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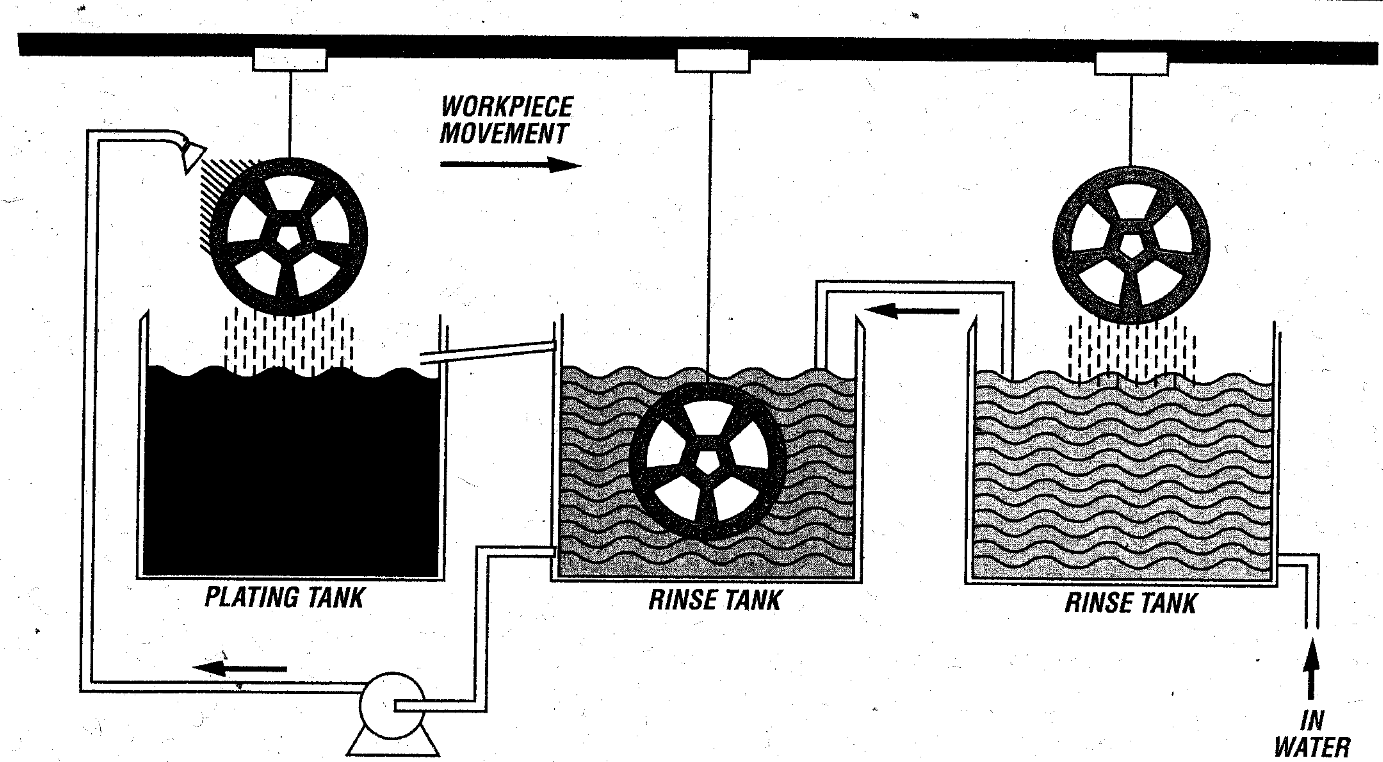
ASSESSMENT OF THE METAL FINISHING AND PLATING INDUSTRY SOURCE REDUCTION PLANNING EFFORTS



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OFFICE OF POLLUTION PREVENTION AND TECHNOLOGY DEVELOPMENT

JULY 1996

MPOT602F

ASSESSMENT OF THE METAL FINISHING AND PLATING INDUSTRY SOURCE REDUCTION PLANNING EFFORTS

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July 1996

This report was prepared by Pat Bennett under the direction of David Hartley and Kim Wilhelm, Pollution Prevention Clearinghouse, Office of Pollution Prevention and Technology Development. Kathryn Barwick and Daniel Q. Garza provided critical comment and review.

ACKNOWLEDGEMENTS

The Department sincerely appreciates the efforts of the various metal finishing and plating facilities who provided source reduction information and allowed the Department to tour the processing areas to become familiar with the metal finishing and plating processes. A special thanks to Mr. Dan Cunningham of the Metal Finishing Association of Southern California, Mr. Russ Kingsley of Kwikset Corporation, Mr. Jim Miille of Chemical Solutions, Inc., and Mr. Pat Burt of Acteron Corporation for additional technical review of this report.

DISCLAIMER

The mention of any products, companies, or source reduction technologies, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products, companies or technologies.

REPORT OVERVIEW

This report summarizes the results of the Department of Toxic Substances Control's (Department) assessment of the metal finishing and plating industry's source reduction efforts as mandated by the Hazardous Waste Source Reduction and Management Review Act of 1989 (Act). The Act requires that the Department select at least two categories of generators by SIC (Standard Industrial Classification) Code every two years for evaluation. The metal finishing and plating industry was selected as one of the targeted categories of generators for review by the Department.

Seventy-five source reduction documents were received by the Department from metal finishing and plating businesses in California (SIC Code 3471 - Plating and Polishing). Sixty-nine percent of the businesses submitted source reduction plans and the remaining businesses submitted checklists in lieu of the plan. The Department's industry specific checklist or Compliance Checklist can be submitted if the facility meets the criteria of a "small business" defined in Government Code, Article 2, Section 11342. Over Ninety percent of the source reduction documents reviewed were from businesses located in Southern California with the remaining businesses located in the San Francisco Bay area and surrounding counties.

Although the majority of these documents were prepared in 1991, some of these facilities provided updates when submitting the source reduction documents to the Department. Department staff also followed up on some source reduction documents with site visits and telephone communications. The source reduction documents were submitted to the Department throughout 1994 and 1995.

A summary of findings from the SB 14 document reviews is provided in a matrix format in Appendix A. The matrix describes the waste reduction activities that were implemented by each business, and the strategies that are being researched or considered for future waste reduction implementation. The matrix also lists the reasons why certain waste reduction measures were rejected. The matrix in Appendix A was further condensed into Table 1 to quantify the number of businesses that have either implemented or are considering implementing various source reduction measures. Table 1 identifies source reduction measures that are commonly employed within the metal finishing and plating businesses, which include:

- maintaining bath parameters;
- controlling rinsewater flow rates;
- reusing drag-out solutions and spent acids/alkalines;
- converting to non-solvent cleaning solutions;

TABLE 1

Source Reduction Measure	Type of SB 14 Document Submitted and Number of Facilities Impementing or Considering to Implement the following S.R. Measures *					Total Number of Facilities that Identified the S.R. Measure as being Implemented or Considered for Implementation			
	Metal Finishing Checklist	City/County Checklist	Compliance Checklist	1991 SB 14 Plans	1995 SB 14 Plans	Number of Facilities Implementing	% of Facilities Implementing	Number of Facilities Considering	% of Facilities Considering
Bath Maintenance									
Filtered, Tested, Treated & Replenished	13(1)	2	(1)	14(1)	3(1)	32	43%	4	5%
Reduce Drag-Out									
Lower Bath Concentrations	11		(1)	5(1)		16	21%	2	3%
Increased Drain Times	6	1		4(1)	3	14	19%	1	1%
Drain Boards/Splash Guards	7	2	1	4	1	15	20%		
Drain Bars/Rotators		1		2	2	5	7%		
Drag-out Tanks	7(1)			6(1)	1	14	19%	2	3%
Improve Rinse System									
Pretreat Water	5			2(1)	3	10	13%	1	1%
Rinsewater Flow Control	12	2	(1)	12(1)	2(1)	28	37%	3	4%
Spray Rinsing	5	2		7	2	16	21%		
Fog Rinsing/Halo Mist Rinsing	(1)	1		3		4	5%	1	1%
Air Knives	1			1		2	3%		
Countercurrent Rinse	4	1	1	7(2)	2	15	20%	2	3%
Cascading Rinse	1			3		4	5%		
Rinse/Workpiece Agitation	8	2		3		13	17%		
Multiple Rinse Tanks	2			1		3	4%		
Reactive Rinse		1		1	2	4	5%		
Recycling									
Rinsewater:									
Ion Exchange	2	1		2	1	6	8%		
Evaporation	1					1	1%		
Electrolytic Recovery	2		(1)	(1)	1	3	4%	2	3%
Reverse Osmosis				(3)				3	4%
Bath Chemicals:									
Ion Exchange	1			3		4	5%		
Evaporation	3	1		4(4)	1(1)	9	12%	5	7%
Electrolytic Recovery	1			(2)		1	1%	2	3%
Reverse Osmosis				(4)				4	5%
Reuse									
Drag-Out Solutions	7		(1)	11	1	19	25%	1	1%
Spent Acids/Alkalines	12	1		9	1	23	31%		
Rinsewater	5			4(2)	2(1)	11	15%	3	4%
Input Substitutions									
Aqueous Cleaners	2		1(3)	13(1)	1(1)	17	23%	5	7%
Cyanide Substitute	2(1)	1	1	6(2)	1(1)	11	15%	4	5%
Chrome Substitute				1(3)	(1)	1	1%	4	5%
Methylene Chloride Substitute				2		2	3%		
Administrative Improvements									
Inventory Control	14		6	5(1)	3	28	37%	1	1%
Employee Training / P2 Program			5(1)	11(5)	3	19	25%	6	8%
Quality Control	(1)			2(1)	1	3	4%	2	3%
Operational Improvements									
Routine Inspection & Maintenance	11	1	7	6	2	27	36%		
Segregate Wastestreams	8	2	4	6	1	21	28%		

( ) - Considered for Implementation

*** In some cases, the Plans did not address all of the source reduction measures that have been implemented by the businesses. The number of businesses that have implemented a particular source reduction measure will most likely be greater than shown in the table above.**

- improving inventory controls and establishing employee pollution prevention programs;
- routinely inspecting and maintaining shop equipment and machinery;
- segregating hazardous and non-hazardous waste streams;
- improving rinse systems (i.e., use of spray rinses and countercurrent rinses); and
- reducing drag-out (i.e., reducing bath chemical concentrations and using drain boards or splash guards).

Table 1 does not represent a comprehensive overview of pollution prevention within California's metal finishing and plating industry. Many businesses did not report previously implemented source reduction measures, and therefore, the number of businesses implementing any one measure will be greater than shown in Table 1. What Table 1 and Appendix A shows is that most businesses are implementing some type of measure(s) to reduce their waste(s). Some measures appear to be widely used (i.e., 65% of the businesses have taken measures to reduce the generation of wastewaters). It is also important to note that there is no single solution to reduce waste(s). There are, however, a wide variety of opportunities that can contribute to reducing waste(s).

Table 1 shows that businesses are continuing their efforts to:

- convert to non-solvent cleaning solutions;
- eliminate or reduce hexavalent chrome wastes in anodizing and chromating operations;
- convert to non-cyanide plating solutions;
- recycle rinsewater and plating chemicals for reuse; and
- improve production quality controls.

The conversion to non-solvent cleaning alternatives is being driven by the phase-out of ozone-depleting substances. The U.S. Clean Air Act in 1990, revised by the Montreal Protocol and its subsequent amendments, established a time frame to eliminate production of all fully halogenated chlorofluorocarbons, certain chlorinated hydrocarbons, and hydrochlorofluorocarbons. Solvents containing halogens, such as 111-trichloroethane, were included in the first phase-out schedule. Most facilities that were using solvents have switched to alkaline-based cleaners. The facilities that have successfully switched to alkaline cleaners did not specify in their source reduction documents the type of cleaner(s) used, because many of the alkaline cleaning formulations are proprietary. Substitution of alkaline cleaners resulted in elimination of ozone-depleting chemical emissions but created an alkaline waste stream to be treated (neutralized) in the facilities' on-site wastewater treatment units.

Businesses that evaluated surface treatment solutions for source reduction alternatives targeted solutions containing hexavalent chromium. Hexavalent chromium has been and continues to be a targeted constituent by regulatory agencies due to its known toxicity and carcinogenicity. Facilities investigating or using non-chromium alternatives stated that such alternatives are expensive.

Most of the businesses that evaluated plating solutions for source reduction opportunities targeted solutions containing cyanides. The use of cyanides not only creates a concern for worker health and safety, but spent cyanide solutions also require an additional treatment operation (cyanide destruction) prior to conventional wastewater treatment. Most of the facilities that substituted their cyanide solutions did not identify the new chemistries being used.

Wastewater is by far the largest wastestream targeted for reduction. Many of the facilities were concentrating their efforts at reducing rinsewater flow rates, recovering drag-out solutions for reuse, and recycling wastewaters to recover water and valuable plating chemicals for reuse. Rinsewater flow rates are being controlled through the use of flow restrictors and through improved rinse efficiencies attained by using countercurrent rinse tanks, spray rinsing, air knives, and by agitating rinse tanks. Space limitations, however, seem to be a limiting factor for some facilities in installing countercurrent and spray rinsing systems.

Reductions of metal concentrations in rinsewaters were being achieved through the reuse of concentrated metal rinses. In many cases, the first rinse following plating operations is being used to replenish evaporative losses in the plating bath. Evaporative losses either occurred naturally or through forced evaporation (applying heat). In some cases, drag-out solutions were concentrated further to allow reuse in the plating bath.

A number of facilities have implemented or are researching technologies to purify rinsewaters and to recover valuable plating bath chemicals for reuse. These technologies are ion exchange, evaporation, and electrolytic recovery. Reverse osmosis was seldom used. The most common use of reverse osmosis units appears to be for treating incoming water to the facility. By treating incoming water, many facilities were able to reduce the quantity of sludge generated through waste water treatment and reduce the contamination loadings in their plating baths.

By fully recovering and reusing the chemicals and water, a facility could create a "closed loop" condition by not discharging any wastewater to the sewer. The term "zero discharge" is used within the industry, meaning no discharge to the sewer. This does not mean, however, that 100% of the chemicals and water are reused or that no hazardous waste is generated. Many of the metal plating and finishing businesses would like to create this "closed loop" condition. Unfortunately, only a limited number of facilities have achieved "closed loop" conditions on their processing line(s). Facilities may not be able to achieve closed loop conditions in their processing line(s) due to economic or technical barriers.

A final source reduction method noted in the SB 14 Plans is the continuous monitoring of plating bath chemistries. Some facilities are closely monitoring and maintaining chemistry proportions and concentrations to ensure quality plating and to decrease reject rates. Rejected parts require additional processing, which means that additional wastes are generated and production costs are increased. Facilities have found this alternative to be very effective at reducing wastes and improving production efficiencies. Statistical process control techniques, in addition to employee training programs, are being used by several facilities to minimize reject rates and to reduce wastes.

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1.0 BACKGROUND

The Hazardous Waste Source Reduction and Management Review Act of 1989 (Act - commonly referred to as SB 14) requires generators that produced over 12,000 kilograms (13.2 tons) of hazardous waste or 12 kilograms (26 pounds) of extremely hazardous waste in 1990 to prepare two documents and summaries of each by September 1, 1991. The SB 14 reporting cycle occurs every four years, provided that the above thresholds are exceeded in the year previous to the year in which SB 14 documents need to be prepared. The first document, the Source Reduction Evaluation Review and Plan (Plan), identifies all "major" hazardous waste streams generated at the site and evaluates the potential options for reducing wastes at the point of generation (i.e., the "source"). The second document, the Hazardous Waste Management Performance Report (Report), assesses the effectiveness of hazardous waste management procedures implemented by the generator, including source reduction, recycling and treatment activities.

Under the provisions of SB 14, the Department of Toxic Substances Control (Department) is required to select at least two categories of generators by SIC Code every two years and request that selected generators submit their Plans, Plan Summaries, Report, Report Summaries, and Progress Reports for review. The SB 14 documents are evaluated for compliance with the Act. Successful source reduction measures are collected from the documents, put into fact sheets or reports and disseminated back to generators with similar operations, and other interested parties. As a partial fulfillment to the above requirement, the Department selected the metal finishing and plating industry (Standard Industrial Classification Code 3471) as one of the targeted categories for the years 1994 and 1995.

The intent of the Act is to promote hazardous waste reduction at the source (i.e., point of generation), and whenever source reduction is not feasible or practicable, to encourage recycling. Where it is not feasible to reduce or recycle hazardous waste, the waste should be treated in an environmentally safe manner prior to disposal to minimize the present and future threat to public health and the environment.

According to the above hierarchy, source reduction is given the highest priority. Source reduction is defined in the Act as:

1) Any action which causes a net reduction in the generation of hazardous waste; or

2) Any action taken before the hazardous waste is generated that results in lessening of the properties which causes it to be classified as hazardous.

The Act clearly states that source reduction does not include any of the following:

- Actions taken after a hazardous waste is generated.
- Actions that merely concentrate the constituents of the hazardous waste to reduce its volume or that dilute the hazardous waste to reduce its hazardous characteristics.
- Actions that merely shift hazardous wastes from one environmental medium to another environmental medium.
- Treatment.

This report focuses on reduction of hazardous waste within the metal finishing and plating industry. Throughout this report, activities implemented by the industry which eliminate or reduce waste at the source will be given the highest priority for discussion. Following this discussion, industry's efforts to reuse and/or recycle wastes for use as input materials will also be discussed.

SB 14 Review Approach

A list of metal finishing and plating businesses selected for this industry review was assembled using the following databases: 1) top quantity generators on the 1992 Toxics Release Inventory database; 2) top revenue generators listed in the 1994 California Manufacturers Register; and 3) top "100" quantity generator database assembled using 1991 U.S. EPA Hazardous Waste Report Data and the Department's 1990 manifest data. In addition, some metal finishing and plating facilities were asked to submit their SB 14 documents based on local enforcement referrals.

2.0 SB 14 DOCUMENT REVIEW

Seventy-five SB 14 Plans were received by the Department from metal finishing and plating businesses in California (Standard Industrial Code 3471 - Plating and Polishing). Approximately 69% of the businesses submitted source reduction plans and the remaining businesses submitted checklists in lieu of the plan. The Department's industry specific checklist or Compliance Checklist can be submitted if the business meets the criteria of a "small business" defined in Government Code, Article 2, Section 11342. Over 90% of the source reduction documents reviewed were from businesses located in Southern California with the remaining businesses located in the San Francisco Bay area and surrounding counties.

The purpose of the focused source reduction Plan review was to assess and document this industry's progress in implementing source reduction activities. Although the majority of these documents were prepared in 1991, some of these facilities provided updates when submitting their documents to the Department. Department staff also augmented some Plans with site visits and telephone communications. The SB 14 Plans were submitted to the Department from 1994 to 1995.

A summary of findings from the SB 14 Plan reviews is provided in a matrix format in Appendix A. The matrix describes the waste reduction activities that were implemented by each business, and the various activities that are being researched or considered for future waste reduction implementation. The matrix also lists the reasons why certain waste reduction measures were rejected.

This section of the Report describes common metal finishing and plating activities conducted within the industry and identifies waste(s) generated from these activities. Wastes are classified by California Waste Code (CWC). Descriptions of CWCs are found in Appendix B. Also included in this section is a discussion of source reduction approaches and waste management techniques for generated wastes.

2.1 Metal Finishing Processes, Generated Waste Streams, Source Reduction and Waste Management Approaches

The metal finishing and plating industry uses a wide variety of processes and chemistries to apply surface finishes to metallic and non-metallic substrates. Neither the processes nor the chemistries are exactly the same from one facility to another. Processes may be fully manual to semi or fully automated. The sequence of routing parts through cleaning, surface treatment, and plating processes varies. Each facility has unique processing parameters such as cleaning methods, bath operating conditions, plating times, rinsing methods, and other operations to achieve customer-specified surface characteristics. Solution chemistries also vary widely among facilities. Many of these chemistries are proprietary. Cleaning solutions contain various types of alkaline and acidic cleaning agents and inhibitors, and plating solutions contain varying concentrations of metals and brighteners. For the most part, solution chemistries were not fully described in the SB 14 Plans submitted.

Although there are variations between metal plating and finishing facilities, the overall processing of a part through a facility is generally the same. The part is cleaned, surface treated or plated, and final-rinsed. In some instances, rejected parts may require rework. For purpose of the following discussion, the above activities are segregated into the following processes: surface preparation, surface treatment, plating, rinsing, and rework. Surface treatment and plating activities are discussed separately since these activities result in two different surface compositions. Metallic surface coatings have properties different than the base metal, whereas, the composition of treated surfaces usually consists of the base metal.

2.1.1 Surface Preparation

Prior to surface treatment or plating, the part is processed to remove surface defects and soils. Preparing the surface of a part is a critical step in the metal finishing and plating industry. An improperly prepared surface may result in poor bonding with the metal plate, increased porosity, and decreased corrosion resistance. Preparing surfaces for subsequent treatment or metal plating is achieved using mechanical and/or chemical techniques.

2.1.1.1 Mechanical Techniques

Mechanical methods for preparing surfaces for treatment or plating include machining, grinding, bead blasting, filing, sanding, polishing, and buffing. These activities are conducted to remove surface defects, or, in the case of buffing, to achieve a desired surface finish. The most common method noted in the SB 14 Plans is buffing. Many of the metal finishing businesses reviewed are considered job shops and do not perform major metal-removing operations such as machining, grinding, or sanding. Major metal-removing operations are typically performed by the part supplier.

Cotton fabric wheels are commonly used buffing materials, in conjunction with buffing compounds containing aluminum oxide, silicon carbide, or silica. Buffing compounds were typically applied to the buffing wheel via a bar (bar compound containing a binder and an abrasive) or liquid spray.

The waste generated from buffing operations contains a mixture of buffing lint, buffing compounds, and metals (substrate), and is classified as California Waste Code (CWC) 181. This waste is generally manifested off-site for disposal in a hazardous waste landfill.

Source Reduction Activities

Although many facilities perform buffing operations, the wastes generated from these operations were typically below the threshold to qualify as a "major" waste stream. SB 14 requires facilities to address only those waste streams which exceed 5% (i.e., "major" waste stream) of the total yearly volume of hazardous wastes. Only two facilities identified CWC 181 as a major waste stream. The targeted source reduction opportunity was to substitute the type of buffing material used. The purpose of this substitution was to reduce the amount of lint accumulated. One facility switched to a synthetic buffing wheel (Scotch-Brite buffing wheel by 3M Corporation) and reduced its CWC 181 waste by 98%. In addition, the synthetic buffing wheel provided a cleaner surface, which minimized the subsequent cleaning step prior to metal plating. Another facility replaced its buffing wheel material (type unknown) and achieved a 20% waste reduction. Although a significant reduction was achieved in this case, the finished product was unsatisfactory in appearance. This facility is continuing its efforts to test other types of buffing wheels.

2.1.1.2 Chemical Techniques

Following mechanical surface preparation, parts usually require cleaning to remove soils such as rust, scales, oxides, machine oils, corrosion-preventative oils, and polishing/buffing residues. Removal of these contaminants involves the use of chemical processes. These processes utilize chemicals such as organic solvents, acids, and alkalines. Organic solvents (i.e., perchloroethylene, 111-Trichloroethane, tetrachloroethylene, Freon TE, Freon TF, Freon TA, trichloromethane, isopropyl alcohol) are used to remove oils, greases, machining fluids, and polishing/buffing compounds. Acids (i.e., nitric, sulfuric, hydrochloric, fluoboric, sodium metabisulfite) are used to remove rust, scales, and oxides and to activate the metal surface for plating (termed "pickling"). Alkaline cleaners (i.e., sodium hydroxide, potassium hydroxide) are also used to remove oils, greases, and solid particles. Unlike solvents, which dissolve soils from the surface of parts, alkaline cleaners displace and suspend the soils in solution.

Parts are typically dipped in static or agitated cleaning tanks, cleaned by hand, and in some cases spray-rinsed. There are several other processes used to clean parts which increase the cleaning rate and/or the level of cleanliness. These processes are electrocleaning, electrolytic pickling, and ultrasonic cleaning. Electrocleaning utilizes alkaline cleaners, whereas pickling utilizes an acid. Electrocleaning and electrolytic pickling rely on the liberation of hydrogen gas at the cathode and oxygen gas at the anode (electrolysis) to provide the cleansing action. In both cases, the part can be made either the cathode or anode, depending on the type of contaminant, cleaning rate and level of cleanliness, and the type of substrate. Ultrasonic cleaning utilizes high frequency sound to create cavitation within the cleaning solution. The cavitating bubbles provide the cleansing action. Ultrasonic cleaning is typically used on intricate, complex part configurations and hard-to-remove soils.

Following the alkaline and acid cleaning operation(s), parts will then proceed to water rinse tanks to remove residual cleaning solutions(s) and to inhibit further chemical reaction with the substrate.

The wastes generated from cleaning operations fall into two categories: spent cleaning solutions and rinsewaters. The SB 14 Plans identified the following California Waste Codes (CWC) for the above waste categories (CWCs descriptions are found in Appendix B).

- Spent cleaning solutions
  - solvents: CWC 211, 212, 213, 214, 741
  - solvent still bottoms: CWC 741
  - alkalines: CWC 121, 122, 123
  - acids: CWC 791, 792
- Rinsewaters: CWC 121, 122, 132, 792

Spent organic solvent solutions are typically manifested off-site for recycling. Very little on-site recovery of solvent solution(s) occurs. Many of the facilities stated that spent acid and alkaline cleaning solutions are used for pH adjustment in the facility's on-site waste water treatment unit. Source reduction and waste management techniques regarding rinsewater will be discussed in Section 2.1.4.

Source Reduction Activities

Twenty-three percent of the facilities reported switching to non-solvent cleaners, mostly alkaline-based, and another 7% are considering non-solvent alternatives. These facilities did not specify in their SB 14 Plans the type of alkaline cleaner(s) used, because many of the alkaline cleaning formulations are proprietary. Substitution of alkaline cleaners resulted in elimination of ozone-depleting chemical emissions but created an alkaline waste stream, which could be treated in the facilities' on-site treatment units.

Only two facilities provided economic and technical information regarding their alkaline cleaning systems. One facility quoted a capital cost of $150,000 for its alkaline-based cleaning system. This included a three tank cleaning system in one process line and a two tank cleaning system in another process line. Another facility was evaluating the use of an alkaline-based electrocleaning unit. The cost to install and operate this unit was $4,300. This facility estimated a reduction in the amount of water used by 3,600 gallons per year and a process cost savings of $5,000 per year.

One other source reduction measure identified in the SB 14 Plans was to filter the cleaning baths to increase solution life. Forty-three percent of the facilities reported filtering their process baths. One of these facilities actually doubled its cleaning bath solution life, and also reduced the costs of bath chemicals. Four other facilities were currently considering the use of microfiltration and ultrafiltration systems to extend the life of their caustic cleaning solutions.

Lastly, two facilities have evaluated whether parts actually needed degreasing. One of these facilities has determined that many of its parts did not require degreasing. These parts were re-routed to the facility's washing machine, which contains an alkaline cleaning solution. This operational change resulted in a reduction of 58,000 lbs/yr of air emissions, reduced air emission fees of $15,500/yr, and raw material savings of $18,000/yr.

<u>Reuse Activities</u>

Thirty-one percent of the facilities reported using spent acid and alkaline cleaning solutions for pH adjustment (neutralization) in their on-site wastewater treatment unit. For those facilities that use chrome solutions in their surface treatment or plating processes, the spent acid is also used to adjust pH during chrome reduction operations. Only one facility noted that spent sulfuric acid in chrome reduction could not reduce the pH at a reasonable rate, causing the chrome reduction operation to malfunction. Another facility is reusing its spent hydrochloric acid for chrome strip makeup solution and its spent nitric acid for nickel strip makeup solutions. This facility uses acid solutions to strip the metal plate from rejected parts. The parts are then replated to required specifications. Five percent of the facilities reported using acid rinsewaters in alkaline rinse baths and vice-versa. This process is termed "reactive rinsing".

<u>Recycling Activities</u>

Four percent of the facilities have implemented or considered activities to recycle acids. One of these facilities installed a continuous sulfuric acid recovery system on two of its 4,500-gallon sulfuric acid tanks (sulfuric acid tanks are used as pickling baths). Both baths are continuously recirculated through an acid recovery system that removes dissolved iron and returns clean acid to the baths. The iron salts are removed by chilling the acid solution and then precipitating the iron salt crystals in a centrifuge.

The remaining facilities were currently investigating the use of acid recovery systems. One facility was interested in recovering hydrochloric acid from its pickling operations using a diffusion dialysis unit. Diffusion dialysis is a process that uses ion exchange membranes to separate the anions from the cations. Spent acid is fed into one compartment and deionized water is fed countercurrently into the other compartment. The anions (acid values) diffuse across the membrane into the DI water, leaving the cations (contaminants) in the feed stream. The facility indicated an initial investment for the diffusion dialysis unit at $36,000, with an annual savings of $12,000. The estimated acid recovery was 80%. Unfortunately, this created a financial hardship for the company and the diffusion dialysis system was not purchased.

Another facility generated an acid wastestream, which greatly exceeded that needed to neutralize alkaline wastes and therefore required additional treatment. The facility investigated alternatives for recycling the excessive acid wastestream. Initial evaluations of an acid recovery unit indicated the system to be economically viable. However, further evaluations revealed that it was very difficult to recycle this particular acid wastestream, since it contained three types of acids. The facility was using a triacid bath, which consisted of certain proportions of nitric, sulfuric, and one other type of acid. Maintaining acid proportions in the recovery unit was projected to be not technically feasible.

2.1.2 Surface Treatment

Following surface preparation, parts are then routed to surface treatment and/or plating operations. The most common surface treatment activities identified in the SB 14 Plans include anodizing and chromate conversion coating. These treatment operations convert the part surface to an oxidized layer consisting of the substrate and, in the case of chromate conversion and chromic acid anodizing, an additive mixture of trivalent and hexavalent chrome. Zinc and aluminum are common substrates that are surface treated.

Anodizing involves an electrochemical process where the part is made the anode. During this process, oxygen is emitted at the anode, which creates the oxide layer on the substrate. Chromic acids and sulfuric acids are typically used anodizing solutions.

The anodizing process may generate pores on the surface of the part; these pores then need to be filled or plugged to ensure corrosion quality. Anodized parts are generally immersed in a nickel acetate solution, dichromate solution, or hot water solution to fill or plug the pores. Anodizing provides good corrosion protection, decorative finishes, and can add electrical insulation.

Chromate conversion coatings are generally applied by immersing the part in an acidic hexavalent chromium solution. Chromate conversion coatings provide good corrosion protection, provide decorative finishes, yield good pre-paint surfaces, and provide good electrical conductivity.

Two other surface treatment activities conducted by only a few facilities are passivation and phosphating. To improve steel corrosion properties, steel parts are dipped in a nitric acid solution to lightly oxidize the surface. Phosphate coatings can also be applied to various substrates to improve corrosion resistance. Phosphate coatings can be applied via immersion or spray application. Phosphate coatings identified in the SB 14 Plans are zinc phosphate, iron phosphate, and manganese phosphate. In addition to corrosion resistance, phosphate coatings are also used to promote paint adhesion, and in some cases, to improve surface wear characteristics. Waste streams generated from passivation and phosphating operations were minimal and generally not targeted in the SB 14 Plans for source reduction planning.

Following surface treatment, parts proceed to water rinse tanks to remove residual treatment solutions(s) and to inhibit further chemical reaction with the substrate. The wastes generated from surface treatment operations fall into two categories; spent surface treatment solutions and rinsewaters. The SB 14 Plans identified the following California Waste Codes (CWC) for the above waste categories (CWC descriptions are found in Appendix B):

Spent surface treatment solutions: CWC 723, 791, 792, 726
Rinsewaters: CWC 132, 723

Surface treatment baths will usually last for months prior to becoming spent and the quantity of wastes generated from these operations were minimal compared to other wastes generated, such as wastewater. Therefore, spent surface treatment solutions were generally not identified as major waste streams and therefore not targeted for source reduction evaluation. Businesses who did generate large quantities of spent surface treatment solutions targeted solutions containing hexavalent chromium. Hexavalent chromium has been and continues to be a targeted constituent among regulatory agencies due to its known toxicity and carcinogenicity.

Source Reduction Activities

Seven percent of the facilities identified activities to either reduce or eliminate the use of chromic acid in their anodizing, chromate conversion, and sealing operations.

Boeing's proprietary Boric/Sulfuric Acid Anodize (BSAA) solution for replacement of chromic acid solutions is being evaluated by one facility. The Boeing Company, located in Washington, developed the BSAA solution and is currently using the solution successfully in its operations. A demonstration conducted by the Naval Air Warfare Center at Warminster, Pennsylvania showed that the BSAA process provided equivalent corrosion resistance and paint adhesion, while maintaining mechanical properties similar to that of chromic acid anodize. The BSAA process would eliminate the need for control equipment, reduce bath chemical and treatment costs, operating costs, and disposal costs, and improve worker health and safety. The BSAA chemistry is proprietary; businesses interested in using the chemistry must obtain a license from Boeing. As part of the evaluation of the BSAA process, this facility also needed customer approval.

Another facility has incorporated the use of a non-chrome solution in its chromate conversion operation. This facility is currently using the non-chrome solution for surface treating zinc-plated parts. The non-chrome solution provides similar corrosion resistance, compared to chromate conversion coatings. Worker exposure to chrome emissions were eliminated, and there were modest cost reductions achieved by eliminating the need for annual employee monitoring. Costs for process chemicals, however, increased significantly, due to the fact that these chemicals are proprietary. The main problem with the non-chrome solution is that it did not impart any color, which would indicate that the part was coated. The Lawrence Livermore National Lab is currently researching methods to impart color using this process.

A process modification activity incorporated by a facility is the use of an automatic controller to regulate chromate solution feed rate. The facility was manually adding chromate every 15 minutes; the bath would peak at approximately 5 ounces/gallon chromate concentration. The reason for maintaining the bath at the higher concentration was to cancel out the dilution effects of drag-in and drag-out. An acceptable finish is achieved with a chromate concentration of 2 ounces/gallon. This facility installed an automatic controller, which regulates bath concentration by pH. The facility had to convert to a liquid form of chromate in order for the system to operate. The controller reduced chromate consumption by 65%. The capital investment for the automatic controller was $10,000. This system reduced wastes by 47,000 lbs/yr and resulted in $85,000 yearly savings in raw materials, waste treatment, and disposal.

One other process modification that was proposed by a facility is to reduce the change-out frequency of its chromic acid bath. Chromic acid is used as a sealer following zinc phosphating. This facility determined that the chromic acid bath could be changed out twice a week (instead of twice a day) without affecting product quality. The facility estimated that this change would reduce the amount of aqueous waste treated by 180,000 gallons each year which is a 33% decrease in waste generation for this waste stream. Approximately $200 dollars could be saved in raw material costs and several thousand dollars each year in water bills. Disposal cost savings were difficult to estimate, since wastes from these operations were combined with other wastes prior to treatment or manifesting. In addition, employee exposure to chromic acid was reduced, since change-out frequencies were reduced.

Finally, forty-three percent of the facilities reported filtering their process baths to increase solution life. One facility was able to double the life of its anodizing baths by using filtration units. The anodize solution worked more efficiently, which meant that less chemicals were purchased.

Source reduction and waste management techniques regarding rinsewater will be discussed in Section 2.1.4.

Recycling Activities

Two measures were identified for recycling sulfuric acid used in anodizing operations. One facility evaluated the use of ion exchange units. This facility's anodize operation generated aluminum hydroxide and aluminum sulfate as by-products, which interfered with the anodizing process. The facility determined that aluminum salts could be removed by ionic resins, thereby extending the life of the anodizing solution. The ion exchange system would consist of seven ion exchange units and one resin regeneration unit. The capital cost for each ion exchange unit is $8,000; the capital cost for the resin regeneration unit is $20,000. The facility estimated that the ion exchange system would reduce sulfuric acid purchases by 350 gallons and reduce water usage by 4,210 gallons annually. This system would also reduce liquid wastes by 5,240 gallons annually, which computes to a $15,720 savings in disposal costs. However, this system would increase personnel and maintenance costs by $12,000 and would require more energy to operate. After evaluation of the ion exchange system, the company has determined that the system is not economically feasible at this time.

Another facility investigated the use of a diffusion dialysis unit to recover sulfuric acid. The facility stated that the capital cost of a diffusion dialysis unit is $49,800, and would result in an annual cost savings of $10,600. The payback for this system is 4.7 years. This also was deemed economically infeasible.

Waste Treatment

Spent surface treatment solution(s) are managed in a number of ways. Once a solution is spent, the business may manifest the solution off-site for recycling or treatment, batch treat the solution on-site, or in some cases use the solution for pH adjustment in the on-site wastewater treatment unit. The SB 14 Plans did not identify any one common method to manage spent surface treatment solutions. How a business manages this waste depends on technical, economical, and regulatory factors.

As mentioned in the surface preparation section, spent acid and alkaline solutions are generally used to control pH in the on-site waste water treatment unit. It may be that acidic solutions generated from surface treatment operations are in excess of what is needed for on-site pH control. If this is the case, the business may batch treat the solution or send the solution off-site. Many businesses may choose the latter if off-site treatment is less costly than on-site treatment, or if the batch treatment operation requires a permit under California's tiered permitting regulations.

How businesses manage spent surface treatment solutions may also depend on how often the solution becomes spent. If the solution becomes spent once a year, for example, it may be more viable for the facility to manifest the spent solution off-site. However, if a facility generates spent solution every week or every month, the facility may batch treat or recycle the solution(s) on-site.

2.1.3 Metal Plating

Similar to surface treatment, metal plating also provides corrosion protection and decorative finishes. Plating may also be necessary to improve surface wear characteristics, surface hardness, and/or conductivity.

The SB 14 Plans identified the following metals used in plating: nickel, copper, chrome, zinc, cadmium, tin, lead, gold, silver, brass, and bronze. The most common technique identified for applying metal to a substrate is electroplating. Electroplating uses a direct electric current to deposit a metallic coating on a substrate (workpiece). The electric current allows for the reduction of metal ions at a negatively-charged cathode (workpiece). Another plating process identified in the SB 14 Plans, which does not require an electric current is electroless nickel plating. In this process, a chemical reducing agent is used, which provides the electrons needed for the reduction of metal ions on the surface of the workpiece.

Many chemicals are used to make up a plating bath solution. The solutions are either weak or strong acid, or alkaline-containing chemistries. Examples of strong acid chemistries are copper sulfate and chromium plating solutions. Nickel plating and acid zinc plating solutions are considered weaker acid solutions. Zinc plating solutions may also be alkaline or contain cyanide chemistries. Other common cyanide chemistries identified in the SB 14 Plans are copper cyanide, cadmium cyanide, and gold cyanide solutions.

Some common techniques used to plate workpieces are racking and barrel plating. A plating rack is a fixture that holds and conducts current to one or more workpieces. A plating rack can be used for small, lightweight workpieces or large, heavy workpieces. The plating rack is either lowered into the plating bath solution by an overhead hoist or manually suspended from the side of the plating tank. When there is a large number of small parts (i.e., bolts, nuts, screws) which do not lend themselves to be hung via a rack, they are usually placed in a barrel for plating. The barrel takes the place of the cathode and is rotated in the plating bath.

Wastes generated from plating operations fall into three categories: spent plating bath solutions, plating bath treatment residuals, and rinsewaters. Spent plating bath solutions are either treated in the on-site waste water treatment unit, batch treated, or sent off-site for treatment. On-site treatment also includes the reduction of chrome-bearing solutions and destruction of cyanide solutions. During the plating operation, plating baths are usually filtered to remove suspended solids, some organics and other contaminants. Polypropylene, cotton, and carbon filtering media are used. The SB 14 Plans identified the following California Waste Codes (CWC) for the above waste categories (CWCs descriptions are found in Appendix B).

Spent plating baths: CWC 121, 131, 711, 723, 724, 726, 792
Plating bath residuals: CWC 181, 352
Rinsewaters: CWC 131, 132, 135, 711, 723

Similar to surface treatment solutions, plating baths will usually last for months prior to becoming spent. Through continuous monitoring, treatment, filtering and replenishing of plating baths, it takes some time for the baths to be contaminated to the point where the bath is no longer usable. The quantity of spent plating solutions were minimal compared to other wastes, such as wastewater. Therefore, spent plating solutions were generally not identified as a major waste stream. Plating baths were, however, targeted for waste reduction evaluation, since the plating baths are the source of contamination in the rinsewater waste streams.

Source Reduction Activities

Most of the businesses that evaluated plating solutions for source reduction opportunities targeted solutions containing cyanides. Fifteen percent of the businesses reported having successfully incorporated non-cyanide solutions into their operations and an additional 5% are researching non-cyanide alternatives. The use of cyanides not only creates a concern for worker health and safety, but also creates the need for an additional treatment operation (cyanide destruction) prior to conventional wastewater treatment.

The most common material substitution activities noted in the SB 14 Plans were the substitution of copper and zinc cyanide solutions with non-cyanide solutions. Copper cyanides, for the most part, were being replaced with acid copper solutions in the facilities' copper strike operations. A copper strike is usually applied to metal parts to improve the adhesion and protective value of subsequent metal deposits such as nickel and chrome.

Several facilities, however, tested non-cyanide copper solutions with negative results. In one case, the non-cyanide solution affected product quality due to etching of the substrate. In another case, the non-cyanide bath became contaminated quickly, which affected plating efficiency. The third case is unique in that the facility was using copper as a high ductility lubricant for severe forming conditions. The acid copper did not have the ductility required for forming operations.

Three facilities reported having successfully switched to a non-cyanide zinc bath. One facility stated that it was using a cyanide solution for its high throwing power (throwing power is defined as an improvement in metal distribution on a part over that which would be expected from purely geometric considerations). The facility switched to an alkaline non-cyanide bath. This change reduced sodium cyanide usage by 380 lbs/yr and zinc cyanide usage by 180 lbs/yr. The facility stated that the operating costs are comparable between the two compositions, but the waste treatment costs are now lower due to the reduction in chlorine consumption for cyanide destruction. This facility reduced the cost of waste treatment chemicals by $150/yr.

Three other facilities were considering non-cyanide zinc alternatives. One of these facilities quoted an implementation cost of $6,000 in converting from a cyanide zinc solution to an acid zinc solution. The major cost was replacing or modifying existing cyanide tanks to be compatible with the acid solution. Another facility estimated an annual cost savings of $3,000 dollars by converting to a non-cyanide zinc operation. Most of these savings were realized from reduction of treatment chemical purchases. This facility anticipated a 5% reduction in sludge generation. In addition, the elimination of cyanides will reduce worker exposure to toxic chemicals and potentially lower the facility's liability insurance premiums.

Non-cyanide cadmium substitutions are also being considered by several facilities. In one case, using a non-cyanide cadmium solution produced an inferior finish. This facility is now investigating the use of an advanced replacement product, which is an alloy of zinc and nickel. One facility has successfully replaced the cadmium plate with a customer-approved aluminum pigment, resin bonded coating. This facility was using a cadmium plate over a nickel strike on titanium parts. This substitution eliminated the nickel strike and cadmium plating. The facility realized savings in pretreatment costs and reduced the volume of filter cake by approximately 1.5%.

Although some facilities have successfully changed their plating chemistries, others have not due to inferior quality, customer specifications, or customer resistance to change. One of the commonly-noted barriers is government and customer specifications. Although viable alternatives exist, many metal finishing businesses are prohibited from implementing product replacements until the specifications allow them to do so. Customer approvals usually entail further product testing and, if approved, revised specification and/or drawings. This is a time consuming and in some cases a very costly process.

Another input substitution identified in the SB 14 Plans is the use of an electroless nickel bath instead of an electrolytic nickel bath. Three percent of the facilities are using electroless nickel baths. Electroless nickel baths operate at around a five gram/liter (g/L) nickel concentration, whereas electrolytic baths operate at around 75 g/L nickel concentration. The reduced nickel concentration in the electroless bath results in less drag-out waste per part. Although less drag-out waste is created per part, the electroless nickel bath has a shorter life compared to the electrolytic bath. Additional waste is therefore created when the electroless nickel bath is replaced. This facility plates out the nickel in the electroless bath prior to replacement, which reduces the nickel concentration in the bath solution prior to treatment.

A final input substitution identified was the substitution of reusable cloth or polypropylene membrane filters in lieu of throwaway paper filters. By implementing this source reduction measure, one facility reduced its wastes by 40,000 lbs/yr. The capital investment was $2,500. Annual savings in raw materials and disposal costs are $52,000 and $46,000 respectively.

As an operational improvement, one facility proved that the installation of drainage racks are an easily-implemented and cost-effective measure to reduce wastes. This facility was operating a hand line, which consisted of a series of free-standing tanks. The operators were moving 20 pound work racks from tank to tank. To minimize drag-out and to relieve the strain on the operators, the facility installed drainage racks over the plating tanks. The capital investment was $2,000 for labor and materials. The facility estimated a 50% reduction in drag-out and realized raw materials savings of $5,000. The facility also reduced treatment and disposal costs by $480 and $550 per year, respectively.

A final operational improvement is the maintenance of process baths. Forty-three percent of the facilities maintain process bath parameters to ensure plating quality and to prolong the life of plating bath solutions. Maintenance activities include bath filtering, testing, treatment, and bath replenishing. These activities are conducted on a routine basis. On-site or off-site laboratory testing is conducted to monitor bath chemistries and concentrations. These parameters vary, depending on drag-in and drag-out rates, evaporation rates, chemical usage rate, part variability, and recovery and bath replenishing variables. Two treatment activities identified in the SB 14 Plans are filtering and low current dummying. Plating baths are usually filtered to remove suspended solids, some organics and other contaminants. Polypropylene, cotton, and carbon filtering media are used. Two facilities operating chrome baths use "Porous Pot Filtration" to remove unwanted contaminants such as trivalent chromium, copper, and zinc. This is an electrowinning unit that uses an electrical potential across a ceramic membrane, which separates the chrome solution from the contaminants.

Two facilities identified electrolytic dummying as a technique to remove plating bath contaminants. Electrolytic dummying is similar in principle to electroplating in that trace metal impurities are removed via a cathode. Low-current-densities are applied to remove these impurities from the plating bath.

Source reduction and waste management techniques regarding rinsewater will be discussed in Section 2.1.4.

<u>Reuse Activities</u>

The only reuse activity noted in the SB 14 Plans is the reuse of drag-out solutions. Twenty-five percent of the facilities were reusing drag-out solutions to replenish their plating baths. Drag-out recovery activities will be discussed in Section 2.1.4.

Recycling Activities

Twelve percent of the facilities use evaporative techniques to recover drag-out solutions for reuse. Evaporation serves to: 1) create volume in the plating bath to allow for reuse of drag-out solution; or 2) concentrate drag-out solution for reuse in the plating bath. Use of an evaporator on the plating solution or drag-out solution depends on plating bath operating parameters and evaporation rates. The following facilities provided information regarding the implementation or research of evaporative recovery techniques.

One facility installed an evaporative recovery system on its chrome and nickel plating baths. In the chrome plating line, the warm plating solution is sprayed over a packed bed. Air is blown in a countercurrent fashion through the unit to enhance evaporation (this is called "atmospheric evaporation"). The plating solution is then returned to the plating bath. This evaporation technique reduces enough volume in the plating tank to allow for complete reuse of the drag-out solution. This recycling activity, however, created a contamination problem within the chrome bath. To overcome this problem, an electrowinning unit was installed to purify the bath. This facility estimated a 50% chrome recovery using the evaporative recovery system. The total capital investment for the recovery system was $11,000. This strategy reduced waste generation by 11,700 lbs/yr, and reduced annual raw material and disposal costs by $9,000 and $2,050, respectively.

An evaporative recovery unit was also installed on this facility's black nickel plating line. This system operates at approximately 60% recovery efficiency. Capital costs for the recovery unit was $5,000. The recovery system reduced waste generation by 5,300 lbs/yr, and reduced annual raw material and waste disposal costs by $13,000 and $1,100, respectively.

The second facility has also successfully installed and operated an evaporative recovery unit on its nickel plating line. In addition, this facility installed evaporative recovery units on its copper and zinc plating lines.

Two other facilities were considering the use of evaporative units. One of these facilities estimated a capital cost of $15,000 to $25,000 per atmospheric evaporative unit. The other facility estimated a capital cost of $50,000 to install evaporators on its zinc tanks, with a payback period of two years. This facility estimated a 20% reduction in sludge generation. To incorporate the evaporators into its zinc plating line, two other changes must be made. First, deionized water must be used for rinsing to prevent the buildup of contaminants in the plating bath. Secondly, the rinsewater flowrate must be reduced as much as possible to reduce the evaporative load on the recovery system. The concentrated rinsewater can then be returned to the plating bath thereby closing the loop on the zinc plating system.

2.1.4 Rinsing

Following surface preparation, treatment and plating operations, workpieces are rinsed to remove excess plating chemicals and contaminants that may cause spotting or staining. Workpieces are generally immersed in static or multiple rinse tanks. Spray rinsing and pressurized air are also used to remove residual plating chemicals from workpieces. The SB 14 Plans identified the following California Waste Codes (CWC) for wastewaters generated in the rinsing operations (CWCs are described in Appendix B).

Surface preparation rinsewaters;
- following acidic solutions: CWC 132, 792
- following alkaline solutions: CWC 121, 122, 132

Surface treatment rinsewaters: CWC 132, 723
Plating rinsewaters: CWC 131, 132, 135, 711, 723

The SB 14 Plans revealed that wastewater was the most commonly targeted wastestream for waste reduction evaluation. One reason for this focus is that wastewaters are the largest wastestreams generated by the metal finishing and plating industry. Secondly, there is technology available to recycle water and recover valuable chemicals. Lastly, there is pressure by local wastewater treatment facilities to reduce hazardous constituents within wastewater discharged to the industrial sewer.

Source Reduction Activities

As shown in Table 1, various source reduction measures have been implemented by metal finishing and plating businesses to reduce the amount of hazardous wastewater generated or reduce the constituents which cause the rinsewater to become hazardous. These measures include:

- the use of flow restrictors and other control devices to reduce rinsewater flow rates;
- the use of countercurrent rinse tanks, rinse water agitation, spray rinsing, and air knives to improve rinse efficiency;
- the use of drain boards and extended drainage times to reduce drag-out; and
- employee training to reduce the generation of wastes via improved operating practices.

Approximately 65% of the facilities have taken measures to reduce the generation of hazardous wastewater.

The most common source reduction activity described in the SB 14 Plans is the control of rinsewater flow rates. Thirty-seven percent of the facilities have implemented this measure. The following facilities have proven that simple control of rinsewater flow rates will dramatically reduce water usage and reduce utilities and sewer fees. Two facilities showed optimum reductions by turning off rinsewaters when not needed, or reducing flow rates by manually turning down flow valves. With no capital investment, one facility reduced its water usage by 2,000,000 gallons a year, which resulted in an annual water savings of $12,000. By using similar reduction techniques, another facility showed an annual savings of $3,000. Instead of manually controlling rinse water flows, another facility investigated the use of a central timer and shut-off valve. The total capital investment was estimated at $800, with an annual savings in utilities and sewer surcharge fees of $3,000. This facility also investigated the use of a timer and independent shut-off valves for each of its 15 process lines. The total capital investment was estimated at $8,500, with similar annual savings in utilities and sewer surcharge fees.

The SB 14 Plans indicated that flow restrictors are a commonly-used rinsewater control device. One facility researching the use of flow restrictors and control valves estimated that this technique would reduce their wastewater by 2,400,000 gallons per year. This facility estimated the capital cost at $15,000, with a payback period of 1.2 years. The capital cost also included a continuous monitoring program to identify water usage. Another facility was interested in setting up a monitoring program to track water usage. This facility investigated the use of a flowmeter. Although the flowmeter would not directly reduce water usage, it would allow the facility to correctly measure the quantity of water used during rinsing operations, and to pinpoint those operations in which water can be reduced. The estimated capital cost for an adequate flowmeter was $120.

Another common practice among metal finishing and plating facilities is the use of spray rinses over the process bath or the first rinse tank. Twenty-one percent of the facilities are using this source reduction measure. Spray rinsing over the process tank can work if the process bath evaporation rates are similar to the rinsewater flow rates. If the evaporation rates are minimal, spray rinsing will usually take place in the first rinse tank. One facility showed significant reductions in flow rates and metal concentrations in the drag-out solutions by installing spray rinses over two of its process baths. In one process line, this facility reduced the concentration of nickel in the rinsewater from 1,000 ppm to 440 ppm. The spray system cost was $3,600. In the other process line, the facility was able to reduce the rinsewater flow rate from 7 to 2.5 gallons/minute and reduce nickel concentration in the wastewater from 1,200 ppm to 1,100 ppm. The spray system cost was $2,500.

Spray rinsing is being taken one step further by another facility. This facility is currently using a high pressure water spray gun to rinse parts. This facility has determined that the spray gun nozzle can be interchanged with another nozzle to reduce water flow rate by 10% without reducing water pressure. The facility stated that the cost for the interchangeable nozzle would be $100.

Several facilities stated that spray rinsing was not feasible due to part configuration, space limitations, or because the spray mist poses a health hazard. Low evaporation rates, however, are the main reason why spray rinsing systems are not installed above the process bath. One facility abandoned its spray rinse system because the brass fittings were externally eroding due to the external environment, and internally clogging due to the city's water hardness. This facility was investigating the use of polyethylene fittings, which would withstand the external environment. The water hardness is another issue under research.

A final source reduction measure common among metal finishing and plating facilities is countercurrent rinsing. Twenty-percent of the facilities are using countercurrent rinsing. Many businesses stated that this measure was the most effective for reducing rinsewater flows. However, other facilities could not incorporate countercurrent rinsing in all or part of their operations due to space limitations.

<u>Reuse Activities</u>

Twenty-five percent of the facilities stated that they use drag-out solutions to replenish their plating baths. This can be achieved if certain parameters are met. First, the drag-out rinse must reach a desired chemical concentration in order to be used back in the process bath. Secondly, there must be room in the plating bath to add the drag-out solution. Lastly, there must be continuous monitoring of the plating bath to ensure correct proportions and quantities of plating chemistries. Volume in the plating bath is usually obtained through natural or forced evaporation. If minimal evaporation occurs in the plating bath and the volume of drag-out solution is greater, some facilities will concentrate the first rinse by using evaporation, ion exchange or other techniques. These recovery techniques will be discussed in the next section. One facility estimated a cost of $2,500 for a static drag-out tank on each rinse system. Installing a static drag-out tank on four of the facilities wastewater streams would reduce wastewater generation by 800,000 gallons.

Five percent of the facilities stated that they used wastewaters in other rinsing processes. One facility used reactive rinsing, in which rinsewater following an acid cleaning bath was reused as rinsewater following a mild acid etch. The rinsewater following the mild acid etch was then reused as rinsewater following an alkaline cleaning bath. Another facility was using the rinsewater following the plating operations as influent water to the alkaline cleaning and acid cleaning rinse operations. The capital cost to replumb for this arrangement was $5,000. This facility estimated an annual reduction in wastewater generation of 120,000 gallons.

Recycling Activities

Twenty-three percent of the facilities have implemented measures to purify rinsewaters for reuse and/or to recover valuable plating bath chemicals for reuse. These technologies are ion exchange, evaporation, and electrolytic recovery. The most common use of reverse osmosis units appear to be for treating water coming into the facility. An additional 5% of the facilities are researching the above technologies for potential implementation.

Two facilities provided information regarding the use of ion exchange units to recover chromic acid, nickel salts, and water for use as rinsewater. The first facility installed an ion exchange unit to recover chromic acid. The drag-out solution is routed to the ion exchange unit. The drag-out solution is run through anion and cation exchange resins. Purified water is generated and used back in the rinse system. When the ion exchange units are spent, they are regenerated on-site. The regenerant is chromic acid, which is added back into the chrome bath. The total capital costs, including installation, was approximately $225,000. Annual savings in chemical and disposal costs were estimated at $67,000 and $4,000, respectively, and estimated operational costs are $15,000. The payback period for this project is approximately four years.

The second facility used ion exchange units on two nickel plating lines. In the first plating line, the facility operated a drag-out rinse, followed by three countercurrent rinse tanks. The drag-out rinse is used to replenish the nickel bath when necessary. The first rinse in the countercurrent rinse system is routed to the ion exchange unit. The purified water is then routed to the last tank in the countercurrent rinse system. When the ion exchange beds become spent, they are regenerated on-site. The regenerant is a mildly acidic nickel sulfate solution, which is then added back into the nickel plating bath. The capital investment for the ion exchange system was $27,000. The system reduced waste generation by 8,000 lbs/yr. Savings in raw materials, water, and disposal costs were $33,000, $4,000, and $1,700, respectively.

In the second nickel plating line, the facility operated a drag-out rinse followed by two countercurrent rinse tanks. The first counter rinse is routed to the ion exchange unit. Similarly, water is recovered for rinsing operations and nickel salts are recovered for replenishing the plating bath. Since the facility already had a regeneration system, the capital investment for the second ion exchange unit was less. The capital investment for the second unit was $9,500. Waste reduction and cost savings have not been determined at this time.

No facility provided financial or technical information on evaporation units used in rinsewater applications. Similarly, there was limited data from facilities regarding electrolytic recovery. One facility did provide technical data regarding its electrolytic metal recovery (EMR) units on its copper, chromium, nickel, lead, silver, and zinc rinses. The EMR units removed zinc by 55%, lead by 50%, chrome by 50%, nickel by 4%, and copper by 99%. An ion exchange unit was used in conjunction with the EMR to reduce copper loadings. Silver influent and effluent concentrations were non-detectable.

Reverse osmosis was not commonly used to recover rinsewaters or plating chemicals. Two facilities attempted to use reverse osmosis but abandoned this technology due to technical or financial reasons. One facility had used a reverse osmosis unit for two years in its nickel plating rinses. The cost for the unit was $72,000 and the operating costs were estimated at $6,000. Initially, the facility projected annual cost savings of $50,000. The reverse osmosis unit did return nickel solution to the plating bath, but not at the expected rate. This facility also stated that the volume of filter cake was not reduced and that the maintenance cost was higher than expected. After two years of using the reverse osmosis system, the facility was purchased by new owners. The new owners deemed this technology not economically feasible.

The second facility tried using a reverse osmosis unit for rinsewater following its anodizing process. The capital cost for the unit was $3,500, with a projected annual cost savings of $4,800. Unfortunately, the amount of dissolved solids in the rinsewater was higher than the membrane could handle. The facility abandoned the use of this unit for rinsewater purification and is now using the reverse osmosis unit to produce deionized water.

Waste Treatment

Rinsewaters following surface preparation, surface treatment, and metal plating operations are usually treated in the facility's on-site wastewater treatment unit. The general wastewater treatment process is neutralization, precipitation, flocculation, and in many cases, sludge dewatering. If chrome-and cyanide-containing solutions are used, two additional treatment methods must be used: chromium reduction and cyanide oxidation.

Only two facilities stated that they were researching different precipitants and flocculants to reduce sludge volumes. One of these facilities is considering the use of magnesium hydroxide in lieu of sodium hydroxide as a metal precipitant. This facility estimated that the capital investment would be $10,000 to $20,000 to convert to a magnesium hydroxide system. There would be a cost savings of approximately 30% to 50% of current disposal costs. To further reduce sludge weight, this facility also considered purchasing a sludge dryer, with capital costs estimated at $20,000 to $35,000.

The second facility did successfully substitute its flocculent chemical with an aluminum chloride-based product. Sludge generation has been reduced from an average of 25 cubic yards per month to 25 cubic yards per quarter.

2.1.5 Rework

Businesses may perform rework on rejected parts, or they may perform services on recycled parts, such as used automobile bumpers. In these cases, the surface coating (paint/metal) on the part requires removal. Usually, the removal process incorporates some kind of stripping solution, such as methylene chloride/hydrofluoric acid (methyl ethyl ketone) for organic coating removal, and sodium hydroxide, acids (nitric/sulfamic) and cyanides for inorganic coating removal. Following the stripping process, the parts generally undergo surface preparation processes and then are replated.

The SB 14 Plans identified the following California Waste Codes (CWC) for rework operations (CWCs are described in Appendix B): CWC 121, 131, 711, 722, 723, 726.

<u>Source Reduction Activities</u>

An important source reduction method noted in the SB 14 Plans is the continuous monitoring of plating bath chemistries. As stated previously, 43% of the facilities closely monitor and maintain bath parameters to ensure quality plating and to decrease reject rates. Rejected parts require additional processing, which means that additional wastes are generated and production costs are increased. Facilities have found this alternative to be very effective at reducing wastes and improving production efficiencies. Two facilities are using statistical process control techniques to monitor and minimize reject rates.

To eliminate the use of methylene chloride in paint stripping operations, a facility was investigating the use of hot alkaline strippers. These hot stripping solutions have a high boiling point, are odorless and contain organic compounds of glycols, polyglycols, ketones, and amines. They have low toxicity and the capability to strip paint efficiently from aluminum and steel. Further research is required, however, to determine if the hot alkaline strippers can be processed in the on-site wastewater treatment unit. This facility is still investigating the use of hot stripping solutions.

Another facility has targeted methylene chloride for elimination, because it was an identified chemical on EPA's 33/50 Pollution Prevention Program. EPA's 33/50 Program is a voluntary pollution prevention initiative that targets certain chemicals for reduction. The goals for the 33/50 Program is a 33% reduction in these chemicals by 1992 and 50% reduction by 1995. This facility had formulated a new chemistry (proprietary) to take the place of methylene chloride. The makeup cost for this new formulation is $5.27 per gallon, compared to the methylene chloride cost of $4.07 per gallon. The strip time using the new formulation is 10 minutes, compared to 24 hours using the methylene chloride solution. The processing cost per part is $.036 using the new formulation, compared to $.034 using methylene chloride. There are no emission fees using the new formulation. The new formulation also does not need to be reported to EPA on SARA 313 Form R, which eliminates reporting efforts. The reporting effort previously required 168 person-hours, which is equivalent to $8,400 in savings.

3.0 ADDITIONAL FINDINGS

Reviewing the SB 14 Plans not only enabled the Department to become familiar with industry's successful source reduction approaches, but also gave the Department insight to the obstacles and challenges facing industry. This section identifies these obstacles and discusses the challenge of measuring source reduction progress.

3.1 Data Normalization

Businesses found it difficult to determine actual reductions achieved through their source reduction efforts. Many of the facilities are job shops, and because of the variety of parts processed (i.e., size, configuration, surface area), it is difficult to determine how much waste was generated per part or per job. In addition, the facility may have experienced an increase or decrease in business activity, which would also affect waste generation.

Some businesses determined source reduction percentages by comparing the quantity of wastes generated from one year to another, but this waste reduction figure may be misleading, due to the above factors. For those facilities with a fairly constant product, source reduction evaluations will be more accurate by using production rates or other production variables to normalize the data.

One method was used by two facilities to determine source reduction progress which may be applicable to job shops. These facilities stated that the best measure to evaluate source reduction progress is using ampere-hours, which is the quantity of electricity used to deposit a certain amount of metal onto a cathode (workpiece). Since the amount of metal deposited and quantity of waste (i.e, wastewater) generated is a function of the workpiece's surface area, these facilities were able to correlate the total electricity (ampere-hours) used and the total quantity of waste generated. Although using ampere-hours may generate a closer estimation of source reduction progress, there are variables, such as cathode and current efficiencies, which may skew this estimation.

Similar to any source reduction estimation, there are always concerns as to the validity of the estimate. It is very difficult to determine an accurate figure because there are many variables that affect waste generation rates (i.e, production rates, job variability, process efficiencies). In summary, most businesses did not state whether these variables were considered in their source reduction estimates. The source reduction figures stated in the SB 14 Plans, however, are referenced in Appendix A.

3.2 Barriers to Source Reduction

The rejection of source reduction and other waste management measures was mainly due to economical or technical barriers. Some of the common barriers for not implementing source reduction measures are costs, product quality, product specifications and/or customer acceptance, and available space for equipment. Another concern, especially for job shops, is the potential impact a measure may have on their business. Job shops do not have the resources to research or test various source reduction options. Prior to changing any part of their processes, these job shops want assurance that a source reduction measure is fail-safe. In addition, job shops are unwilling to invest large amounts of capital, since there is uncertainty as to how long the facility will be in business. Because of this, job shops usually require a short-term payback on investments.

The most common technical barriers documented in the SB 14 Plans are:

- input substitutions and production changes were prohibited by government and customer specifications; and
- limited space for process improvements such as installing countercurrent rinse tanks, static rinse tanks, or spray rinsing systems.

The first technical barrier noted above could also be considered an administrative barrier. If the technology is feasible for government and private industry, then specifications must be changed to reflect this technology acceptance. Changing government and industry specifications is more of an administrative change and can be time consuming and costly. When a business provides services for both the government and private sectors, a source reduction technology may be approved by the private industry customer and not by the government. The business providing the service will not want to invest in the source reduction technology if it is not applicable to both customers. This prevents the business from having to run two operations to satisfy both customers, which would not be economically or technically feasible.

Only a few facilities noted that the use of non-cyanide copper and non-cyanide cadmium plating solutions produced inferior products. In addition, these non-cyanide solutions became contaminated quickly, which affected plating efficiency.

The concentration of metals in the wastewater treatment sludge could prohibit the implementation of source reduction activities. Several businesses are concerned that reducing metals in the wastewater stream, and ultimately the sludge, could prevent the business from recycling the sludge. Sludge recycling is less costly than sludge disposal, due to the valuable metals recovered from the sludge.

Metal recovery facilities do require a certain metals concentration in the sludge prior to accepting the sludge for recycling. If source reduction activities are implemented to reduce the concentration of metals in wastewater, the concentration of metals in the sludge may be reduced to the extent that recycling is no longer feasible.

Lastly, chemistries to replace solvents, non-cyanide and non-hexavalent chrome chemistries are very expensive, due to the proprietary nature of these chemicals. In one case, a license and an annual fee was required to use a patented chemistry and process.

3.3 SB 14 Planning

Review of the SB 14 planning documents revealed that several elements within these documents were not thoroughly addressed. First, in many instances there were insufficient descriptions of site operations. The purpose for preparing a good description of site operations is to give the generator a thorough understanding of the overall waste generating processes, i.e., process inputs and quantities, operating parameters, process outputs and quantities, waste handling and management methods, and overall resource allocations. Not understanding the specific process operations and how processes relate to one another may limit the generator in identifying valuable source reduction activities.

Many facilities did not provide a thorough evaluation of potential source reduction measures. Facilities were to evaluate potential source reduction measures using the factors outlined in SB 14, which include:

- expected change in the amount of hazardous waste generated;
- technical feasibility
- economic evaluation
- effects on product quality
- employee health and safety implications
- permits, variances, and compliance schedules
- releases and discharges

Using these factors is important in determining the potential implications of implementing a source reduction measure and in comparing one source reduction alternative to another. Not evaluating a potential source reduction measure to its fullest extent may reduce the scope of source reduction opportunities available to the business.

Many facilities did not provide abstracts of previously implemented source reduction measures. These abstracts should be prepared to document the actual results of implementing a source reduction measure, i.e., costs, reduction in wastes, impacts to other environmental media, process efficiencies, effects on quality, effects on employee health and safety, and lessons learned. These abstracts are important for several reasons:

- The facility realizes the true benefits of source reduction.
- The facility can use these abstracts as future reference to compare with other source reduction opportunities.
- The facility can use these abstracts to document the lessons learned in implementing a source reduction measure.
- The facility can show the general community its commitment to reduce impacts to the environment and public health and safety.
- The abstract shows the state and local regulators the feasibility in implementing source reduction activities. This information is valuable to the state and local programs which promote source reduction and waste minimization activities.

Lastly, some of the activities identified in the SB 14 Plans are not actually source reduction activities, but rather waste minimization activities. Source reduction differs from waste minimization in that source reduction does not include reuse and recycling. Source reduction techniques are used to prevent waste from being generated in the first place. The focus of SB 14 Planning is to evaluate measures which: 1) causes a net reduction in the generation of hazardous wastes; or 2) lessens the properties which cause the waste to be classified as hazardous. Reducing drag-out from a plating bath by installing drain boards or increasing drag-out time would be considered a source reduction measure. In this case, there is a net reduction of metal concentration in the waste water. By incorporating these measures, the generated waste per part is reduced.

Another example of a source reduction measure is the substitution of cyanide plating solutions with non-cyanide solutions. In this case, this substitution would result in the elimination of an additional treatment operation (cyanide destruction), and the waste generated would be upgraded from an extremely hazardous to a hazardous classification. In addition, worker health and safety would be improved.

Reuse and recycling are good activities to implement when the waste is already generated. Examples of reuse and recycling activities noted in the SB 14 Plans are: 1) reuse of drag-out solutions for replenishing plating tank solutions; 2) reuse of wastewater (reactive rinsing) and; 3) recycling wastewater using ion exchange or other recovery technique. Reuse and recycling techniques do have a positive impact on the environment since these methods recover and reuse valuable chemicals and water, thereby, preventing the use of virgin resources.

The SB 14 law requires generators to consider source reduction as the top priority before considering other beneficial waste management alternatives. As with other waste management methods, source reduction may have technical and economic limitations. Although a facility may have incorporated all the source reduction measures that are feasible, the facility may still generate a hazardous waste. The next approach may be to incorporate reuse or recycling techniques to manage this waste.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The SB 14 Plans revealed that most of the metal finishing and plating facilities have identified source reduction measures that they implemented or evaluating for implementation. Table 1 provides an overview of the number of facilities that have either implemented or are considering implementing various source reduction and waste management measures. It should be noted that the Plans may not have addressed all of the source reduction measures implemented by the businesses. Some of the reasons for not identifying an implemented source reduction measure are:

- the source reduction measure was overlooked;
- the source reduction measure was implemented long ago and not considered part of the current planning exercise;
- the business could not measure the benefits of the source reduction activity; or
- the business did not know what information was required in the planning documents.

The number of businesses that have implemented a particular source reduction or waste management measure will most likely be greater than shown in Table 1.

Recommendations for Source Reduction Improvement

1. Thoroughly Evaluate Source Reduction Measures

The SB 14 Plans showed that most facilities have taken some kind of action(s) to reduce their wastes. Many of these facilities considering further source reduction opportunities, however, did not provide a thorough evaluation of these measures. Not evaluating a potential source reduction measure to its fullest extent may: 1) reduce the scope of source reduction opportunities available to the business; and 2) limit the facility from understanding the full implications of their actions. A thorough evaluation is also necessary to compare against other potential source reduction measures. The SB 14 planning guidelines provide a good format to effectively evaluate potential source reduction activities.

2. Consider Source Reduction First

Consider source reduction first prior to any other waste management option. A benefit of considering source reduction prior to recycling was discussed in a workshop that was conducted by the U.S. EPA and the Metal Finishing Association of Southern California. The title of the workshop, held in November of 1995, was "Reverse Osmosis Applications for Metal Finishing". One of the speakers was a reverse osmosis vendor. The speaker said that a good principle to follow prior to installing any kind of recovery equipment is to optimize your process first and then size your recovery equipment.

For example, if a business is considering the installation of a reverse osmosis system, the business should first consider optimizing its rinse water system. Optimizing rinse water systems may include installing counter current rinsing, spray rinsing, drain boards, flow restrictors and flow meters. Optimizing systems by incorporating the above activities reduces water usage and water treatment requirements, as well as reducing loadings onto the reverse osmosis system. Once the rinse system is optimized, the reverse osmosis system can then be appropriately sized. A smaller reverse osmosis system may be purchased, thereby reducing capital costs and, possibly, operating costs.

3. Build Facility and Customer Relationship

Some of the technical and financial barriers in implementing source reduction may be overcome by involving both the facility and customer(s) in the source reduction planning process. The facility and customer should work together to incorporate source reduction in the design and manufacture of a product. This type of relationship has several advantages:

- reduce generated wastes (and possible regulatory relief) and, therefore, lower processing cost(s) per unit of product;
- eliminate potential environmental liabilities;
- produce an environmentally preferred product; and
- establish a more competitive position in the industry.

Further Research

After review of the SB 14 Plans, the Department has identified two source reduction activities which need further research:

- substitution of hexavalent chrome solutions and cyanide solutions in surface treatment and plating operations;
- acceptance of material substitutions within industry.

The above activities were either noted in the SB 14 plans as either producing an inferior product or not accepted within industry. More information is needed to quantify these barriers and develop solutions.

Additional research is also needed on closed-loop recycling processes. The SB 14 Plans identified only a handful of facilities that incorporated closed-loop in all or part of their processes. Research efforts should focus on those facilities that have achieved closed-loop and also on vendors to obtain recycling equipment information. Topics for research could include:

- closed-loop application;
- equipment selection;
- equipment and operation costs; and
- other process information.

Lastly, industry review of this report indicated that many facilities do not know the level of cleanliness at which the rinse bath should be maintained. In other words, what is the optimum water flow that a facility could maintain in its flowing rinse without affecting rinse efficiency and part quality? Although this issue may be process specific, cleanliness levels in rinse baths may be similar within certain plating and rinsing applications. Preliminary research is needed to determine the correlation of rinse water cleanliness levels on various metal plating operations.

APPENDICES

APPENDIX A: SB 14 PLAN REVIEW MATRIX

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
01PLB09943471	Decorative electroplating of copper, nickel, trivalent chrome, brass, gold, silver, and antique finish.	1. Drag-out 2. Soak cleaners and ultrasonic cleaning	2. Reduced air release of perchloroethylene more than 50%. Expect further reductions of 30% in 1991	Ion exchange - regeneration process uses large amounts of water Reverse osmosis - too costly
02PLB10943471	Hard chrome plating of pipe for oil industry	1. FIFO 2. Routine inspection & maintenance 3. Lower bath concentrations 4. Reuse drag-out solutions 5. Bath testing, treatment, and replenishing 6. Rinse water reuse 7. Spent acid for chrome reduction 8. Spent acids and alkalines for neutralization 9. Ion exchange and evaporation 10. Solvent recycling 11. Sludge dewatering and drying		
03PLB06943471	Mfr. of locks and key blocks. Processes include metal melting, die casting, phosphating, chromating, anodizing, passivation, metal coating, degreasing, painting/baking, assembly and packaging.	1. Preventative maintenance program 2. Employee participation/recognition program 3. Buffers with alternative materials (1) 4. Automated RO system (Zero Discharge Recovery) to recover nickel and brass process solution and rinse water (1) 5. Plating cell recovery for copper strike tank (1) 6. Waste segregation 7. Alternative waste water flocculents (1)	4. 20-30% reduction in sludge and 30-40% reduction in waste water	
04PLB07943471	Plating of chrome, brass, nickel, gold, silver, copper on auto parts, furniture, plumbing and others. Closed loop system.	1. FIFO 2. Buffing wheel replacement - "Scotch Brite" wheel by 3M Corporation 3. Lower bath concentrations 4. Static drag-out tanks 5. Reuse drag-out solutions 6. Baths filtered, treated, & replenished 7. Optimum rinse flow rates 8. Spray rinses	2. 98% reduction in lint and buffing compound waste.	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		9. Flow restrictors/flow control devices 10. Spent acids/alkalines used for neutralization 11. Rinse water treatment & recycling 12. Sludge dewatering		
05PLB08943471	Decorative chrome/nickel plated mild steel.	1. Improved maintenance program 2. Splash guards 3. Use of catchers and stagnant drag outs. 4. Flow restrictors 5. Use of cascaders 6. Use spent acid for pH adjustment 7. Use longer life alkaline cleaners.	4-5. 15% reduction in waste water 6. 550 gallons of sulfuric acid saved Note: Ampere-hours used for normalization.	Ion exchange, ultra-filtration, and reverse osmosis projects could not be funded through parent company. Payback not justifiable. Spray rinses used but abandoned. Brass fittings were externally eroding (env.) and internally clogging (water hardness).
06PLB12943471	Inspect, paint, & anodize aluminum parts	1. Better housekeeping & inventory control 2. Employee training & waste reduction incentive program 3. Increased drainage time with the use of two cranes without affecting production. 4. Cadmium plating cession.	1. 50% reduction in paint sludge, misc aqueous solution, oil & water, and 20% reduction in surplus organics	Governed by aerospace military specifications
07PLB12943471	Mechanical polishing, bright dip, anodizing, vacuum impregnation, conversion coating, passivation, and zinc plating	1. FIFO 2. Routine inspection & maintenance 3. Optimum removal & drainage 4. Lower bath concentrations 5. Baths tested, filtered, and replenished 6. Static drag-out tanks 7. Flow restrictors 8. Rinse water agitation 9. Multiple rinse tanks 10. Waste stream segregation 11. Spent acids/alkalines for pH adjustment & chrome reduction 12. Ion-exchange for rinse water recycling 13. R.O. to pretreat H2O 14. Sludge dewatering 15. Proposed acid recovery unit (1)	15. Estimated 80% acid recovery using Diffusion Dialysis Acid Recovery Unit.	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
08PLB12943471	Cleaning & etching of aluminum, steel, titanium; conversion coating of aluminum; x-ray; paint coatings	1. FIFO 2. Employee source reduction training 3. Routine inspection & maintenance 4. Waste stream segregation 5. Reuse solvents 6. Aqueous cleaner instead of 111-TCA 7. Poly-pro shields to catch drag-out 8. HVLP paint spray unit 9. Microseperators for waterfall paint booths 10. Hercules spray gun cleaning unit 11. Recycle and reuse fixer	6. 850 gallons of 111-TCA reduced 8. 32% reduction in solid wastes 10. 15-20% reduction in solvent usage Estimated source reduction goal of 20% between 1993 and 1996 In one instance, waste reduction measured by paint application efficiency.	Abandoned the use of spent sulfuric acid in chrome reduction. Spent acid could not reduce the pH at a reasonable rate causing chrome reduction to malfunction.
09PLB12943471	Anodizing, plating of cadmium,chrome, copper, & nickel; ion vapor deposition, passivation, phosphating, non-destructive testing, and metal grinding.	1. Recycle chrome from fume scrubbers 2. Electroless nickel instead of electrolytic nickel 3. Plating out nickel prior to bath disposal 4. Aqueous cleaners 5. Electrostatic paint guns	1. 1% waste reduction 3. 80-85% waste reduction 4. 95% reduction in halogenated solvents	Nickel/Tungsten/Boron as replacement for chromium produced inferior product Non-cyanide copper effected quality Nickel/Zinc as replacement for cadmium is not approved by Boeing Aircraft
10PLB12943471	Barrel plating of zinc & cadmium on mild steel & brass; chromating/passivating	1. FIFO 2. Routine inspection & maintenance 3. Bath testing, treatment, & replenishing 4. Drain boards & drag-out tanks 5. Occasional reuse of drag-out solution for cadmium bath 6. Optimum drainage time 7. Lower bath concentration	13. 15-20% waste reduction 14. Treats 500 gal/2 days resulting in 25gal concentrate used for bath and remaining usable distilled rinse water 15. Proposed reduction to	Attempted to use non-cyanide solutions but the final product was unsatisfactory to customers. No product on market which uses a non-cyanide cadmium solution.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		8. Flow restrictors 9. Counter-current rinsing 10. Waste stream segregation 11. Spent acids & alkalines for pH adjustment & chrome reduction 12. Aqueous cleaners 13. Electrowinning 14. Cold Vaporization 15. Electrolytic recovery 16. Sludge dewatering	500ppm cadmium and oxidation of cyanide.	
11PLB12943471	Electroplating of cadmium, copper, chromium, lead; painting	1. FIFO 2. Routine inspection & maintenance 3. Baths tested, treated, & replenished 4. Lower bath concentrations 5. Ultrasonic & abrasive cleaning 6. Aqueous cleaners 7. Spray rinses & air knives 8. DI water 9. Drain boards & static drag-out 10. Automatic timer rinse water turn off 11. Waste stream segregation 12. Spent solutions used in treatment system 13. Evaporation cold process & electrolytic recovery to recycle bath chemicals 14. Ion-exchange and evaporation to recycle rinse water. 15. Solvent recycling 16. Sludge dewatering & drying		Attempted to replace cad/nickel with tin/lead and zinc/nickel
12PLB12943471	Mfrs. electromechanical and solid state relays. Processes include metal stripping, plating, header firing, assembly, inspection, & tool making. Chemical cleaning, etching, gold & electroless/electrolytic nickel & copper & Palladium/alloy plating.	1. Employee training & participation in waste reduction 2. Spent plating solutions in waste water treatment 3. Water replaced Freon 113 and IPA 4. Decrease copper sulfate usage in frame cleaning 5. NV residue test of Freon reduced, 5 days to 3 days	2. 25% reduction in raw chemicals 3. 20% reduction in waste 4. 20% reduction is usage 5. 20% reduction in waste 6. 25% reduction in waste	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		6. Magnesium oxide replaces sodium hydroxide in treatment.		
13PLB01953471	Decorative chrome plating, bright & semi-bright nickel plating, alkaline and acid copper plating, gold & brass plating of aftermarket automobile wheels.	1. Counter current rinses (1) 2. Recycle decorative chrome rinses (1) 3. Use cyanide copper for strike only (1) 4. Potential hot alkaline or organic strip in lieu of methylene chloride in paint stripping (1) 5. Sludge dewatering & drying	Estimated source reduction goal of 3% for the years 1990-1993	Carbon dioxide blastor for removing paint not cost justified for the minimal paint sludge generated. Vacuum evaporators in flow rinses economically infeasible. Electrolytic metal recovery in flow rinses economically infeasible.
14PLB01953471	Hard chrome, copper, & nickel plating of rolls, rotors, & cylinders.	1. Employee waste reduction training 2. Spray rinse over process baths 3. Copper sulfate replaced copper cyanide in strike 4. Low flow nozzle in water spray gun 5. Chrome scrubber solution used for chrome bath make-up	2,5. Spray rinse and reuse of chrome scrubber solution resulted in closing of onsite waste water treatment. 4. 10% in rinse water reduction	Electroclean unit did not minimize waste water. Parts would still need to be rinsed to remove caustic
15PLB01953471	Electroplating and chemical etch of lead frames for mounting of integrated circuit devices. Plating includes copper, silver, gold, nickel, tin, and tin/lead. Chemical etch of copper.	1. Employee & contractor waste reduction training 2. Substitute ammonium sulfate with potassium persulfate. 3. Substitute sodium chlorate for chlorine gas in cuprous chloride/HCL regen process 4. Air knives 5. Bath filtration	Equipment and process modifications has resulted in 30% copper reduction and 42 % silver reduction in treatment effluent between 1990 and 1993.	Equipment modifications to recover cupric chloride chemical to the concentrated bath was deemed not economical.
16PLB01953471	Manufacture and chrome plating of steel and aluminum auto wheels; copper, nickel and chrome plating	1 FIFO 2. Routine inspections 3. Employee waste reduction training 4. Bath testing, treatment, and replenishing 5. Non-cyanide plating solutions (copper) 6. Dragout tanks, reuse solution 7. Spray rinses above static drag-out 8. Lower bath concentrations		Trivalent chrome is not accepted in the automotive industry and presents technical production problems associated with plating automotive wheels.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		9. Counter flow rinses 10. Flow restrictors & meters 11. Rinse water reuse 12. Segregate waste streams 13. Spent acids & alkalines used for pH adjustment 14. Ion exchange for chrome recovery 15. Sodium metabisulfite in chrome reduction		
17PLB01953471	Supplying, repairing, and salvaging vehicle bumpers. Plating processes include copper, nickel, and chromium. Note: Close of plating operations	1. FIFO 2. Routine inspection & maintenance 3. Bath testing, treating, repleneshing 4. Lower bath concentrations 5. Drain boards 6. Counter flow rinsing 7. Stagnant & spray rinsing 8. Fog rinsing (1) 9. Reuse drag-out solution 10. Flow restrictors 11. Pretreat water 12. Waste stream segregation 13. Use spent acid/alkalines for neutralization 14. Sludge dewatering		
18PLB12943471	Precious metals, electroless nickel, tin and tin/lead electroplating	1. FIFO 2. Routine inspection 3. Non-cyanide plating solutions (copper, sulfamate nickel)(1) 4. Bath filtering, testing, & treating (dummying)(1) 5. Lower bath concentrations 6. Static dragout tanks, reuse chemicals 7. Spray rinse		

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		8. Counter current rinse 9. Flow restrictors 10. Product agitation 11. Waste segregation 12. Spent acid & alkaline used for pH adjustment 13. Improve product quality thereby reducing rework (1) 14. Sludge dewatering		
19PLB02953471	Anodizing, painting, polishing, passivation, titanium processing, chem film, shot peen	1. FIFO 2. Routine inspection & maintenance 3. Bath testing, treatment, & replenishing 4. Drain boards 5. Workpiece agitation 6. Increased work piece drainage 7. Multiple rinsing 8. Flow restrictors 9. Rinse water reuse 10. Waste segregation 11. Spent acid & alkalines for pH adjustment and chrome reduction 12. Onsite solvent recycling 13. Pretreat water 14. Non-cyanide plating chemistries 15. Sludge dewatering		
20PLB02953471	Precious & non-precious metal plating of contacts and connectors for automotive & electronics industries. Plating processes include copper, nickel, gold, and tin or tin/lead.	1. Counterflow rinse 2. DI water rinse (1) 3. Rinse water reuse (1) 4. Redesign gold cyanide plating cell (1) 5. Filter system for caustic cleaner (1) 6. Air cooled chiller in lieu of water cooled 7. High pressure spray floor cleaner	1. 32% waste reduction 2,3. Reduction in 1 million lbs of rinse water 4. Reduction of 20,000 lbs of cyanide strip 6. Reduction of 10 million lbs of rinse water 7. 70% waste reduction Estimated 4-year source reduction goal is 25%	Electrowin operation not effective in reducing metals & not economically practicable. Closed loop recycling not economically feasible ($170,000)

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
21PLB03953471	Printed circuit boards	1. Employee training 2. Flow restrictors 3. Device to plate out electroless copper 4. Carbon-based electroless bath in lieu of lead 5. Automated system for adding polyneutralites in water treatment 6. Closed-loop system (1)	3. 95% reduction in copper in treatment system	
22PLB05953471	Plating, polishing, & anodizing	1. FIFO 2. Employee source reduction training 3. Routine inspection & maintenance 4. Plating line change (1) 5. Elimination of ODS (1)	Estimate 5% source reduction from 1992-1996	
23PLB05953479	Continuous coating of galvanized and cold rolled steel strip	New facility, new site (1992). New site to include(1) 1. Employee waste training 2. Roll-on type application of passivate solution rather than spray-on. Replace non-chrome passivating solution. 3. Water reuse 4. Incinerator (99.9% VOC destruction)	2. Elimination of hexavalent chrome, sludge 3. 70% water recycled and reused 4. 70% VOC reduction	
24PLB05953429	Plating, painting, degreasing, & polishing of door hardware. Plating includes chrome, copper, zinc, nickel. brass, bronze; chromate conversion	1. Re-evaluated whether parts needed degreasing 2. Alkaline, non-cyanide zinc bath 3. Reduce brass concentration in plating bath 4. Polypropylene cloth filters in lieu of paper filters 5. Drag-out tanks 6. Installed hanging bars for proper drainage	Over 3 years, implemented 12 waste reduction projects. Invested $82,000 and saved $224,700 in chemical purchases, $79,000 in waste disposal, & $46,130 in misc. costs.	Trivalent chrome has been pilot tested unsuccessfully. The trivalent bath was sensitive to contamination. Four non-chromate type conversion coatings for zinc were studied but did not meet industry standards for their parts.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		7. Counter current rinsing 8. Ion-exchange on nickel plating line, reuse nickel sulfate & water 9. Evaporative recovery & electrowinning unit on chrome acid bath 10. Evaporative recovery unit on black nickel bath 11. R.O. for cyanide drag-out (1) 12. Evaporative recovery unit on bright nickel baths, ion-exchange on rinses 13. Automated chemical feed for chromate (Ionic) 14. Automatic chemical feed on chromate bath (Prosmatic machine)(1) 15. Energy efficient lighting 16. Powder coating in lieu of solvent-based clear coating (partial) 17. Aqueous cleaning in lieu of freon degreasing 18. Wet scrubbers on nickel, acid, & copper plating operations 19. UV coating in lieu of solvent-based coating (1)	1. 58,000 lbs/yr reduction in air emissions 2. 380 lbs cyanide/yr waste reduction 3. 19,400 lbs/yr 4. 100 drums, 40,000 lbs/yr waste reduction 6. 50% drag-out reduction 8. 100% of nickel & water recycled (8000 lbs/yr reduction) 9. 50% chrome recovery (11,700 lbs/yr waste reduction) 10. 5300 lbs/yr waste reduction 13. 47,000 lbs/yr waste reduction 15. Reduction in energy consumption by 60% 17. Eliminated 2500 lbs of ozone depleting chemical emissions	Evaporator w/ion exchange for chromate rinse (w/zinc) not economical. Electrodialysis w/ion exchange not economical Peen plating in lieu of brass plating resulted in poor surface finish Ion exchange for copper & brass plating solutions not technically Electrowinning for cyanide solutions not technically / economically feasible. Acid copper in lieu of copper cyanide failed due to contamination Dyed lacquer coating failed performance criteria Ion exchange on zinc rinse not technically feasible Centrifugal barrel technology for polishing castings caused distortion of parts Peen plating of zinc on steel not economical R.O. or electrowinning on zinc rinsewater not economical Coil coated steel failed performance criteria

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
25PLB05953452	Manufacture, plate, and polish fasteners; plating of nickel, cadmium, & copper; chromic and sulfuric anodize, chrome conversion	1. Employee source reduction training (1) 2. Flow restrictors 3. DI, electrowinning, evaporation & R.O. will be investigated for chemical recovery(1) 4. Replace naphthalene in lube application w/ water based cetyl alcohol. 5. Trichloroethane replaced w/biodegradable cleaner 6. Improved control technology to reduce VOC emissions (99.5%)	2. 33% reduction in waste water	Customer & military specs preclude the use of cadmium & cyanide substitutions. Further reduction in rinse water recycling not considered due to significant reductions from installing restrictors.
26PLB06953728	Manufacture of fasteners which includes machining, heat treating, plating & anodize; nickel & cadmium plate, chromate conversion, sulfuric acid anodize.	Same as above	Same as above	Same as above
27PLB06953452	Manufacture of fasteners	1. Counter current rinsing 2. Bath conductivity meters 3. Flow restrictors 4. Minimize types of oils used 5. Water-based cleaning solutions in lieu of degreasing 6. Waste solvents used as reducing solvents 7. Sludge dewatering & drying	4. Increase oil recyclability 7. 74% reduction in sludge	Calcium chloride used as precipitate. Other precipitates (ferric sulfide, sodium hydrosulfide, ferric chloride, and magnesium chloride) were tested and proved inferior.
28PLB06953312		1. Chrome recovery unit on rinse waters from electrotinning lines 2. Spent sulfuric acid for pH adjustment & water treatment (positive results, completing design)(1) 3. Ultrafiltration system installed on annealing lines (AL). 4. Piping modification on AL 5. Ultrafiltration system on Continuous Coating Galvanizing line (1) 6. Process modification of Chrome Recovery unit	1. Non-hazardous treatment sludge 2. Reduce purchase of HCL and reuse pickle liquor 4. Reduced caustic waste by 600,000 gallons 5. Reduce caustic waste by 850,000 gallons 6. Reduced chromium bearing waste by 500,000 gallons	The SB 14 documents were sent back to facility because every page was marked confidential

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
29PLB06953471	Zinc & cadmium electroplating, aluminum anodizing & chem film, zinc & iron phosphate, stainless steel passivation	1. FIFO 2. Routine inspection & maintenance 3. Bath testing, treatment, & replenishing 4. Lower bath concentrations 5. Some tanks agitated & filtered 6. Some drain boards & drag out tanks 7. Air agitation in chrome & cyanide rinse 8. Cascade rinsing 9. Flow restrictors at rinse inputs 10. Electrowinning on zinc rinse 11. Spent acids & alkalines used for pH adjustment & chrome reduction		Spray rinse & drain bar over zinc tank proved unsatisfactory due to complex part shapes. Degradation of quality due to extended exposure to air. Lots of rework. Commercial conductivity meters are high costs Conversion to non-cyanide zinc, cadmium, & non-hexavalent chrome solutions not feasible due to government specifications. Elevated process bath temperatures & reduced bath concentrations limited by understanding or specifications. Space limited for more drag-out tanks. Would require major modifications and downtime
30PLB07953479	Architectural paint and powder coating on aluminum & steel parts: chrome phosphate: chrome conversion	1. Training on racking parts 2. Schedule similar jobs 3. Fresh water input lines eliminated. Water loss from drag out and evaporation replenished with used rinse water. 4. Pressure regulated halo misting nozzle as final rinse. 5. Waste segregation (1)	1-4. Overall 25% source reduction in one year 4. 50% decrease in water usage; cleaner parts & control of water usage 5. Potential reduction of 20%	Attempted using halogenated solvents in lieu of MEK. This could not accomplish the cleaning required.
31PLB07953674	Manufactures multichip modules. Processes include plating & etching: copper plating / copper & chrome etching	1. Bath replenishing 2. Drain boards 3. Conductivity meters 4. Etch rinse purged with nitrogen 5. Spray rinse 6. Workpiece & rinse tank agitation 7. Flow restrictors	The Electrolytic Metal Recovery Unit removes 99% of copper, 50% of lead, 55% of zinc, 65% of chromium, & 4% of nickel.	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		8. Waste segregation 9. Concentrated rinse waters are treated by Electrolytic Metal Recovery 10. Rinse waters treated by DI Reclaim System (Ion-exchange beds) and reused in Fab.		
32PLB07953641	Manufactures solid dry film lubricants, aerospace metal finishing	1. Drip guards & drain boards 2. "Kill" tanks for cyanide &chromate 3. Static rinse tanks 4. Hand/foot activated spray/fog rinses 5. Design refrigerated chiller for vapor degreaser (1) 6. Acidic rinse water used for alkaline rinse and visa-versa 7. Waste segregation 8. Spent acids & alkalines in water treatment	SB 14 documents sent back to facility due to confidentiality	8 flow restrictors were installed & all but 1 failed. Cause: quality of water & local corrosion from overspray & dripping. Reformulation of solvent admixtures for "wipe solvents" did not remove specific paints & greases, cause skin irritation.
33PLB10943471	Plating, stripping, etching, cleaning, degreasing, electropolishing, passivation, & coating; cadmium, nickel, copper, silver, & tin plating; zincating, chromate conversion; passivation; aluminum etch.	1. Process bath filtration and dummying 2. Use of alkaline & water based cleaners (1) 3. Use of DI water for bath makeup and rinse 4. Spray rinse over nickel plating tanks (1) 5. Use of spray rinses; rinses used to replenish bath 6. Flow restrictors and reduced water flows (1) 7. Increased drainage (1) 8. Acid rinse waters used in alkaline rinse bath 9. Spent HCL used as makeup for chrome strip 10. Spent nitric acid used as makeup for nickel strip	15. 50% reduction in spent acid 16. 50% reduction in filter cake Estimated 4-year source reduction goal is 60%	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		11. Ion exchange and electrolytic recovery for recycling rinses. ER only for silver 12. Degreaser cooling water used in deoxidizer rinse tank and al-etch alkaline rinse tank 13. Cyanide rinse water is evaporated 14. Spent acid & alkalines use for pH adjustment & chrome reduction 15. Evaporation of spent acid (1) 16. Use of caustic soda in nickel and chrome treatment instead of calcium hydroxide 17. Sludge dewatering (1)		
34PLB09953471	Job shop which cleans, electroplates or anodizes, and chromate conversion coats metal parts. Cadmium and zinc plating, Type I, II, and III anodizing	1. Flow restrictors 2. Counter-current rinsing 3. Shut off rinse waters when not in use 4. Water conservation awareness 5. Rinsewater reuse (1) 6. Non-cyanide cadmium and zinc solutions (1) 7. Replace chromic acid with BSAA (1) 8. Alternative solvents (1) 9. Evaporative recovery (1) 10. Recycle filter cake sludge (1)	1-4. Site #1 reduced water usage by 42%. Site #2 reduced water usage by 33%. Future goals: Reduce filter cake sludge 50% by 1999 and eliminate waste water & 111-TCA by 1996	Ion-exchange to reduce type II,III anodizing waste not economically feasible Sludge drying not economically feasible Not been able to find recycler for sludge. Sludge contains low concentrations of metals.
35PLB12953482	Manufacturer of machine gun belt links and portions of automobile air bag systems. Manufacturing includes fabrication, painting, and treatment (chemical conversion and annealing)	1. Inventory control (1 month supply) 2. Employee training & feedback 3 Routine inspection 4. Bath replenishment 5. Increased drainage time 6. Use of rotator to drain & transfer parts 7. Longer use of chromic acid 8. Spent acids in alkaline rinse 9. Waste segregation	3. Potential volume reduction of 1000 gallons 6. Potential volume reduction by 33% 7. Reduce aqueous waste by 180,000 gallons (33%)	Stringent government specs. No input or product reformulations or use of less concentrated solutions. Note: Reduction in military contracts and changes in manufacturing operations effected waste generation. Estimated 78% reduction since reduction since baseline year

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
01DFV02943471	Sells, stores, & processes flat rolled steel. Processes include slitting, leveling, and pickling. Future products include tubing, wheels, and appliances.	1. Employee source reduction training (1) 2. Eliminate repickling of rolled steel (1) 3. Operator control in applying oil to steel (1) 4. Reduce equip. wash down (1)	2. Reduced waste oil by 20 gal. 3. Reduced waste oil by 10, 037 lbs (20%) 4. Reduce washdown waste by 4,461 lbs (80%)	Vegetable oil corrosion inhibitor has a short shelf life before oil breaks down. Electrostatic method of applying oil is not economical at this time. Recycling used oil created tension on rollers and stained steel coils.
02DFV02943471	Electroplating, burnishing, and painting of metal and plastic parts; injection molding.	1. Electrostatic paint equipment 2. Electrocoating in lieu of spray paint 3. Powder coatings 4. Paint strip substitution 5. Reduce bath salt concentrations 6. Bath treatment 7. Spray rinses over plating baths 8. Early lifts, static drag-out, & counter current rinsing 9. Eliminate rinse where process baths have similar chemistry 10. Ion-exchange and evaporation of chromic acid rinsewater	1. Increase transfer efficiency from 25% to 60% 2. 90% transfer efficiency 3. Eliminates solvent use 4. Eliminates methylene chloride Note: Best measure to reflect waste reduction estimates without incurring additional costs is using chrome electroplated ampere-hours (current density per square foot)	New technology: potential replacement for electroplating plastic without etching
03DFV02943471	Produces metal parts including projectiles, cartridge cases, and missile motor bodies. Processes include metal fabrication, forming, and finishing. Note: Company is seizing operations	1. Employee waste generation & minimization program (1) 2. Establish inventory program to track purchases versus usage (1) 3. Preventative maintenance program 4. Optimized chemical bath change-out schedule (1) 5. Flow restrictors/control valves (1) 6. Counter current rinse (1) 7. Stagnant rinse to recover drag-out (1) 8. Automated process control on drip lines 9. Ion exchange on phosphate rinse to eliminate iron 10. Eliminate hexavalent chrome rinse for phosphate process (1) 11. Sludge dewatering		Input substitutions & product reformulations not feasible due to stringent specifications

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
04DFV02943471	Anodizing, painting, and plating	1. Process tank filtering 2. Replace 111-TCA with alkaline system 3. Use of 5 gallon still to recycle paint waste	1. Doubled process solution life and resulted in less chemicals purchased 3. Purchase of MEK was cut in half	
05DFV05943471	Wet-coat and powder-coat painting, aluminum anodizing, chemical conversion, impregnation and metal polishing.	1. Require customers to minimize oil & buffing compound prior to receiving 2. Wipe parts w/talc powder prior to cleaning 3. Partial switch to aqueous cleaners 4. DI rinse tank prior to bath to reduce drag in & extend bath life (1) 5. Spray rinse over rinse & process tanks 6. Closed loop still (1)	1. Reduction of 110 lbs of perc. 2. Reduction of 205 lbs of perc. 5. Reduction of 1000 lbs of chromate solution 6. Reduction of 110 lbs of solvents & strippers	
06DFV06943471	Manufactures thin-film, rigid, memory (hard) disks for personal computer disk drive industry. Processes include electroless nickel plating, nickel polishing, electroless cobalt plating, and solvent cleaning.	1. Employee training & suggestion program (cash incentive). 2. Statistical Process Control (SPC) 3. Product testing 4. Bath tested, filtered, & replenished 5. Computerized chemical additions (1) 6. Low nickel bath temperatures 7. Improved electroless nickel chemistry resulting in less waste per part (1) 8. Minimize nickel layer thickness (1) 9. New tanks, continuous filtration system (1)	7. 10% sludge volume reduction	No metals acceptable in lieu of nickel. Ceramic and glass not commercial yet. No alternatives effective as hydrochloric acid to dissolve metals and regenerate sludge dewatering membranes.
07DFV09943471	Chrome, copper, nickel, brass, zinc, tin, gold, silver, anodizing	1. FIFO 2. Pre-treat water using ion exchange 3. Non-cyanide solutions 4. Bath testing, filtering, and repleneshing 5. Low temperature baths 6. Reduced bath concentrations 7. Successive and counter current rinsing 8. Spray rinsing 9. Flow restrictors	1992 -12.24 tons 1993 - 8.61 tons	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		10. Air agitation 11. Baths treated by electrolytic dummying & ion exchange 12. Spent acids & alkalines for neutralization 13. Waste stream segregation		
08DFV09943471	Plating of zinc, nickel, and chrome. Product includes tools, fasteners, plumbing fixtures, chair frames, etc. using rack and barrel plating.			Customers resilient in changing to trivalent chrome Longer drainage time results in oxidation of the part resulting in further cleaning & wastes generated. Reducing water will have no net effect since concentrations of metal will be the same Two drawbacks to the Soviet Union process called "Surface Alloying" - Intense energy consumption and unacceptable appearance.
09DFV10943471	Performs plating, anodizing, and polishing operations, i.e., copper, nickel, chrome, zinc, and cadmium plating; hard anodizing,color anodizing, and chemical film processing.	1. Bath testing & repleneshing 2. Conversion to non-cyanide zinc & trivalent chrome chemistry (1) 3. Water soluble buffing compound 4. Counter current rinsing 5. Drag-out tanks 6. Flow restrictors 7. Air agitation in rinse 8. Evaporation recovery of drag-out solution (1) 9. Reuse drag-out solution 10. Use of magnesium oxide in lieu of sodium hydroxide (1) 11. Sludge dewatering & drying	8. Decreased filter cake sludge from 63.92 tons in 1991 to 52.40 tons in 1993	Drag-out tanks allow the counter flow rinse system to be operated at a lower flow rate Magnesium oxide reduces sludge volume, is easier to dry & yields a dryer filter cake

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
10DFV10943471	Plating, polishing, and painting hardware pieces. Plating of copper and nickel	1. FIFO 2. Routine inspections 3. Bath testing and filtering 4. Sufficient drain time 5. Drag out tanks 6. Counter current rinsing 7. Rinse agitation 8. Flow control 9. R.O. water 10. Water reuse 11. Switched from non-chromate to low VOC water based coating 12. Sludge dewatering	Estimated source reduction goal is 10% for the years 1995-1999	Spray rinsing, drip pans, splash guards require more room. Plant redesign to separate cyanide wastes. High production rates won't allow foot controlled rinsing. Changing chemical formulas may cause plating failure. Treatment may remove wanted chemicals. Evaporation and sludge drying is unacceptable due to regulatory conflict (LA Basin)
11DFV10943471	Alumiliting & color processing	1. Routine maintenance 2. Eliminate cyanide baths 3. Bath filtering & repleneshing 4. Bath agitation 5. Increased drag out time 6. Drain boards/drip guards 7. Drip bars 8. Static & counter current rinsing 9. Spray/fog rinsing 10. Flow restrictors & meters 11. Waste stream segregation 12. Spent acids/alkalines for neutralization 13. Evaporation 14. Eliminated vapor degreasing, 111-TCA, & hydrochloric acid	Reduced chemical storage by 30% Past 3 years reduced water consumption from 90,000 gpd to 36,000 gpd	This company is participating in EPA's 33/50 program
12DFV10943471	Clear and color anodizing, chemical bright dip, tin and chrome plating, and polishing	1. FIFO 2. Routine inspection & maintenance 3. Bath testing, treatment (filtered), & replenishing 4. Lower range bath concentrations 5. Increased drainage 6. Drain boards 7. Drag-out tanks, reuse drag-out 8. Spray rinse above process tanks		

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		9. Flow restrictors 10. Rinse water reuse 11. Spent acid for chrome reduction 12. Spent acids & alkaline for neutralization 13. Waste stream segregation		
13DFV10943471		1. FIFO 2. Routine inspections 3. Cyanide copper replaced w/hydrochloric acid 4. Bath treatment & repleneshing 5. Reduced nickel & chrome bath concentrations 6. Agitated rinses 7. Flow restrictors 8. Wastes segregation 9. Spent acids/alkalines for neutralization 10. Sludge dewatering		
14DVF10943479	Provides chromium plating & anodizing	1. FIFO 2. Extend bath filters from 1 use per filter to three uses (1) 3. Reuse static rinse solution for bath repleneshing 4. Alkaline cleaners in lieu of 111-TCA 5. Reduce rework (1) 6. Sludge dewatering	5. Currently at 20% of sales. Estimated reduction to less than 5%	
15DVF10943471	Metal plater - brass, nickel, and chrome plating	1. Water use reduction 2. Lower chromic acid concentration (1) 3. Non-chelated chemicals 4. Evaporators to reduce chemical drag-out (chrome & brass rinses) 5. Purchase more evaporators (1) 6. Researching R.O. for closed loop (1) 7. Batch treat solutions	1. 12,000 gal/day to 6,000 gal/day 2. 38 oz/gal to 28-30 oz/gal 4. 90% recovery 7. Reduction in treatment chemicals used	

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
16DFV11943471	Decorative nickel-chrome plating on steel and aluminum auto parts.	1. Routine tank inspections 2. Porous pot purification for chrome baths 3. Filter nickel baths (continuous) 4. Drain boards & bars 5. Splash guards 6. Increased drain times 7. Counter-current rinsing 8. Flow restrictors 9. Reuse nickel rinse in nickel plating bath 10. Chrome recovery (1) 11. Nitric acid recovery (1) 12. Hand line redesign (1) 13. Sludge recycling	10. Estimated 90% recovery of chrome solutions	Fog/Spray nozzles not practical due to space limitations Trivalent chrome not acceptable to customers Note: Waste Minimization Opportunity Assessments for East LA Enterprise Zone Metal Plating Facilities submitted with SB 14 documents.
17DFV11943471	Services include electroplating, anodizing, & application of chemical films & chromated dyes. Plating processes include electroless nickel, nickel strike, nickel sulfamate, cadmium cyanide, acid copper, tin & zinc	1. Alkaline zinc plating solution 2. Reuse of wastewater 3. Evaporation to recover salts for reuse 4. Increase DI water capacity (1)	3. Reduction of filter cake by 2-10%	Converted to closed loop facility in 1993. Reduced amount of waste water treated from 1993 by over 50%.
22DFV02953612	Manufacture of magnetic tape wound cores and cut cores. Processes include coating, winding, resin impregnation and curing, cutting, sanding, polishing, etching, and testing.	1. Inventory control 2. Employee training in material handling	2. Potential 5% waste reduction Estimated source reduction goal over the next four years is <1%.	
23DFV04953471	Job shop electroplating business for aircraft & commercial industries. Processes include vapor degreasing, zinc, cadmium, and nickel plating, chromating. April, 1993 - Discontinued cadmium plating, nickel strike, and vapor degreasing	1. FIFO 2. Routine maintenance 3. Non-cyanide zinc plating solutions 4. Bath testing 5. Minimum bath concentrations 6. Drip trays between tanks 7. Cascade rinse & static rinse tanks 8. Increased drainage time 9. Flow restrictors	Reduction in wastewater flows by 22 gal/min (1990 compared to 1984) Offsite disposal reduction of 104 tons In 1992, wastewater flow was 14.3 gal/min compared to 1994 of 18.6 gal/min	Note: Production in 1992-1993 declined and increased in 1994.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		10. Spent cleaners to neutralize spent acids 11. Waste stream segregation 12. Sludge press & sludge dryer	143,220 tons were disposed off-site comared to 183,040 tons	
24DFV05953471	Convert stainless steel and aluminum hot-rolled rod into aircraft quality cold-heading wire for the aerospace fastener industry	1. Spray rinsing 2. Cascading rinses 3. First stage rinse used for bath make-up 4. Spent acids & alkalines used for neutralization 5. Sludge dewatering and drying	Reduced 75% of waste generated per ton of product over the last six years. Remaining 25% is recycled.	Acid copper does not have the ductility required during fastener manufacture. Copper provides a high ductility lubricant for severe forming conditions.
25DFV06953471	Cadmium, chromium, copper, nickel, and zinc plating.	1. Routine inspection & maintenance 2. Trained employees in Statistical Process Control in machining & plating operations 3. Trained employees on material conservation 4. Preplating inspection to prevent rejects 5. Drip racks over process tanks 6. Longer drip time 7. Barriers between plating tanks 8. Flow restriction valves 9. Drip pans under machinery 10. Eliminated 111-TCA	2. Minimize quantity of unacceptable parts 7. Minimize loss of plating solutions 8. 3 gpm to 1.6 gpm 9. Results in recyclable oil	Input substitutions not feasible due to customer/government specifications. Financial constraints limits Joslyn to operational and administrative improvements. Low concentrations of copper & nickel in sludge makes recycling infeasible. Increased bath temperatures not practical due to increase in noxious fumes and cost to upgrade ventilation system. Spray rinse is a health risk due to exposure. Had trouble in past with increased drain times. Chemicals staining the part. Acid cadmium in lieu of sodium cyanide is inferior

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
26DFV06953315	Wire processing. Processes include cleaning, pickling, annealling, drawing, or shaving to meet customer specifications	1. Improve engineering techniques and routing 2. Upgraded cutter/shaving system, in-line die, and lubrication 3. Bath filtration & treatment 4. Sulfuric acid recovery (Unipure System) 5. Installation of Beta Acid Recovery System	1. Rejection rates minimized, wastes reduced, and productivity improved 2. Reduction of zinc phosphate filtercake, grinding sludge, and red filtercake by 69% from 1990 baseline levels 5. Ferrous Sulfate Hepta Hydrate filtercake sold as a fertilizer	
27DFV06953471	Electroplating job shop. Processes include copper, zinc, brass, and nickel plating; chromate conversion coating.	1. Purify rinse water for reuse. 2. Closed loop on plating rinses. Rinses used to replenish bath. 3. DI unit for rinsing 4. Evaporator on zinc and copper baths. 5. Evaporator for brass bath (1) 6. R.O. or ion-exchange for nickel bath (1)	2. Throughout 1994, there was nickel sulfate or chlorides added to the nickel bath. No copper, zinc, and sodium cyanides added to the copper and brass baths.	
28DFV07953452	Manufacture of precision aerospace fasteners (bolts & nuts) for military and commercial applications.	1. Purchase materials w/non-metallic lubrication coatings. Substitute wax & soap coatings in lieu of copper 2. Soap cleansers in lieu of solvent cleaning 3. Use of fog sprays over plating baths 4. Use static rinse tanks for bath chemical replenishment. Awaiting DI water system (1) 5. Bijur automatic lubrication system 6. Oil recovery equipment	4. Controlled use of oil Note: 85% reduction in total waste generated due to business downsizing	Computer controlled rack line not feasible due to downsizing. Water-based coolants caused grinding wheels to break down faster & it was difficult to hold tolerances. Note: Rule of thumb is that for every pound of metal in the waste stream thare are six pounds of treatment chemicals
29DFV07953471	Plating	1. FIFO 2. Bath tested and replenished 3. Racks agitated manually 4. Drag out tanks (1) 5. Rinse water recycling 6. Reduced rinse water flow rates 7. Sludge dewatering		Non-cyanide zinc not feasible with current business activity Rinse water reuse not feasible

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
30DFV07953463	Precision forging of aluminum and titanium parts or components for aerospace and defense applications.	1. Reuse of clarified neutralized water (55%) 2. Reuse of hydraulic oil by means of filtration. 3. Hydraulic system modification	3. Reduced pipe breakage by 20%	
32DFV07952819	Manufactures high purity etchants, solvents, and cleaning agents; aluminum sulfate.	1. Raw materials testing (hydrogen fluoride & DI water). 2. Product quality training. Less rejects 3. Reuse boiler condensate 4. Reuse spent sulfuric acid in lieu of virgin acid 5. Cooling water reuse/elimination. 6. Etchants not meeting specs are relabeled or reformulated as a lower grade product. 7. Recycle aluminum process residue (landscape industry).	1. 100% waste reduction 2. 20% waste reduction 3. 100% waste reduction 6. 80% waste reduction Overall hazardous waste reduction of 40% between 1990-1994	
33DFV07953471	Major products are aluminum and steel wheels. Processes include chrome, nickel, and copper plating; decorative barrel plating with nickel, zinc, and chrome.	1. FIFO 2. Lower end bath concentrations 3. Process baths tested, filtered, treated, & replenished 4. Drain boards 5. Vary part drainage due to production rates 6. Flow restrictors/control meters 7. Rinse agitation 8. Reuse concentrated drag out solutions 9. Use first rinse for nickel bath repleneshing 10. Spent acid solutions used in chrome reduction 11. Evaporator for recovering nickel & chrome	20% reduction goal for the years 1995-1999	If parts hang too long, they may be subject to spotting (dry spots), especially true for parts coming out of the nickel tanks. Non-cyanide solutions would require additional plating & cleaning lines to serve few clients. Alt. treatment too costly.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
34DFV07953471	Electro-zinc coat cold rolled steel coils. Processes include cleaning, zinc plating, phosphating, chromating, coil slitting, and metal forming.	1. FIFO 2. Employee source reduction training 3. Routine equip. inspections 4. Counter current rinsing 5. Rotating brush for cleaning 6. Waste stream segregation 7. Electrolytic recovery of rinse water (1)	15% reduction for years 1994-1998	
35DFV07953471		1. Routine Inspections & maintenance 2. Automated oil application 3. Wastes segregation	Estimated source reduction of 5% for the years 1994 to 1998	
36DFV07953471	Provides services to the aerospace, automotive, household fixtures/hardwares, medical, and sporting industry. Services include polishing, painting, anodizing, gold, silver, bronze, brass, copper, nickel, and chrome plating.	1. Periodic inventory & inspection of hazardous waste. 2. Scheduling similar painting operations to reduce solvent use, hazardous waste &VOC emissions 3. Switched to water based lacquer 4. Switched to non-cyanide strip solution 5. Substituted less hazardous organic paint stripper 6. Established contamination limits on anodize bath prior to dump or replenishing 7. Arranged process tanks to reduce cross contamination 8. Automated the brightener feeding system 9. Spray rinse over process tanks 10. Drag-out tanks 11. Conductivity sensors in rinse tanks	5. Eliminated 200 gal/yr of haz stripper 6. Reduced dump frequency by 20% (1500 gal/yr sulfuric anodize solution) 9-11. Reduce CWC 131, 132, 135 by 5% annually	Most effective method to reduce waste is counter current rinsing, however, space for additional rinse tanks are limited. Drag-out tanks and spray rinses will be utilized.

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Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
37DFV07953479	Plating and polishing	1. FIFO 2. Training on work removal rates & drainage times (1) 3. P2 training (1) 4. Routine maintenance 5. Less toxic inputs (1) 6. Lower bath concentrations (1) 7. Reuse drag-out solutions (1) 8. Install flow restrictors (1) 9. Waste stream segregation	Note: 20% source reduction goal for the years 1995-1999	
38DFV07952752	Manufacture of graduation announcements, business cards, envelopes, and letterheads	1. Separate wash up sink for metallic ink. 2. Spray wash system 3. Smaller ink fountain & roller assembly 4. Additional fountain trays to eliminate major wash-up when color changes. 5. Environmental coordinator assigned for each flow line	1. Reduction in wastewater by 74,011 lbs (20%) 3-4. Reduction in waste metallic inks by 67 lbs (5%)	Metallic ink substitutions do not meet customer quality
40DFV10953471	Aircraft plating and specialty aluminum washers	1. FIFO 2. Employee source reduction training 3. Routine inspections 4. Ultrasonic cleaner in lieu of Perchloroehylene (1)	Source reduction goal of 10% for the years 1995 to 1999	
41DFV11953471	Manufacturers air horns used in trucks and marine vessels. Processes include die casting, machining, welding, polishing, cleaning, painting, nickel, copper, and chrome plating.	1. FIFO 2. Source reduction training 3. Routine inspections 4. Converted to powder coating 5. Acid copper strike in lieu of cyanide 6. Full cyanide replacement (1) 7. Bath microfiltration (1) 8. TCA replacement (1)	Estimated 18% reduction for the years 1994 to 1997	Note: During chrome VI plating, electrolysis occurs resulting in the bubbling of oxygen and hydrogen gases dispersing hexavalent chromium into the atmosphere. Electrolysis consumes 90% of the current, 10-20% is used in the actual electroplating process.
19AJS06953452	Manufacture of threaded fasteners for aerospace industry; machining, heat treating, plating, & surface finishing; silver and cadmium plate, zinc phosphate, chromate conversion.	1. Replacement of cadmium plate over nickel strike using a customer approved barrier coating 2. Increased drain time 3. New perc parts cleaning machine 4. Machine oil filtering & reuse 5. Evaluation of equipment to recycle water soluble cutting oils (1)	1-2. 5% reduction in filter cake 3. 50% waste reduction 4. 30% waste reduction 5. 25% waste reduction 6. Increase recyclability of oils	Measure to reduce copper, cadmium, & sodium cyanide bath concentrations requires extensive laboratory time to develop. Counter flow rinses only reduced volume of water, not mass of metals

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
		6. Study to reduce the number of machine oils used (1)	Overall reduction achieved within 4 year period is 28%	Drag out tanks & metal recovery units are costly with low returns Alkaline soap cleaning system not technically feasible due to complex part geometries and the properties of the aqueous based system. Semi-aqueous parts cleaning system due to high capital cost & maintenance cost.
20AJS06953674	No description provided	1. Improve drainage over nickel plating bath. Increase number of shakes 2. Water quality meters in rinse tanks (1) 3. Longer use of cyanide gold stripping solution 4. Substitution of butyl acetate & 111-TCA with non-toxic cleaner 5. Sludge dewatering		1. Water treatment system is efficient in removing nickel & nickel in sludge is recycled, further action to reduce the nickel was deemed not economical Measures to reduce cyanide gold stripping solution were not undertaken due to restrictions under PBR.
48PAL05953471	Polishes and electroplates steel auto & motorcycle parts; decorative nickel chrome & black chrome electroplate; black oxide treatment	1. 6 inch splash guards on employee side of process tanks 2. Wash employee protective gear over rinse tanks 3. Employee training	1-2 Expected 80% reduction in waste generated	Did not mention any waste reduction measures for the chrome & nickel plating lines.
49PAL05953429	Manufacture door hardware components; brass, bronze, stainless steel and zinc-plated hardware; chromate conversion	1. Incorporate water-based metal working fluids (1) 2. Replace solvent cleaners with aqueous cleaners (1) 3. Substitution of no-rinse, non-chrome seal (1) 4. Elimination of cyanides in plating processes 5. Ultrafilter on spent aqueous cleaners (1) 6. Evaporators on zinc plating tanks, reuse zinc containing rinsewaters (1)	1. 75% waste reduction 2. Elimination of CWC 211, 75% reduction in CWC 213 &741 3. 10% reduction in sludge 5. Eliminate off site disposal not waste generation 6. >20% reduction in sludge	Costs for no-rinse non-chrome seal chemicals increased significantly & increased operating costs. Process did not impart any color (major problem). Lawerence Livermore Labs is investigating the color issue.

Generator	Activity	Waste Reduction Technique	% Reduction	Rejected Waste Reduction Techniques/Comments
53PAL07953452	Manufactures fasteners for aerospace & military applications. Processes include nickel & cadmium plating, chromium conversion	1. Spill/leak prevention (1) 2. Eliminate cross contamination (1) 3. Flow restrictors, conductivity meters, & timers 4. Double dip on barrel line 5. Increase drag out time (1)		No alternative was rejected, however, PB stated that it needs information on various SR measures in order to evaluate & implement.

(1) Waste reduction activity to be incorporated within the next four year reporting cycle.

APPENDIX B: CALIFORNIA WASTE CODES

Appendix B
California Waste Codes

California Nonrestricted Wastes

Inorganics

121. Alkaline solution (pH> or = 12.5) with metals (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, or zinc)
122. Alkaline solution without metals (pH > or = 12.5)
123. Unspecified alkaline solution
131. Aqueous solution (2 < pH < 12.5) containing reactive anions (azide, bromate, chlorate, cyanide, fluoride, hypochlorite, nitrite, perchlorate, and sulfide anions)
132. Aqueous solution with metals (< restricted levels and see 121)
133. Aqueous solution with total organic residues 10 percent or more
134. Aqueous solution with total organic residues less than 10 percent
135. Unspecified aqueous solution
141. Off-specification, aged, or surplus inorganics
151. Asbestos-containing waste
161. FCC waste
162. Other spent catalyst
171. Metal sludge (see 121)
172. Metal dust (see 121) and machining waste
181. Other inorganic solid waste

Organics

211. Halogenated solvents (chloroform, methyl chloride, perchloroethylene, etc.)
212. Oxygenated solvents (acetone, butanol, ethyl acetate, etc.)
213. Hydrocarbon solvents (benzene, hexane, Stoddard, etc.)
214. Unspecified solvent mixture
221. Waste oil and mixed oil
222. Oil/water separation sludge
223. Unspecified oil-containing waste
231. Pesticide rinse water
232. Pesticides and other waste associated with pesticide production
241. Tank bottom waste
251. Still bottoms with halogenated organics
252. Other still bottom waste
261. Polychlorinated biphenyls and material containing PCBs
271. Organic monomer waste (includes unreacted resins)
272. Polymeric resin waste
281. Adhesives

291. Latex waste
311. Pharmaceutical waste
321. Sewage sludge
322. Biological waste other than sewage sludge
331. Off-specification, aged, or surplus organics
341. Organic liquids (nonsolvents with halogens)
342. Organic liquids with metals (see 121)
343. Unspecified organic liquid mixture
351. Organic solids with halogens
352. Other organic solids

Solids

411. Alum and gypsum sludge
421. Lime sludge
431. Phosphate sludge
441. Sulfur sludge
451. Degreasing sludge
461. Paint sludge
471. Paper sludge/pulp
481. Tetraethyl lead sludge
491. Unspecified sludge waste

Miscellaneous

511. Empty pesticide containers 30 gallons or more
512. Other empty containers 30 gallons or more
513. Empty containers less than 30 gallons
521. Drilling mud
531. Chemical toilet waste
541. Photochemicals/photoprocessing waste
551. Laboratory waste chemicals
561. Detergent and soap
571. Fly ash, bottom ash, and retort ash
581. Gas scrubber waste
591. Baghouse waste
611. Contaminated soil from site clean-ups
612. Household wastes
613. Auto-shredder waste

California Restricted Wastes

711. Liquids with cyanides > or = 1000 Mg/L
721. Liquids with arsenic > or = 500 Mg/L
722. Liquids with cadmium > or = 100 Mg/L
723. Liquids with chromium(VI) > or = 500 Mg/L
724. Liquids with lead > or = 500 Mg/L
725. Liquids with mercury > or = 20 Mg/L
726. Liquids with nickel > or = 134 Mg/L
727. Liquids with selenium > or = 100 Mg/L
728. Liquids with thallium > or = 130 Mg/L
731. Liquids with polychlorinated biphenyls > or = 50 Mg/L
741. Liquids with halogenated organic compounds > or = 1000 Mg/L
751. Solids or sludges with halogenated organic compounds > or = 1000 mg/Kg
791. Liquids with pH < or = 2
792. Liquids with pH < or = 2 with metals
801. Waste potentially containing dioxins