicals, such as sulfuric acid.

There have been significant declines in the release of TRI chemicals from 1991-1994. Regulatory pressure to discontinue the use of ozone depleting chemicals and the increased cost to purchase many of these chemicals has caused the biggest change in chemical usage patterns the plating industry has seen in decades. Particularly notable is the dramatic (73%) decline in releases of the chlorinated solvents: TCA and TCE, and the solvent MEK. Figure 3 illustrates the decline in use of these solvents.

TCA, TCE, and the solvent MEK were ranked the top three substances, by volume, released into the environment by electroplating facilities in 1992. Interestingly, of the hazardous substance use reductions reported by the 23 facilities in their Annual Progress Reports, seventy-one percent (by weight) were reductions for these three chemicals. A large decline (64%) was also seen for toluene, another organic solvent which ranks $6^{th}$, nationally, on the list of chemicals released into the environment.

In 1992, hydrochloric acid, sulfuric acid and nitric acid ranked $7^{th}$, $8^{th}$ and $9^{th}$ respectively, in national releases by volume. There was a decrease of nine percent in the release of nitric acid and hydrochloric acid for the 23 sector facilities between 1991 and 1994. Sulfuric acid was not addressed as it is no longer listed as a SARA Title III chemical.

**Figure 3: Chemical Releases for Three Solvents 1991-1994**



# Chapter 4
# Progress In Implementing P2 Opportunities

## Summary

Pollution prevention is an important tool to help Washington's electroplating facilities attain compliance and reduce operating costs. The 23 facilities in this study have made considerable progress in identifying and implementing the P2 opportunities outlined in their P2 Plans. In all, the 23 sector facilities have implemented 126 P2 opportunities, either prior to or since planning began. Table 7 lists and Figure 4 illustrates the number of opportunities for each opportunity status.

There were five status categories for the P2 opportunities identified by the electroplating sector facilities through the P2 planning process. These categories are defined as follows:

| | |
|---|---|
| Prior to Planning | Reduction opportunities implemented prior to the planning process. |
| Implemented | Reduction opportunities implemented between the time the plan was written and the submittal of the last Annual Progress Report. |
| Selected | Reduction opportunities selected, but not yet implemented. |
| Rejected | Reduction opportunities that will not be implemented. |
| Further Study | Reduction opportunities under technical or economic research. |

**Table 7: Pollution Prevention Opportunities by Status**

| Status of Opportunity | Number of Opportunities |
|---|---|
| Prior to Planning | 84 |
| Implemented | 42 |
| Selected for Implementation | 50 |
| Selected for Further Study | 37 |
| Rejected | 7 |
| **TOTAL** | **220** |

**Figure 4: P2 Opportunity Distribution by Implementation Status**

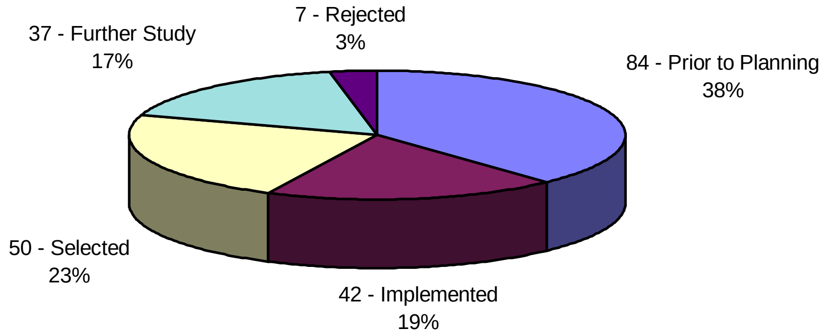



Table 8 indicates that although pollution prevention activities have occurred across a range of opportunity types, the focus has been the reduction or elimination of the use of solvents, especially chlorinated solvents, and rinse water reduction. P2 opportunities in wastewater treatment technologies, improved operating practices, and cyanide use reduction or elimination also rank high for opportunities implemented either prior to or following planning. Most opportunities that facilities are working to implement are the same types of opportunities for which much implementation has already taken place. Three opportunities are under further study, two for ion exchange and one for electrowinning.

P2 opportunities identified in the sector facility P2 Plans have been primarily directed toward six general types of activities. The general P2 activity categories listed below conform with the format used in the National Center for Manufacturing Sciences (NCMS) survey report (Ref.1):

- Improved Operating Practices
- Solvent Use Reduction/Elimination
- Rinse Water Reduction
- Drag-out Reduction
- Wastewater Treatment
- Chromium & Cyanide Use Reduction/Elimination

The following sections of this report discuss the P2 opportunities grouped under each of the six NCMS activity categories in approximate order of frequency as indicated by facility P2 Plans. Table 8 lists the sector P2 opportunities broken out by NCMS general category. Chemical solution maintenance and chemical recovery are not discussed in detail because of the relatively few scattered opportunities identified by the sector facilities. A comprehensive list of all opportunities, including those for chemical solution maintenance and chemical recovery that were identified by the sector facilities is included in Appendix A.

**Table 8: P2 Opportunities Grouped by Status and NCMS Category**

| Opportunity Status & Category of Opportunity | No. of Opportunities[7] |
|---|---|
| **Prior to Planning** | |
| Solvent use reduction/elimination | 15 |
| Rinse water reduction | 12 |
| Conventional wastewater treatment technologies | 9 |
| Improved operating practices (+general housekeeping) | 8 |
| Drag-out reduction | 5 |
| Filtration (Chemical solution maintenance) | 4 |
| Subtotal | 53 |
| | |
| **Implemented** | |
| Solvent use reduction/elimination | 17 |
| Rinse water reduction | 7 |
| Cyanide use reduction/elimination | 3 |
| Improved operating practices (+general housekeeping) | 2 |
| Conventional wastewater treatment technologies | 1 |
| Drag-out reduction | 1 |
| Subtotal | 31 |
| | |
| **Selected for Implementation** | |
| Improved operating practices (+general housekeeping) | 7 |
| Drag-out reduction | 6 |
| Conventional wastewater treatment technologies | 6 |
| Solvent use reduction/elimination | 5 |
| Rinse water reduction | 4 |
| Subtotal | 28 |
| | |
| **Further Study** | |
| Solvent use reduction/elimination | 6 |
| Chromium use reduction/elimination | 6 |
| Rinse water reduction | 3 |
| Electrowinning | 3 |
| Drag-out reduction | 2 |
| Improved operating practices (+general housekeeping) | 2 |
| Chemical recovery (ion exchange) | 2 |
| Subtotal | 24 |
| | |

[7] Only includes opportunities for the six NCMS activity categories.

| Rejected Opportunities | |
|---|---|
| Rinse water reduction | 1 |
| Chemical recovery (ion exchange) | 1 |
| Solvents use reduction | 1 |
| Chromium use reduction/elimination | 1 |
| Conventional wastewater treatment technologies | 1 |
| Other | 2 |
| Subtotal | 7 |
| **TOTAL** | **143** |

## Improved Operating Practices

Improved operating practices (including housekeeping) are normally the first step in any pollution prevention program. These opportunities are typically easy to identify and inexpensive to implement. Table 9 lists the number of facilities that selected each improved operating practice P2 opportunity identified and sorts them by status category. Eight opportunities were implemented prior to planning and seven have been selected for implementation in the future.

Improving operating practices can have many benefits. Training employees on pollution prevention is a good place to start because employees are usually in the most advantageous position to identify and implement pollution prevention measures. Involving employees in all aspects of pollution prevention is essential to assure their "buy-in."

Opportunities to manage chemical purchasing, storage, usage, and handling are important because they can increase the amount of purchased material that actually gets used in the processes they are intended for rather than wasted. They may also reduce worker exposure to chemicals. For example, small leaks over long periods of time can add up to large losses in bath and rinse water. Over one-half (58%) of the 318 shops responding to the NCMS national survey indicated that they have established a preventive maintenance program for tanks. Regular maintenance of racks and/or barrels is performed by sixty-five percent of survey respondents.

**Table 9: Number of Sector Facilities Targeting P2 Opportunities for Improved Operating Practices**

| P2 Opportunity | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Train employees on efficient use of chemicals/minimize spills | | 1 | 2 | | | 3 |
| Improved housekeeping | 1 | | | | | 1 |
| Improve maintenance (reduce leaks, improve squeegee rollers, etc.) | | | 1 | | | 1 |
| Use just-in-time purchasing practices | 1 | | | | | 1 |
| Improve chemical storage to reduce contamination and waste | 1 | | 1 | | | 2 |
| Install new chemical storage area | 1 | | | | | 1 |
| Install secondary containment for each process tank | 2 | | | | | 2 |
| Install drip pans | 1 | | 1 | | | 2 |
| Work with customers to minimize oil on incoming parts | | | | 1 | | 1 |
| Minimize production of metallic floor sweepings | | 1 | 1 | | | 2 |
| Reclaim metallic floor sweepings (by hand sorting zinc) | 1 | | | | | 1 |
| Increase space | | | | 1 | | 1 |
| Install loading meters on mechanical scrub | | | 1 | | | 1 |
| **TOTAL** | **8** | **2** | **7** | **2** | **0** | **19** |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation, "FS" - Further Study, "R" - Rejected

Improved operating practices appear to be an underutilized area for many facilities nationwide, as well as in Washington. Table 10 lists improved operating practices, mostly related to bath maintenance, that were not specifically identified by the 23 sector facilities. These opportunities appear to be overlooked and may be worth consideration (Ref.1). One exception is "using bath analysis to extend bath life," which has been implemented by one sector facility and is being studied further by two additional facilities. For each opportunity in Table 10, the percentage of facilities in the NCMS survey using the method is shown and a success rating ranging from 1 to 5, with 1 being the least successful, and 5 the most successful assigned. The national users survey also indicated an unusually high percentage of shops (85.8%) that use specifically assigned personnel for chemical additions, and many shops surveyed (72%) have written procedures for bath make-up and chemical additions. Both measures received top success ratings.

**Table 10: Improved Operating Practices by National Survey Possibly Underutilized by Washington's Electroplating Facilities**

| P2 Opportunity | Percentage of Shops Using Method Nationally[8] | Success Rating[9] |
|---|---|---|
| Perform routine bath analysis | 92.1 | 4.37 |
| Use specific personnel for chemical additions | 85.8 | 4.16 |
| Maintain bath analysis/addition logs | 85.8 | 4.35 |
| Use process baths to maximum extent (no dump schedule) | 73.6 | 4.21 |
| Strict chemical inventory control | 65.1 | 3.83 |
| Install overflow alarms on process tanks | 15.7 | 3.36 |

## Solvent Use Reduction/Elimination

The most significant trend in the electroplating industry in recent years has been the dramatic movement away from solvents and toward aqueous cleaning chemicals and other less hazardous solvents. Solvents are commonly used in vapor degreasers, immersion or spray operations and hand wiping. The solvents most commonly in use by the electroplating sector facilities are: 1,1,1 TCA, TCE and MEK. As mentioned in Chapter 3, significant reductions in the use of these solvents and releases to the environment of have been reported by sector facilities.

The move to reduce or eliminate the use of chlorinated and some non-chlorinated solvents has caused more pollution prevention activity than any other opportunity type. As illustrated in Table 11, 44 individual P2 opportunities were described in the sector P2 Plans and Annual Progress Reports that relate to solvent reduction. Thirty two of those opportunities (72%) have been implemented either prior to, or since P2 planning was completed.

Regulations restricting the use of ozone-depleting chemicals, voluntary actions by industry under EPA's 33/50 program, rising costs for the purchase and disposal of many solvents, and concerns by many workers over the health effects have contributed to the decline in solvent use.

Solvent use declined by approximately fifty percent between 1986 and 1993 according to the national NCMS survey report. Not only has the number of solvent applications declined, but the quantities of solvent used per application have also declined (Ref.1).

The biggest incentive in Washington to discontinue use of solvents was the 1992 regulation adopted by the Puget Sound Air Pollution Control Authority (PSAPCA) which required

[8] Adapted from the National Center for Manufacturing Sciences report, Pollution Prevention & Control Technology for Plating Operations, 1994. The survey was based on 318 survey responses.

[9] Respondents were asked to rate the success on a scale of 1 to 5, with 1 being the least successful, and 5 being the most successful.

companies to discontinue the use of vapor degreasers. If a company could demonstrate that they had no other feasible alternative, they could continue to use vapor degreasers while paying a hefty fee. Fourteen P2 opportunities identified by sector facilities involve modification to or elimination of vapor degreasers. The NCMS national survey reported that the majority (75%) of facilities with degreasers in operation in 1993 had modified their degreasers to reduce emissions. Typical modifications included increasing freeboard, adding a roll-top, controlling hoist speed, or adding a refrigeration zone.

Although there has been an increase in the use of alkaline cleaning, many facilities have had difficulty eliminating solvent applications. Common problems reported with discontinuing solvent use are:

- Long drying time for parts using solvent substitutes
- Skin rashes from citrus based cleaners
- Extra labor and time needed for alkaline cleaning operation
- Solvent substitutes often do not clean as well
- Production problems often created by substitution for solvents

**Table 11: Number of Sector Facilities Targeting P2 Opportunities for Solvent Use Reduction/Elimination**

| P2 Opportunity | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Substitute “alternative” in place of vapor degreasing | 2 | 6 | 1 | | | 9 |
| Modify vapor degreaser (freeboard, cooling coil, spray controls) | 3 | | | | | 3 |
| Reduce operation time of vapor degreaser | | 1 | 1 | | | 2 |
| Recycle spent solvents using distillation | 6 | 3 | 1 | | | 10 |
| Identify alternative to TCA | | | | 3 | | 3 |
| Substitute Brulin 815GD in place of 1,1,1 TCA | 1 | 4 | | | | 5 |
| Substitute aqueous cleaning in place of TCA | 1 | 1 | 1 | | | 3 |
| Substitute alternative in place of MEK | | 1 | | 1 | | 2 |
| Substitute Citra-Safe in place of MEK | 1 | | | | | 1 |
| Reuse MEK in place of “new” MEK | | | 1 | | | 1 |
| Evaluate alternatives to MEK for off-line strip | | | | 1 | | 1 |
| Reclaim resins from MEK wastes | | | | 1 | | 1 |
| Substitute low VOC primer in place of MEK | | 1 | | | | 1 |
| Use ultrasonic bath with alkaline cleaner | | | | | 1 | 1 |
| Substitute Alodyne 600 for Alodyne 1200S | 1 | | | | | 1 |
| **TOTAL** | **15** | **17** | **5** | **6** | **1** | **44** |

“P” - (Implemented) Prior to Planning, “I” - Implemented, “S” - Selected for implementation, “FS” - Further Study, “R” - Rejected

## Rinse Water Reduction

The drag-out of process solutions from plating tanks and subsequent contamination of rinse waters is one of the primary environmental concerns for most electroplaters. This is illustrated by environmental management costs by media, which indicate that the majority of such costs (62%) is attributed to water, while only thirty-two percent is attributable to waste (Ref.2).

Reducing wastewater flows can have the following advantages:

- Lower operating costs for water bills, heating bills, waste pretreatment and materials purchase and storage costs
- Reduce quantity of treatment chemicals used
- Potentially improve the efficiency of waste treatment systems
- Reduce the needed size and capital expense for future end-of-pipe treatment systems
- Improved product quality

Several sector facilities significantly reduced the quantity of hazardous wastewater generation between 1991 to 1994. However, an equal number of firms reported increases in water use. Chapter 3 includes more detail on reductions of hazardous wastewater.

Nationally, considerable progress has been made in reducing water use. The NCMS national survey indicated that over two-thirds (68%) of the plating shops have reduced flows by implementing pollution prevention. The average reduction for facilities that were able to quantify their reductions, was about 20,000 gallons per day, or thirty percent of their water use.

Table 12 lists 27 P2 opportunities that were identified for rinse water conservation by sector facilities. Nearly half of these opportunities were implemented prior to P2 planning. Seven opportunities were reported as implemented following planning. Approximately seventy percent have been implemented, either as previous practices or following P2 planning. No reductions in hazardous wastewater generation have been reported in Annual Progress Reports however. Because waste streams are often combined in electroplating operations, it is difficult to correlate reductions resulting from implementing a single up-stream opportunity.

Sector facilities indicated that “evaporation of rinse water” and “recycling rinse water to make-up tanks” were the most frequently implemented P2 opportunities in this category. Although rinse water reduction (along with wastewater treatment) was second to reduction of chlorinated solvents in P2 activity, it appears that considerable opportunities still remain in rinse water reduction for the sector facilities. Comparing with national figures, it appears that a smaller percentage of Washington facilities have implemented rinse water conservation than the national average.

The most common and the most successful rinse water reduction methods are listed in Table 13. Based on their relatively “high” success rating and their lower utilization factor, spray rinses, cascade rinsing, and timer rinse controls may be underutilized opportunities.

**Table 12: Number of Sector Facilities Targeting P2 Opportunities for Rinse Water Reductions**

| P2 Opportunity | P | I | S | F | R | Total |
|---|---|---|---|---|---|---|
| Concentrate rinse water via evaporation | 2 | | 1 | | | 3 |
| Install improved tank heating system | 1 | | | | | 1 |
| Install counter current rinse configurations | 1 | 1 | | 1 | | 3 |
| Recycle rinse water to make-up process tanks | 2 | 2 | | | 1 | 5 |
| Install spray rinses | 1 | 1 | | | | 2 |
| Rinse over process baths (in-tank spray bars) | 1 | 1 | | | | 2 |
| Use ion exchange to recover rinse water | | | 1 | 1 | | 2 |
| Rinse water recovery | | 1 | | 1 | | 2 |
| Install dead rinse tanks | 1 | | | | | 1 |
| Automatic pH controls on rinse water | 1 | | | | | 1 |
| Automatic rinse water addition (conductivity activated controls) | 1 | | | | | 1 |
| Install flow meters on rinses | | | 1 | | | 1 |
| Install flow restrictors to conserve water on rinses | 1 | | | | | 1 |
| Recovery rinse after chromate | | 1 | | | | 1 |
| Use HVLP spray nozzles on spray rinses | | | 1 | | | 1 |
| **TOTAL** | **12** | **7** | **4** | **3** | **1** | **27** |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation, "FS" - Further Study, "R" - Rejected

**Table 13: The Most Common Rinse Water Use/Reduction Methods Nationally[10]**

| Method | # Rank in Use | Percentage of Use | # Rank in Success | Success Rating[11] |
|---|---|---|---|---|
| Flow restrictors | 1 | 69.8 | 2 | 4.10 |
| Counter current rinses | 2 | 68.2 | 1 | 4.21 |
| Manually turning off rinse water when not in use | 3 | 65.7 | 8 | 3.63 |
| Air agitation in rinse tanks | 4 | 58.2 | 7 | 3.71 |
| Spray rinses[12] | 5 | 39.0 | 3 | 3.82 |
| Cascade rinsing or reactive rinsing | 6 | 23.9 | 4 | 3.79 |
| Timer rinse controls[13] | 9 | 11.3 | 5 | 3.78 |

## Drag-out Reduction

Process solutions that drip from parts undergoing plating are dragged out of the plating tanks and eventually contaminate rinsing operations. The contamination of rinse water due to drag-out is among the most pervasive pollution control problems for most platers. Most drag-out reduction methods are inexpensive and offer quick pay back of investment through savings in chemicals purchased, reduced water use and improved quality and decreased operating costs of a pollution control system. Many devices and procedures have been used successfully to reduce drag-out. These techniques have the effect of altering: bath viscosity, chemical concentration, surface tension, velocity of part withdrawal, or temperature (Ref.1).

Sector facilities identified 14 opportunities for reducing drag-out. Several opportunities were targeted by more than one facility as seen in Table 14. Six of the opportunities were implemented prior to planning while only one, optimizing parts orientation on racks, has been implemented since planning. Six opportunities have been selected for implementation and two are under investigation. No drag-out reduction opportunities have been rejected.

No reductions have thus far been reported in Annual Progress Reports related to the implementation of drag-out techniques. This is not surprising since waste streams affected by drag-out reduction measures are typically combined with other waste streams prior to treatment. This makes measurement of the effects of a specific measure difficult.

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[10] Adapted from the National Center for Manufacturing Sciences report Pollution Prevention & Control Technology for Plating Operations, 1994.

[11] Respondents were asked to rate success on a scale of 1 to 5, with 1 being the least successful, and 5 being the most successful.

[12] Spray rinsing is most commonly used as a water use reduction method rather than a drag-out reduction method.

[13] Fewer of the shops surveyed used timer rinse controls than conductivity controllers, but the success rating for timed controls was considerably higher 3.78 vs. 3.25.

**Table 14: Number of Sector Facilities Targeting P2 Opportunities for Drag-out Reduction**

| P2 Opportunity | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Drag-out reduction techniques | 1 | | | 1 | | 2 |
| Use drag-out reduction techniques (optimize parts orientation) | 1 | 1 | 1 | | | 3 |
| Use drag-out reduction techniques (extended hang times) | 1 | | 1 | 1 | | 3 |
| Install splash guards between process tanks | 2 | | | | | 2 |
| Install hi-pressure blowers on etchers to reduce drag-out | | | 1 | | | 1 |
| Improved blower nozzles on DES to reduce drag-out | | | 1 | | | 1 |
| Use trays for processing large panels | | | 1 | | | 1 |
| Improved containment on stripper | | | 1 | | | 1 |
| **TOTAL** | **5** | **1** | **6** | **2** | **0** | **14** |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation, "FS" - Further Study, "R" - Rejected

Measures to reduce drag-out and rinse water volumes have been implemented by more than ninety percent of the shops nationally. Survey respondents gave drag-out reduction techniques an above average success rating (Ref.1). The most frequently used drag-out reduction techniques are listed in Table 15. They include: allowing parts to drip over process tanks, use of drag-out rinses, reducing the speed of rack/part withdrawal, use of drip shields, orienting parts on racks to minimize solution holdup (Ref.1). The utilization of these drag-out reduction techniques by Washington's electroplating sector facilities appears to be an area where P2 measures could be significantly improved.

**Table 15: The Most Common Drag-out Reduction Methods Nationally[14]**

| Method | # Rank in Use | Percentage of Use | # Rank in Success | Success Rating[15] |
|---|---|---|---|---|
| Drag-out rinse tanks; return chemicals to process bath (manual) | 1 | 61.0 | 4 | 3.77 |
| Allow rack/part to drip over plating tank (manual) | 2 | 60.4 | 10 | 3.44 |
| Drip shields (boards) between tanks | 3 | 56.9 | 7 | 3.68 |
| Position work piece to minimize solution holdup | 4 | 51.9 | 5 | 3.75 |

[14] Adapted from the National Center for Manufacturing Sciences report Pollution Prevention & Control Technology for Plating Operations, 1994.

[15] Respondents were asked to rate the success of on a scale of 1 to 5, with 1 being the least successful, and 5 being the most successful.

| | | | | |
|---|---|---|---|---|
| Reducing speed of rack/part withdrawal (manual) | 5 | 38.1 | 16 | 3.14 |
| Lower bath concentrations | 6 | 34.6 | 13 | 3.37 |
| Using a wetting agent to reduce surface tension | 7 | 32.4 | 17 | 3.12 |
| Drip tanks; return chemicals to process bath (manual) | 8 | 27.0 | 11 | 3.40 |
| Allow rack/part to drip over plating tank (automatic) | 9 | 25.8 | 3 | 3.61 |
| Reducing speed of rack/part withdrawal (automatic) | 10 | 21.7 | 9 | 3.61 |
| Using drag-in/drag-out arrangement (manual) | 11 | 20.8 | 12 | 3.39 |
| Use automatic return of process chemicals to bath | 12 | 19.5 | 2 | 3.81 |
| Increasing solution temperatures | 13 | 17.9 | 16 | 3.14 |
| Using drag-in/drag-out arrangement (automatic) | 14 | 10.7 | 1 | 3.82 |
| Drip tank: return chemicals to process bath (automatic) | 15 | 6.6 | 15 | 3.24 |
| Air knives that blow off drag-out (automatic) | 16 | 5.7 | 6 | 3.72 |
| **Average** | | | | **3.50** |

## Wastewater Treatment

Conventional wastewater treatment (metals removal of combined metal-bearing wastewaters by hydroxide precipitation and sludge dewatering) has allowed most facilities to meet federal industrial pretreatment water quality discharge standards. Those facilities which discharge to sewage treatment plants with discharge standards more stringent than federal standards may have resorted to alternative technologies such as membrane filtration or ion exchange to meet discharge limits. Most shops using conventional technology had their wastewater treatment systems completed by 1985, after which the Federal Electroplating Categorical Pretreatment Standards (40 CFR 413) were applicable (Ref.1).

The conventional wastewater treatment P2 opportunities, and alternative technology opportunities identified in facility P2 Plans are listed in Table 16. Nine of the conventional treatment opportunities were implemented prior to planning, while two were completed following planning. The purchase of sludge drying equipment to reduce sludge volume has been the primary wastewater treatment waste minimization activity pursued by sector facilities. This activity accounts for 10 of the 18 identified opportunities. Thirty percent of the respondents to the nationwide NCMS survey have also purchased sludge drying equipment.

Electroplaters are more frequently concentrating their wastewater treatment sludge to increase sludge metals content thereby making them more acceptable to metal recyclers. Unfortunately, the higher metals content of the sludge has caused the sludge to designate as an extremely hazardous waste more often. Between 1991 and 1994, wastewater treatment sludge designation as an extremely hazardous waste has increased from approximately thirty-four percent to forty-nine percent. Thirty percent of the respondents in the national survey are using off-site metals recyclers as an alternative to land disposal of their treatment sludge and spent process solutions (Ref.1).

The application of alternative technology for wastewater treatment has been limited to three facilities that evaporated spent process baths after neutralization. These applications were end-of-pipe treatment options with no recovery of plating chemicals. One facility is currently investigating using reverse osmosis as a final step to remove metals from a wastewater effluent. The national survey respondents indicated that approximately ten percent of the shops rely on non-conventional treatment methods. Zero-discharge accounted for eight percent of the shops (Ref.1). Chrome platers experienced the most success achieving zero-discharge due to a high ratio of evaporation to drag-out and robust plating solutions (Ref.1). More frequent use of advanced technologies may exist in captive shops such as in the aerospace industry.

**Table 16: Number of Sector Facilities Targeting P2 Opportunities for Wastewater Treatment**

| P2 Opportunity | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| **Metals Removed by Hydroxide Precipitation:** | | | | | | |
| Alternative to sodium hydroxide precipitation | | | 1 | | | 1 |
| Substitute magnesium hydroxide in place of calcium or sodium hydroxide precipitation | | | | | 1 | 1 |
| Reuse spent alkaline cleaning solution for neutralization | 2 | | 1 | | | 3 |
| **Sludge Dewatering - thickening, thermal dehydration:** | | | | | | |
| Install sludge dryer | 3 | | 1 | | | 4 |
| Install/ improve sludge dewatering (sand filters, filter press, etc.) | 3 | 2 | 1 | | | 6 |
| Use galvanizing kettle heat to dry wet sludge | | | 1 | | | 1 |
| **Evaporation:** | | | | | | |
| Evaporate all rinse water, spent process baths after neutralization | 3 | | | | | 3 |
| **Membrane Filtration:** | | | | | | |
| Reverse osmosis | | | | 1 | | 1 |
| **Chromium Reduction - hexavalent to trivalent:** | | | | | | |
| Substitute “alternative” for chromic acid treatment | | | 1 | | | 1 |
| **Cyanide Oxidation to nitrogen, carbon:** | | | | | | |
| Use electrolytic cyanide destruction and metal recovery | 1 | | | | | 1 |
| **Other Wastewater Treatment:** | | | | | | |
| Reuse spent nitric acid baths in WWTP | 1 | 1 | | | | 2 |
| Segregate and treat influent waste stream | 1 | | | | | 1 |
| Batch treat waste solutions | | | 1 | | | 1 |
| **TOTAL** | **14** | **3** | **7** | **1** | **1** | **26** |

“P” - (Implemented) Prior to Planning, “I” - Implemented, “S” - Selected for implementation, “FS” - Further Study, “R” - Rejected

# Chromium & Cyanide Use Reduction/Elimination

**General**

Environmental concerns have been the primary drivers for research and development into alternatives for the use of cyanide, cadmium and hexavalent chrome. Many regulators, the military and some in the private sector feel that cyanide, chromium and cadmium should be targeted for substitution or elimination to meet health, safety and environmental goals. In some cases, the alternatives provide a lower quality finish and create new health and safety, or environmental problems (Ref.1).

**Chrome**

Sector facilities identified 11 opportunities related to chromium use reduction or elimination (See Table 17). Only two P2 opportunities have been implemented: substituting boric acid in place of chromic acid for conversion coatings and converting hexavalent chrome to trivalent chrome. Both of these implemented opportunities are under further study by two other sector facilities. Six opportunities are under study. One opportunity was rejected, using non-chromate conversion coatings for aluminum.

There is no single substitute that meets all the requirements of hard chrome plating and therefore multiple substitutes must be used. Often, the bath solutions for the substitutes are not amenable to recovery or maintenance and, in the end, produce more waste per part than chrome plating. Hard chrome has an advantage of being able to be operated in a closed-loop without discharges (Ref.1).

**Cyanide**

The management of cyanide wastes and the expense of using and treating cyanide have made the search for alternatives a top priority for many plating shops. The NCMS survey of 318 plating shops showed that fourteen percent of the respondents currently have compliance problems with cyanide. Finding an alternative for cyanide, or better means to control its release to the environment, was the single biggest technology transfer need identified by plating shops nationwide (Ref.1).

Sector facilities identified eight P2 opportunities related to cyanide use reduction or elimination. Five of the eight opportunities have been implemented. The most common change was the use of alkaline-zinc in place of zinc-cyanide plating. Substituting alkaline-zinc in place of zinc-cyanide plating has been the most successful cyanide use reduction method with three sector facilities successfully making the change. This trend was also noted nationally where more than ninety percent of the shops attempting the conversion were able to make the change (Ref.1).

**Table 17: Number of Sector Facilities Targeting P2 Opportunities for Chromium & Cyanide Use Reduction**

| P2 Opportunity | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| **Chromium Use Reduction/Elimination:** | | | | | | |
| Use non-chromate conversion coatings for aluminum | | | | 2 | 1 | 3 |
| Substitute boric acid in place of chromic acid for conversion coatings | 1 | | | 1 | | 2 |
| Convert hexavalent chrome to trivalent chrome | | 1 | | 1 | | 2 |
| Substitute non-chromate solution in place of chromic acid | | | 1 | | | 1 |
| Use chrome free primer | | | 1 | | | 1 |
| Reduce liquid level in chromic acid conversion tanks | | | | 1 | | 1 |
| Subcontract out chromium conversion | | | | 1 | | 1 |
| **TOTAL** | **1** | **1** | **2** | **6** | **1** | **11** |
| | | | | | | |
| **Cyanide Use Reduction/Elimination:** | | | | | | |
| Substitute non-cyanide Ni Zn in place of cyanide (cadmium plating) | | 1 | | | | 1 |
| Use alkaline-zinc in place of zinc-cyanide plating process | 2 | 1 | | | | 3 |
| Substitute alkaline copper chemistry for cyanide copper | | | | 1 | | 1 |
| Substitute ammoniacal chemistry in place of cyanide chemistry for copper strip | | 1 | | 1 | | 2 |
| Use non-cyanide Enstrip C-38 for copper stripping | | | 1 | | | 1 |
| **TOTAL** | **2** | **3** | **1** | **2** | **0** | **8** |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation, "FS" - Further Study, "R" - Rejected

# Chapter 5
# Conclusions

Ecology evaluated the Pollution Prevention Plans of 23 Washington businesses in the electroplating industry. That evaluation yielded many insights into the implementation of pollution prevention efforts by this industrial sector and they are included in this report. Below is a summary of the conclusions Ecology developed in its review of the electroplating sector.

1. Significant reduction efforts were made by sector facilities prior to being required to develop P2 Plans. Nearly forty percent of the P2 opportunities were implemented prior to planning. Unfortunately, the results of this significant effort have not been quantified in a manner which would allow them to be aggregated and reported for the sector facilities.

2. Reductions have occurred for hazardous wastes and hazardous substances targeted for reductions by the facilities.

3. Using "pounds reduced" from Annual Progress Reports as a measure of pollution prevention progress does not fully capture the nature or extent of progress made by implementing P2 strategies.

4. The limitations associated with this information, the incorrect reporting of information by facilities and the lack of annual totals for hazardous substances used, made the measurement of P2 progress for the sector facilities problematic.

5. Few pollution prevention opportunities have been rejected - only three percent.

6. There is still considerable opportunity for further reductions in rinse water. The excessive use of rinse water is notable. Many P2 opportunities have been identified for implementation by only a small number of sector facilities. It appears that sector facilities have implemented fewer rinse water conservation measures and achieved smaller reductions than facilities have nationally. Sector facilities were still generating 42 million pounds of wastewater annually in 1994.

7. In addition, there appears to be several overlooked or underutilized P2 opportunities for bath maintenance and drag-out reduction. Many P2 opportunities have been considered by only few sector facilities. Fewer drag-out opportunities have been implemented by the sector facilities than have been implemented nationally.

8. Finding alternatives for cyanide use is the biggest need for technology transfer nationally. Three P2 opportunities are being investigated by sector facilities for substituting non-cyanide chemistry for copper stripping. Three sector facilities successfully substituted alkaline-zinc in place of zinc-cyanide.

Ecology is committed to providing ongoing technical assistance to Washington's electroplating facilities. Copies of this report will be forwarded to all electroplating facilities in the state that can be identified. Information on P2 opportunities implemented by electroplating facilities for which technology transfer might apply will be shared with industry association members through the Metal Finishing Roundtable in association with the Northwest Pollution Prevention Research Center (206) 223-1151. Ecology also plans to make copies of the national survey on pollution prevention (NCMS report) available for review.

Contact Ecology's technical staff for electroplating for more information. [Rob Reuter (206) 649-7086 or Michael Johnson (360) 407-6338]

# References

1. Cushnie, George Jr., "Pollution Prevention & Control Technology for Plating Operations" sponsored by the National Center for Manufacturing Sciences, 1994.

2. Waste Reduction Institute for Training and Applications Research (WRITAR), "Profile of the Metal Finishing Industry," developed under contract for the Energy, Environment and Manufacturing Project of the Technology Reinvestment Program, 1995.

3. Leviten, David, "Pollution Prevention in Metal Finishing: Plating," Pacific Northwest Pollution Prevention Research Center (PPRC) Report, 1995.

4. EPA, "Guide to Pollution Prevention for the Fabricated Metal Products Industry," EPA/625/7-90/006, 1990, July.

# Appendices

**A: List of Pollution Prevention Opportunities by NCMS Categories**

**B: Reduction Opportunities Database (ROD) Data Elements**

# Appendix: A
# List of Pollution Prevention Opportunities by NCMS Categories

| IMPROVED OPERATING PRACTICES | P | I | S | FS | R | TOTAL |
|---|---|---|---|---|---|---|
| Train employees on efficient use of chemicals/minimize spills | | 1 | 2 | | | 3 |
| Improved housekeeping | 1 | | | | | 1 |
| Improve maintenance (reduce leaks, improve squeegee rollers, etc.) | | | 1 | | | 1 |
| Use just-in-time purchasing practices | 1 | | | | | 1 |
| Improve chemical storage to reduce contamination and waste | 1 | | 1 | | | 2 |
| Install new chemical storage area | 1 | | | | | 1 |
| Install secondary containment for each process tank | 2 | | | | | 2 |
| Install drip pans | 1 | | 1 | | | 2 |
| Work with customers to minimize oil on incoming parts | | | | 1 | | 1 |
| Minimize production of metallic floor sweepings | | 1 | 1 | | | 2 |
| Reclaim metallic floor sweepings (by hand sorting zinc) | 1 | | | | | 1 |
| Increase space | | | | 1 | | 1 |
| Install loading meters on mechanical scrub | | | 1 | | | 1 |
| TOTAL | 8 | 2 | 7 | 2 | 0 | 19 |

| DRAG-OUT REDUCTION | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Drag-out reduction techniques | 1 | | | 1 | | 2 |
| Use drag-out reduction techniques (optimize parts orientation) | 1 | 1 | 1 | | | 3 |
| Use drag-out reduction techniques (extended hang times) | 1 | | 1 | 1 | | 3 |
| Install splash guards between process tanks | 2 | | | | | 2 |
| Install hi-pressure blowers on etchers to reduce drag-out | | | 1 | | | 1 |
| Improved blower nozzles on DES to reduce drag-out | | | 1 | | | 1 |
| Use trays for processing large panels | | | 1 | | | 1 |
| Improved containment on stripper | | | 1 | | | 1 |
| TOTAL | 5 | 1 | 6 | 2 | 0 | 14 |

| RINSE WATER REDUCTION | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Concentrate rinse water via evaporation | 2 | | 1 | | | 3 |
| Install improved tank heating system | 1 | | | | | 1 |
| Install counter current rinse configurations | 1 | 1 | | 1 | | 3 |
| Recycle rinse water to make-up process tanks | 2 | 2 | | | 1 | 5 |
| Install spray rinses | 1 | 1 | | | | 2 |
| Rinse over process baths (in-tank spray bars) | 1 | 1 | | | | 2 |
| Use ion exchange to recover rinse water | | | 1 | 1 | | 2 |
| Rinse water recovery | | 1 | | 1 | | 2 |
| Install dead rinse tanks | 1 | | | | | 1 |
| Automatic pH controls on rinse water | 1 | | | | | 1 |
| Automatic rinse water addition (conductivity activated controls) | 1 | | | | | 1 |
| Install flow meters on rinses | | | 1 | | | 1 |
| Install flow restrictors to conserve water on rinses | 1 | | | | | 1 |
| Recovery rinse after chromate | | 1 | | | | 1 |
| Use HVLP spray nozzles on spray rinses. | | | 1 | | | 1 |
| TOTAL | 12 | 7 | 4 | 3 | 1 | 27 |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation,
"FS" - Further Study, "R" - Rejected

## List of Pollution Prevention Opportunities by NCMS Categories (cont.)

| **CHEMICAL RECOVERY** | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Evaporative concentration of chromic solutions | | | | 1 | | 1 |
| Evaporator to concentrate ion exchange regeneration | 1 | | | | | 1 |
| Ion exchange to recover water | 1 | | | | | 1 |
| Use improved/more selective ion exchange resins | | | 1 | | | 1 |
| Use ion exchange to reclaim acids, metals | | | | | 1 | 1 |
| Use ion exchange + electrolytic recovery to reclaim dissolved metals from rinse | | | | 2 | | 2 |
| Use electrolytic recovery of cadmium and copper | | | | 1 | | 1 |
| Use electrolytic regeneration to reclaim spent acids | 1 | | | | | 1 |
| Reverse osmosis to recover water, chemicals | | | 1 | | | 1 |
| Install sulfuric acid recovery system: chill, centrifuge and filter | 2 | | | | | 2 |
| Reclamation of ferric chloride | | | | 1 | | 1 |
| Eliminate pre-coating bag-house bags with lime (galvanizing) | | 1 | | | | 1 |
| TOTAL | 5 | 1 | 2 | 5 | 1 | 14 |
| | | | | | | |
| **CHEMICAL SOLUTION MAINTENANCE** | | | | | | |
| Install in-process bath filtration | 1 | 1 | | | | 2 |
| Filter stripper solution | | | 1 | | | 1 |
| Filter sulfuric acid in anodize baths | 1 | | | | | 1 |
| Use recyclable cloth filters | 1 | | | | | 1 |
| Filter alkaline cleaner to extend bath life/minimize particulate | | | | 1 | | 1 |
| Install vacuum filter for sodium hydroxide | 1 | | | | | 1 |
| Dummy plate solution to remove metals (electrolysis) | | | | 1 | | 1 |
| Precipitate iron and sulfate out of chrome bath | | | | 1 | | 1 |
| Use ion exchange to treat incoming process water | 1 | | 1 | 1 | | 3 |
| Install ion exchange | 1 | | | | | 1 |
| Ion exchange of sulfuric acid | | | | 1 | | 1 |
| Low current density purification of pickle acid | 1 | | | | | 1 |
| Use statistical process control to extend bath life | | | | 2 | | 2 |
| Optimize plating tolerances on racks | 1 | 1 | | | | 2 |
| Minimize chemical concentrations in baths | | | 1 | | | 1 |
| Reuse acid dip solution in nickel strip process (nickel plating) | 1 | | | | | 1 |
| Reuse copper sulfate solutions | 1 | | | | | 1 |
| Use porous pot extraction of iron from hard chrome tanks | 1 | | | | | 1 |
| Freeze-crystallization of copper sulfate | | | 1 | | | 1 |
| Freeze-crystallization to remove ferrous sulfate and reclaim spent sulfuric acid | | | | 1 | | 1 |
| TOTAL | 11 | 2 | 4 | 8 | 0 | 25 |

"P" - (Implemented) Prior to Planning, "I" - Implemented, "S" - Selected for implementation,
"FS" - Further Study, "R" - Rejected

## List of Pollution Prevention Opportunities by NCMS Categories (cont.)

| SOLVENT USE REDUCTION/ELIMINATION | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Substitute “alternative” in place of vapor degreasing | 2 | 6 | 1 | | | 9 |
| Modify vapor degreaser (freeboard, cooling coil, spray controls) | 3 | | | | | 3 |
| Reduce operation time of vapor degreaser | | 1 | 1 | | | 2 |
| Recycle spent solvents using distillation | 6 | 3 | 1 | | | 10 |
| Identify alternative to TCA | | | | 3 | | 3 |
| Substitute Brulin 815GD in place of 1,1,1 TCA | 1 | 4 | | | | 5 |
| Substitute aqueous cleaning in place of TCA | 1 | 1 | 1 | | | 3 |
| Substitute alternative in place of MEK | | 1 | | 1 | | 2 |
| Substitute Citra-Safe in place of MEK | 1 | | | | | 1 |
| Reuse MEK in place of “new” MEK | | | 1 | | | 1 |
| Evaluate alternatives to MEK for off-line strip | | | | 1 | | 1 |
| Reclaim resins from MEK wastes | | | | 1 | | 1 |
| Substitute low VOC primer in place of MEK | | 1 | | | | 1 |
| Use ultrasonic bath with alkaline cleaner | | | | | 1 | 1 |
| Substitute Alodyne 600 for Alodyne 1200S | 1 | | | | | 1 |
| TOTAL | 15 | 17 | 5 | 6 | 1 | 44 |

| CHROMIUM & CYANIDE USE REDUCTION/ELIMINATION | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| **Chromium Use Reduction/Elimination:** | | | | | | |
| Use non-chromate conversion coatings for aluminum | | | | 2 | 1 | 3 |
| Substitute boric acid in place of chromic acid for conversion coatings | 1 | | | 1 | | 2 |
| Convert hexavalent chrome to trivalent chrome | | 1 | | 1 | | 2 |
| Substitute non-chromate solution in place of chromic acid | | | 1 | | | 1 |
| Use chrome free primer | | | 1 | | | 1 |
| Reduce liquid level in chromic acid conversion tanks | | | | 1 | | 1 |
| Subcontract out chromium conversion | | | | 1 | | 1 |
| TOTAL | 1 | 1 | 2 | 6 | 1 | 11 |
| **Cyanide Use Reduction/Elimination:** | | | | | | |
| Substitute non-cyanide Ni Zn in place of cyanide (cadmium plating) | | 1 | | | | 1 |
| Use alkaline zinc in place of zinc-cyanide plating process | 2 | 1 | | | | 3 |
| Substitute alkaline copper chemistry for cyanide copper | | | | 1 | | 1 |
| Substitute ammoniacal chemistry in place of cyanide chemistry for copper strip | | 1 | | 1 | | 2 |
| Use non-cyanide Enstrip C-38 for copper stripping | | | 1 | | | 1 |
| TOTAL | 2 | 3 | 1 | 2 | 0 | 8 |

| OTHER SUBSTITUTES | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Eliminate bright copper dip | 1 | | | | | 1 |
| Substitute non-copper strike in place of copper for hard chrome plating | | 1 | | | | 1 |
| Substitute acid mixture in place of nitric acid | | | 1 | | | 1 |
| Reduce size of nitric acid tanks | | | 1 | | | 1 |
| Substitute proprietary chemistry in place of nickel sulfate | | | 1 | | | 1 |
| Substitute ethanol in place of methanol in nital etch | | 1 | | | | 1 |
| Use hydrochloric acid for pre-flux production (galvanizing) | 1 | | | | | 1 |
| Substitute zinc-iron in place of cadmium plating | 1 | | | | | 1 |
| TOTAL | 2 | 2 | 3 | 0 | 0 | 7 |

“P” - (Implemented) Prior to Planning, “I” - Implemented, “S” - Selected for implementation,
“FS” - Further Study, “R” - Rejected

## List of Pollution Prevention Opportunities by NCMS Categories (cont.)

| WASTEWATER TREATMENT | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| **Metals Removed by Hydroxide Precipitation:** | | | | | | |
| - Alternative to sodium hydroxide precipitation | | | 1 | | | 1 |
| - Substitute magnesium hydroxide in place of calcium or sodium hydroxide precipitation | | | | | 1 | 1 |
| - Reuse spent alkaline cleaning solution for neutralization | 2 | | 1 | | | 3 |
| **Sludge Dewatering - thickening, thermal dehydration:** | | | | | | |
| - Install sludge dryer | 3 | | 1 | | | 4 |
| - Install/ improve sludge dewatering (sand filters, filter press) | 3 | 2 | 1 | | | 6 |
| - Use galvanizing kettle heat to dry wet sludge | | | 1 | | | 1 |
| **Evaporation:** | | | | | | |
| - Evaporate all rinse water, spent process baths after neutralization | 3 | | | | | 3 |
| **Membrane Filtration:** | | | | | | |
| - Reverse osmosis | | | | 1 | | 1 |
| **Chromium Reduction - hexavalent to trivalent:** | | | | | | |
| - Substitute “alternative” for chromic acid treatment | | | 1 | | | 1 |
| **Cyanide Oxidation to nitrogen, carbon:** | | | | | | |
| - Use electrolytic cyanide destruction and metal recovery | 1 | | | | | 1 |
| **Alternative Technology for Metals Removal:** | | | | | | |
| **Other Wastewater Treatment:** | | | | | | |
| - Reuse spent nitric acid baths in WWTP | 1 | 1 | | | | 2 |
| - Segregate and treat influent waste stream | 1 | | | | | |
| - Batch treat waste solutions | | | 1 | | | 1 |
| TOTAL | 14 | 3 | 7 | 1 | 2 | 27 |

| OFF-SITE METALS RECYCLING | P | I | S | FS | R | Total |
|---|---|---|---|---|---|---|
| Recycle “non-RCRA” wastewater plant sludge | | | 2 | 1 | | 3 |
| Recycle zinc dross to supplier for remelt (galvanizing) | 1 | | | | | 1 |
| TOTAL | 1 | 0 | 2 | 1 | 0 | 4 |
| | | | | | | |
| **OTHER OPPORTUNITIES** | | | | | | |
| Spent solutions used for drilling mud | 4 | | | | | 4 |
| Increase developer makeup | | | 1 | | | 1 |
| Modify etch as developer | | | 1 | | | 1 |
| Reduce developer temperature | | | | | 1 | 1 |
| On-site treatment of spent stripper | | | 1 | | | 1 |
| Improved containment on stripper | | | 1 | | | 1 |
| Improved exposure maintenance to reduce imaging defects | | | 1 | | | 1 |
| Air flotation stripper solution to remove resist skins | | | 1 | | | 1 |
| Recycle photoresist packaging | | | | | 1 | 1 |
| Reuse soluble ferrous chloride as preflux makeup (galvanizing) | 1 | | | | | 1 |
| Skim and reclaim oil from aqueous cleaning process tanks | 1 | | 1 | | | 2 |
| TOTAL | 6 | 0 | 7 | 0 | 2 | 15 |

“P” - (Implemented) Prior to Planning, “I” - Implemented, “S” - Selected for implementation,
“FS” - Further Study, “R” - Rejected

# Appendix B:
# Reduction Opportunities Database (ROD) Data Elements

## PLAN REVIEW

WAD#________________________________ Facility Name___________________________

Industry/Sector_________________________ Baseline Year___________________________

Past P2 Op Implemented?_________________ P2 Op Identified?________________________

Cost / Savings$__________________________________________________________________________

HS Reduction Goal # ____________________ HW Reduction Goal #____________________

Recycling Goal #________________________ Treatment Goal #________________________

Production Factor Units___________________________________________________________________

1st Yr _______ 2nd Yr _______ 3rd Yr _______ 4th Yr _______ 5th Yr _______

Other Successes:

____________________________________________________________________________________

____________________________________________________________________________________

_______________________________________________________________________________

Problems Encountered:

____________________________________________________________________________________

____________________________________________________________________________________

_______________________________________________________________________________

Comments:

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

**Opportunities**

Industry/Sector ______________________ Process_______________________________

Opp Title/Desc_______________________ Status_________________________________

Previous Practice_____________________ Target S/W____________________________

Action______________________________ 5 Yr Reduction Estimate__________________

1st Yr _______ 2nd Yr _______ 3rd Yr _______ 4th Yr _______ 5th Yr _______

Entered By____________________________ Reference_____________________________

Capital Cost___________________________ Annual Savings__________________________

Comments:

___________________________________________________________________________

___________________________________________________________________________

______________________________________________________________________

**Opportunities**

Industry/Sector ______________________ Process_______________________________

Opp Title/Desc_______________________ Status_________________________________

Previous Practice_____________________ Target S/W____________________________

Action______________________________ 5 Yr Reduction Estimate__________________

1st Yr _______ 2nd Yr _______ 3rd Yr _______ 4th Yr _______ 5th Yr _______

Entered By____________________________ Reference_____________________________

Capital Cost___________________________ Annual Savings__________________________

Comments:

___________________________________________________________________________

___________________________________________________________________________

______________________________________________________________________

**APR DATA**

WAD#____________________________ Facility Name_______________________

SIC Description_____________________ Reporting Year_______________________

New HS Goal?___ New HW Goal?___ New Recycling Goal?___ New Treatment Goal?___

HS Reduction Goal______________________ HW Reduction Goal____________________

Recycling Goal_________________________ Treatment Goal________________________

P2 Op Implemented?__________ Production Factor ______________ Production Up?______

Other Successes:__________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

_____________________________________________________Problems
Encountered:____________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

_____________________________________________________

Process____________________________ Opportunity__________________________

Targeted HS/HW____________________ Reduction____________________________

Process____________________________ Opportunity__________________________

Targeted HS/HW____________________ Reduction____________________________

Process____________________________ Opportunity__________________________

Targeted HS/HW____________________ Reduction____________________________

Process____________________________ Opportunity__________________________

Targeted HS/HW____________________ Reduction____________________________

Process____________________________ Opportunity__________________________

Targeted HS/HW____________________ Reduction____________________________