Common Sense Initiative

Metal Finishing Sector

WORKGROUP REPORT: F006 BENCHMARKING STUDY

September 1998

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EXECUTIVE SUMMARY

This report presents current information about the metal finishing industry in the U.S., and is the result of a two year effort of the Metal Finishing workgroup of the Common Sense Initiative (CSI). The CSI was begun by the Environmental Protection Agency (EPA) in 1994 to explore "cleaner, cheaper, and smarter" environmental strategies beyond those required by regulation. Using the special authorities of the Federal Advisory Committee Act (FACA), EPA brought together representatives from federal, state, and local governments, industry, community-based and national environmental interest groups, environmental justice groups and organized labor to explore opportunities for managing environmental issues in new ways. Six industry sectors were chosen for the initial CSI efforts, including petroleum refining, automobile manufacturing, iron and steel production, electronics, printing and metal finishing.

Overview of the Metal Finishing Industry and Hazardous Waste Management.

Metal finishing refers to processes which deposit or "plate" a thin layer of metal and/or apply an additional organic topcoat as an outer coating on products received from other manufacturing operations. Metal finishing is performed for either functional or decorative purposes and affects many products we use everyday. For example, hard chrome plating is a functional plating process that increases the hardness and durability of engine parts. Chrome plating automobile bumpers is an example of a decorative plating process.

EPA estimated that there were approximately 13,400 metal finishing establishments in the United States. Of the total, approximately 10,000 metal finishing facilities are estimated to be "captive" shops contained inside a larger manufacturing operation. The balance of 3,400 metal finishing facilities are "job shops" or "independent" metal finishing operations that operate on a job-specific contract basis.[1] The total number of plating shops has decreased significantly since the 1970's, mainly as a result of increasing regulations and competition.

As in many manufacturing processes, some portion of the materials used in production or in the product itself are not totally captured as salable product, and exit the process in wastewater, solid waste, airborne emissions, scrap metal, or off-spec products. Prior to 1980, there were no federal regulations covering the discharge or disposal of wastes from metal finishing operations, and the wastes, which contained metals as well as other substances, were often directly discharged to surface waters or disposed of in landfills or lagoons.

In 1980, EPA issued the Nation's first hazardous waste management regulations, which "listed" sludges from electroplating wastewater treatment as a hazardous waste (F006), and set standards for the storage, transportation, treatment and disposal of these sludges. EPA simultaneously developed regulations that require metal finishers to significantly reduce or eliminate pollutants in wastewaters discharged to publically owned wastewater treatment systems

[1] Borst, Paul A. U.S. EPA, Office of Solid Waste. Recycling of Wastewater Treatment Sludges from Electroplating Operations, F006. 1997.

(final “pretreatment regulations were issued in 1986).

As a result of the strengthening of the federal regulations, the metal finishing industry implemented many improvements in material use, production processes and waste management methods.

Metals contained in F006 have commercial value if they are present in sufficient concentrations and if other analytes in the sludge are below levels which would interfere with the metal recovery process. There may be other materials contained in the sludge which do not interfere with metals recovery, but which could be hazardous if improperly managed. The economics of hazardous waste management is a strong determinant of whether metal finishers send sludges for land disposal or to recycling facilities. Estimates of the amounts of sludge that are recycled or land disposed vary widely. One source estimates that between 10 and 20 percent is recycled and between 80 and 90 percent is treated and land disposed.[2]

Why was this study conducted?

The CSI Metal Finishing Subcommittee focused on the metal finishing industry's belief that process improvements made by many metal finishers during the past 20 years have significantly changed the composition of the F006 material that was listed and regulated in 1980, and it is the industry's belief that modification of EPA's hazardous waste regulations for F006 could increase the metal finishing industry's ability to recover and recycle more commercially valuable metals from F006 than they currently recover, and simultaneously decrease the amount of metal finishing wastes disposed of in regulated landfills.

In order to evaluate the current status of the industry, the Subcommittee formed a workgroup to complete a characterization of F006 and to report on the results as the foundation for any further discussions regarding potential modifications to F006 regulations.

This report simply presents the data collected during the F006 Benchmarking Study as a foundation for further evaluation of F006. The CSI Workgroup did not attempt to analyze the data to determine the extent to which the characteristics of F006 have changed based on industry pollution prevention practices or other factors. In Phase 2 of this effort, the Workgroup will analyze the information presented in this report, and examine whether potential modifications of the current regulations applicable to F006 should be considered by EPA.

Worker Health and Safety

As part of the benchmarking study, the workgroup collected information on F006 handling practices, identified the potential hazards to workers, and described possible hazard control

[2] Borst, Paul A. U.S. EPA, Office of Solid Waste. Recycling of Wastewater Treatment Sludges from Electroplating Operations, F006. 1997.

methods. In addition, the workgroup developed a list of the current worker health and safety regulations and policies that may apply to on-site and off-site management of F006. This information is presented in Appendix C of this report. Beyond this information, the workgroup did not attempt to complete a comprehensive review of worker health and safety issues associated with F006 management.

As indicated above, in Phase II of this effort the workgroup will examine whether possible modifications of the current regulations for F006 should be considered based on the information in this study. As part of this effort, the workgroup will consider potential worker health and safety issues when examining possible regulatory changes for F006.

The F006 Benchmarking Study Approach

The workgroup focused on three analytical questions to guide its work on characterizing current practices in the metal finishing industry, and the composition and management of F006:

1) What are the characteristics of F006?
2) What can metal finishers do to make F006 more recyclable, while optimizing pollution prevention? What pollution prevention practices are in place at metal finishing facilities?
3) What are the environmental impacts of F006 recycling?

While not an initial focus in this effort, the workgroup also examined worker health and safety impacts in this study.

To answer these questions, the workgroup designed a five part "benchmarking study" to gather current information on the metal finishing industry. This approach carefully balances the need to gather detailed information from a diverse industry with funding and schedule limitations. The workgroup believes the study approach and the data presented in this report provide a very useful characterization of a cross section of "typical" metal finishing facilities and a strong sense for the environmental awareness of many metal finishing companies. The workgroup also recognizes that there are facilities in the metal finishing industry which do not fit within the range of activities and practices characterized in this report, and that discussion of the data presented in this report should take that into account. The workgroup also discussed the possibility that, despite the usefulness of the data gathered in the Benchmarking study, additional data might be needed if subsequent discussions of policy options and/or regulatory options analysis warranted more data.

The study components summarized below, which are discussed in detail in the report, include:

A *Regional Benchmarking Study* that involved site visits to 29 metal finishing shops in three cities to gather detailed data on plating processes, pollution prevention practices, F006 chemical analysis and F006 handling and management practices;

A *National Benchmarking Study* that used a mail survey to gather less detailed data on metal finishing operations, pollution prevention practices, F006 characteristics and management practices from a broad range of metal finishers;

An *Analysis of Statistical Representation* to determine the extent to which the companies participating in the regional and national benchmarking studies represent the universe of metal finishers.

A *Commercial Recycling Company Mail Survey* to gather data on the amount and chemical composition of F006 accepted for recycling by commercial recycling companies, and

A *Community Interest Group Phone Survey* to assess whether community groups in the vicinity of commercial recycling companies believe those companies are good environmental and economic neighbors.

Results of the National F006 Benchmarking Study

The results of the five components of the study are presented in the main body of the report. The results of the Regional and National Benchmarking Studies are presented in summary form and in detail. The data describe the range of production, pollution prevention and waste management practices employed by the facilities studied and the present information about the quantity and composition of F006 wastes produced. For example, the minimum, mean, median, and maximum values of F006 laboratory analyses are provided in a format that allows the reader to compare regional and national data. Detailed data for each of the 29 facilities that participated in the Regional study, and detailed results from the National study are also presented.

The workgroup's statistical analysis examined the extent to which the data gathered in the Regional and National Benchmarking studies represents the metal finishing universe, keeping in mind that the Regional and National Benchmarking studies were designed to give the workgroup descriptive data for facilities which operate the most commonly used metal finishing processes. The Benchmarking study was not designed to capture data on the full range of metal finishing operations. In short, the statistical analysis that was completed indicates that the Benchmarking Study results can not be assumed to statistically represent the entire metal finishing universe. This result does not diminish the value of the Benchmarking study data. The Benchmarking Study does provide substantial additional data characterizing the F006 wastestream and provides a sound starting point for further discussion.

The workgroup was not able to obtain enough data to complete the commercial recycling study, therefore no results are presented. Results of the community group survey, which was designed to accompany the results of the commercial recycling survey, are summarized even though the commercial recycling study was not completed.

The Appendices of this report contain further details supporting various aspects of the study.

Project participants:

The following people participated in this project:

John Linstedt (Artistic Plating, Inc.),
Diane Cameron (Natural Resources Defense Council),
Bill Sonntag, Al Collins, and participating members of the American Electroplaters and Surface Finishers Society, National Association of Metal Finshers, and the Metal Finishing Suppliers Association,
Andy Comai (United Auto Workers),
Tom Wallin (Illinois EPA),
Doreen Sterling (US EPA),
Mike Flynn (US EPA),
Jim Lounsbury (US EPA),
Jeff Hannapel (US EPA)
John Lingelbach (facilitator, Decisions and Agreements, LLC) and,
the SAIC Contractor Support Team.

I. BACKGROUND

A. What is the Common Sense Initiative?

In 1994, the Administrator of the Environmental Protection Agency, Carol Browner, launched the Common Sense Initiative (CSI), describing it as a “fundamentally different system" to explore industry-specific strategies for environmental protection. The program is designed to promote "cleaner, cheaper, and smarter" environmental performance, using a non-adversarial, stakeholder consensus process to test innovative ideas and approaches. Six industry sectors were selected to participate in CSI: Petroleum Refining, Auto Manufacturing, Iron and Steel, Metal Finishing, Printing, and Computers and Electronics.

In January of 1995, the Environmental Protection Agency (EPA) chartered the Metal Finishing Sector Subcommittee of the Common Sense Initiative under the Federal Advisory Committee Act. The Metal Finishing Subcommittee includes representatives of EPA Headquarters and Regional offices, the metal finishing industry and its suppliers, state government, Publicly Owned Treatment Works (POTWs), national and regional environmental organizations, the environmental justice community, and organized labor.

The CSI Metal Finishing Sector was challenged by Administrator Carol Browner to develop a consensus package of “cleaner, cheaper, and smarter” policy actions for the industry as a whole, based on the lessons learned from the Sector's projects and dialogue. Based on this challenge the Subcommittee established a workgroup to develop a strategic policy and program framework for the industry.

The Metal Finishing Strategic Goals Program, designed by this multi-stakeholder group, establishes a set of voluntary National Performance Goals for the industry that represent "better than compliance" environmental performance for metal finishers. The Metal Finishing Goals Program, summarized in Table 1, includes facility-based numerical performance targets which track the CSI themes of cleaner, cheaper, and smarter performance.

The goals program also includes a detailed Action Plan that addresses nine important issue areas (listed in Appendix A) for the metal finishing industry. By implementing the Action Plan, stakeholders provide incentives, create tools, and remove barriers for metal finishers to achieve the National Performance goals. Today’s report presents the results of the first phase of the Waste Minimization and Recovery issue area.

The Waste Minimization and Recovery Issue examines the metal finishing industry’s belief that process improvements made by many metal finishers during the past 20 years have significantly changed the nature of the industry’s wastewater treatment sludges, which are regulated as a hazardous waste known as F006 under the Resource Conservation and Recovery Act (RCRA). The metal finishing industry also believes that modification of EPA’s hazardous waste regulations for F006 could increase the metal finishing industry’s ability to recover more commercially valuable metals (contained in F006) than they currently recover, and simultaneously decrease the amount of metal finishing wastes disposed of in regulated landfills.

Table 1: National Metal Finishing Performance Goals (By Year 2002)

(1) Improved Resource Utilization ("Smarter")

(a) 98% of metals ultimately utilized on product.
(b) 50% reduction in water purchased/used (from 1992 levels).
(c) 25% reduction in facility-wide energy use (from 1992 levels)

(2) Reduction in Hazardous Emissions and Exposures (i.e.,"Cleaner")

(a) 90% reduction in organic TRI emissions and 50% reduction in metals emissions to air and water (from 1992 levels).
(b) 50% reduction in land disposal of hazardous sludge and a reduction in sludge generation (from 1992 levels).
(c) Reduction in human exposure to toxic materials in the facility and the surrounding community, clearly demonstrated by action selected and taken by the facility. Such actions may include, for example, pollution prevention, use of state-of the-art emission controls and protective equipment, use of best recognized industrial hygiene practices, worker training in environmental hazards, or participation in the Local Emergency Planning Committees.

(3) Increased Economic Payback and Decreased Costs ("Cheaper")

(a) Long-term economic benefit to facilities achieving Goals 1 and 2. .
(b) 50% reduction in costs of unnecessary permitting, reporting, monitoring, and related activities (from 1992 levels), to be implemented through burden reduction programs to the extent that such efforts do not adversely impact environmental outcomes.

(4) Industry-Wide Achievement of Facility Goals.

(a) 80% of facilities nationwide achieve Goals 1 - 3.

(5) Industry-Wide Compliance with Environmental Performance Requirements.

(a) All operating facilities achieve compliance with Federal, State, and local environmental performance requirements.
(b) All metal finishers wishing to cease operations have access to a government sponsored "exit strategy" for environmentally responsible site transition.
(c) All enforcement activities involving metal fishing facilities are conducted in a consistent manner to achieve a level playing field, with a primary focus on those facilities that knowingly disregard environmental requirements.

Note: At facilities where outstanding performance levels were reached prior to 1992, the percentage-reduction targets for Goals 1 (b) and (c), and 2 (a) and (b) may not be fully achievable, or the effort to achieve them may not be the best use of available resources. In these instances, a target should be adjusted as necessary to make it both meaningful and achievable.

The group formed to address this issue is the Metal Finishing F006 Benchmarking Workgroup, comprised of representatives from the metal finishing, the recycling industry, environmental interests, organized labor, local government and the EPA. The workgroup has completed a two year effort to gather new information on the generation, characteristics and management of electroplating wastewater treatment sludges (F006). The workgroup's approach and results are described in detail in the remainder of this report.

B. The Metal Finishing Industry and Electroplating Wastewater Treatment Sludges

EPA estimated that there were approximately 13,400 metal finishing establishments in the United States.[3] Of the total, approximately 10,000 metal finishing facilities are estimated to be "captive" shops where the metal finishing operation is contained inside a larger manufacturing operation. The balance of 3,400 metal finishing facilities are "job shops" or "independent" metal finishing operations. Job shops are usually small businesses that operate on a job-specific contract basis.[4] The total number of plating shops has decreased since the 1970's, mainly as a result of increasing regulatory burden and competition. One source estimates that the number of metal finishers decreased to as low as 7,200 in 1992.[5]

Metal finishing refers to processes which deposit or "plate" a thin layer of metal and/or an additional organic topcoat as an outer coating on products received from other manufacturing operations. Metal finishing is performed for either functional or decorative purposes and affects many products we use everyday. A large percentage of all metal or metalized products require surface finishing before the product is ready for final use. Some examples of functional uses include: hard chrome plating to increase hardness and durability in engine parts; zinc plating to increase the corrosion resistance of fasteners; tin and silver plating electrical contacts in electrical distribution switches for electrical enhancement and corrosion resistance; and gold plating in high quality communications applications. Chrome plating automobile bumpers is an example of a decorative plating process.[6]

Metal plating involves a sequence of steps, including metal surface preparation and cleaning, metal deposition, rinsing, and wastewater treatment. The electroplating step involves immersing an object into a solution of metal ions and applying an external reductive source. Control of the electrical current, solution temperature, pH, and solution chemistry determines the thickness of the deposit. Other forms of metal finishing and plating are used by some shops, e.g., electroless plating, however, they are not the focus of this study. Table 2, below, lists frequently used metals and their applications.

C. F006 Sludge Generation and Management

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[3] USEPA, Office of Policy, Planning and Evaluation. SUSTAINABLE INDUSTRY: Promoting Environmental Protection in the Industrial Sector, Phase 1 Report. June 1994.

[4] Borst, Paul A. U.S. EPA, Office of Solid Waste. Recycling of Wastewater Treatment Sludges from Electroplating Operations, F006. 1997.

[5] Kirk-Othmer. Encyclopedia of Chemical Technology (4th ed.), 199--888, v.9

[6] USEPA, Office of Solid Waste, Hazardous Waste F006 Listing Background Document, p.107.

As in many manufacturing processes, some portion of the materials used in production or in the product itself are not totally captured as salable product, and exit the process in wastewater, solid waste, airborne emissions, scrap metal, or off-spec products. Captive shops, which repeat the same plating operations over time, use a relatively homogeneous mix of

Table 2. Frequently Used Metals and Their Applications

Property/Function	Principal Plating Metals
Decorative	Chromium, copper, nickel, brass, bronze, gold, silver, platinum, zinc
Corrosion resistance	Nickel, chromium, electroless nickel, zinc, cadmium, copper, copper alloys, silver, tin, gold
Wear, lubricity, hardness	Chromium, electroless nickel, bronze, nickel, cadmium, silver, tin, metal composites
Bearings	Copper, bronze, silver, silver alloys, lead-tin
Joining, soldering, brazing, electrical contact resistance, conductivity	Nickel, electroless nickel, electroless copper, copper, cadmium, gold, silver, lead-tin, tin, cobalt
Barrier coatings, anti-diffusion, heat-treatment	Nickel, cobalt, iron, copper, bronze, tin-nickel, palladium
Electromagnetic shielding	Copper, electroless copper, nickel, electroless nickel, zinc
Paint/lacquer base, rubber bonding	Zinc, tin, chromium, brass
Electroforming manufacturing	Copper, nickel
Electronics manufacturing	Electroless copper, copper, electroless nickel, nickel, gold, palladium
Dimensional buildup, salvage of worn parts	Chromium, nickel, electroless nickel, iron, silver

Source: Electroplating Engineering Handbook, 1996.

chemicals and, consequently, generate a relatively contant mix of wastes. Job shops are more likely to change processes to meet the demand of a range of customers, which changes the mix of materials used to plate products and the mix and concentration of wastes generated. This difference in operations drives differences in the wastes generated by these shops.

F006 sludge is formed by adding precipitation chemicals in electroplating wastewater treatment systems. The precipitation chemicals are used to remove toxic metals and other hazardous constituents from the wastewater, a large portion of which settle to the bottom as sludge. The sludge (F006) is a very wet metal hydroxide mixture that is removed from the treatment tank and usually "dewatered" in large presses, leaving a wet mud that is generally 25 percent solids by weight. Sludges are sometimes dried to further reduce moisture content and weight. The sludge is stored in containers, such as, "super sacks," or larger "roll off boxes," and is sent by truck or rail to RCRA permitted treatment and disposal facilities, or to hazardous waste permitted recycling facilities, which recover economically valuable metals from the sludge and land dispose the remaining material.

The metals contained in F006 have commercial value if they are present in sufficient concentrations and if other analytes in the sludge are below levels which would interfere with the metal recovery process. There may be other materials contained in the sludge which do not interfere with metals recovery, but which could be hazardous if improperly managed. Recycling facilities generally blend F006 shipments from several generators to meet recycling specifications for a particular target metal in the sludge. Secondary smelting, which is the most frequently used recovery technology, "melts" a target metal (e.g., copper) from mixtures of F006, scrap copper, and other copper containing secondary materials. Often multiple metals are captured. Smelting wastes are generally land disposed.

Estimates of the amounts of sludge that are recycled or land disposed vary widely. One source estimates that between 10 and 20 percent is recycled and between 80 and 90 percent of F006 is treated and disposed of through stabilization and placement in RCRA hazardous waste landfills.[7] In 1993, the National Association of Metal Finishers estimated that approximately 15 to 20 percent of F006 is recycled for metal recovery.[8] EPA's Biennial Reporting System (BRS) indicates that 824 metal finishers which are large quantity (more than 1,000 kg/month) generators of hazardous waste) recycled 282,000 tons of F006 in 1995, and 283 large quantity metal finishing generators treated [9] and disposed of 99,000 tons of F006 in RCRA regulated landfills per year. The results contained in today's report are inconclusive and do not narrow the wide variation in recycling estimates. These figures are explained in more detail in Appendix B.[10]

D. Basis for Listing F006-Electroplating Wastewater Treatment Sludges as a RCRA Hazardous Waste in 1980

In the early 1970's, the U.S. enacted legislation to reduce discharges of pollutants to U.S. waters. In subsequent years, EPA, States and local governments developed wastewater pretreatment regulations which require industry, including metal finishers, to significantly reduce or eliminate pollutants from their wastewater before sending their wastewater to publicly owned

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[7] Borst, Paul A. U.S. EPA, Office of Solid Waste. Recycling of Wastewater Treatment Sludges from Electroplating Operations, F006. 1997.

[8] op. cit.

[9] Prior to land disposal, F006 must be treated to meet the treatment standards specified in EPA's Land Disposal Restrictions regulations, 40 CFR Part 268, to immobilize toxic constituents, mainly metals. Stabilization is one technology that may be utilized, however, other technologies may be used.

[10] The Biennial Reporting System is not designed to provide "treatment train" (e.g., stabilization followed by landfilling) information. Therefore, in an effort to avoid double counting, these quantities were calculated from facilities reporting F006 management as either recycling or landfilling. In other words, the majority of the wastes go through some interim management steps (e.g., stabilization, blending) not accounted for in these calculations. It would be virtually impossible to account for the final management of sludge going through offsite treatment prior to final disposition. In this case, only about 25% of the volume generated is accounted for.

sewer treatment systems (40 CFR Part 413). Final Federal standards were promulgated July,1986 (at 40 CFR §§413 and 433).

Solid waste legislation in 1976, i.e., RCRA, required EPA to designate categories of industrial waste which are "hazardous," and to issue regulations which ensure safe generation, storage, transportation, treatment and disposal of these wastes. Metal finishers were among the first industries to be regulated under the hazardous waste regulations in 1980.

EPA "listed" the wastewater treatment sludges from certain electroplating operations as a hazardous waste (hazardous waste code F006) under Subtitle C of RCRA[11] in 1980 based on a variety of factors (45 F.R. 74884, November 12, 1980). Key to this decision were typically high levels of cadmium, nickel, hexavalent chromium and complexed cyanides in the sludge that could pose a substantial present or potential hazard to human health and the environment if improperly managed. The Extraction Procedure Toxicity Characteristic (or EP) test used at that time (at 43 FR 58956-58957); and the ASTM distilled water leaching test, showed that these metals leached out of the sludge in significant concentrations, which increased the possibility of groundwater contamination if these wastes were improperly disposed. Leaching tests run by the American Electroplaters' Society (AES) under an EPA grant yielded cyanide leach concentrations of 0.5 to 170 mg/l, cadmium levels of non-detectable to 268 mg/l, and chromium levels of 0.12 to 400 mg/l.

At that time, EPA also estimated that a majority of metal finishers discharged their wastewater to POTWs without treating the wastewater. The remainder discharged to waters of the U.S., on-site lagoons, or surface impoundments. Based upon data collected from 48 facilities that did not treat their waste in 1976, EPA estimated that 20 percent disposed of their solid waste on-site while 80 percent sent their solid waste off-site for disposal in a municipal or commercial landfill.

Prior to the issuance of RCRA hazardous waste regulations in 1980, there were no Federal requirements for management of metal finishing sludges. Disposal practices included landfilling, lagooning, drying beds and drum burial. These sites frequently lacked leachate and runoff control practices, which increased the risk of percolation of heavy metals and cyanides into soils, groundwater and surface waters. Numerous damage incidents (e.g., contaminated wells, destruction of animal life) attributable to improper electroplating waste disposal were reported, indicating that mismanagement was an actual, rather than a perceived or potential threat. The long term persistence of heavy metals in the environment increased the potential for risk. The data EPA used for its listing determination came from various sources. Some of the data was over 20 years old while other data used in the determination was current at that time.

Tables 3a and 3b are taken from EPA's F006 listing regulatory support documents (1980). Table 3a summarizes the chemical composition of typical electroplating baths used in the 1970's. Table 3b summarizes information on heavy metal concentrations in sludges.

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[11] A solid waste may be classified as a hazardous wastes if: 1) it exhibits a characteristic for ignitability, corrosivity, reactivity, or toxicity (40 CFR Part 261 Subpart C), or 2) if, classified as a listed waste (40 CFR Subpart D).

Table 3a: Typical Electroplating Baths and Their Chemical Composition		
Plating Compound	Constituents	Concentration (g/l)
1. Cadmium Cyanide	Cadmium oxide Cadmium Sodium cyanide Sodium hydroxide	22.5 19.5 77.9 14.2
2. Cadmium Fluoborate	Cadmium fluoborate Cadmium (metal) Ammonium fluoborate Boric acid Licorice	251.2 94.4 59.0 27.0 1.1
3. Chromium Electroplate	Chromic acid Sulfate Fluoride	172.3 1.3 0.7
4. Copper Cyanide	Copper cyanide Free sodium cyanide Sodium carbonate Rochelle salt	26.2 5.6 37.4 44.9
5. Electroless Copper	Copper nitrate Sodium bicarbonate Rochelle salt Sodium hydroxide Formaldehyde (37%)	15 10 30 20 100 ml/l
6. Gold Cyanide	Gold (as potassium gold cyanide) Potassium cyanide Potassium carbonate Depotassium phosphate	8 30 30 30
7. Acid Nickel	Nickel sulfate Nickel chloride Boric acid	330 45 37
8. Silver Cyanide	Silver cyanide Potassium cyanide Potassium carbonate Metallic silver Free cyanide	35.9 59.9 15.0 23.8 41.2
9. Zinc Sulfate	Zinc sulfate Sodium sulfate Magnesium sulfate	374.5 71.5 59.9

Source: EPA F006 Listing Background Document, 1980

Table 3b: Heavy Metal Content for Chromium and Cadmium in Electroplating Sludges (Dry Weight ppm)		
Primary Plating Process	**Chromium**	**Cadmium**
Segregated Zinc	200	<100
Segregated Cadmium	62,000	22,000
Zinc Plating and Chromating	65,000	1,100
Copper-Nickel-Chromium on Zinc	500	ND
Aluminum anodizing (chromic process)	1,700	ND
Nickel-Chromium on steel	14,000	--
Multi-process job	25,000	1,500
Electroless Copper on Plastic, Acid Copper, Nickel Chromium	137,000	ND
Multi-process with Barrel or Vibratory Finish	570	--
Printed Circuits	3,500	<100
Nickel-Chromium on Steel	79,200	<100
Cadmium-Nickel-Copper on Brass and Steel	48,900	500

Source: EPA F006 Listing Background Document, 1980

Only certain metal finishing sludges were listed as hazardous wastes. Others studied were determined to not pose a substantial hazard. Regulated F006 includes:

> *Wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum.* (see 40 CFR 261.31)

The promulgation of effluent guidelines for the metal finishing industry in 1986 significantly increased the quantities of wastewater treatment sludge generated. This increase occurred because the guidelines required metal finishers to treat their wastewater to remove or reduce pollutants prior to discharge to either a publicly owned treatment works (POTW) or directly to waters of the U.S. To comply with the effluent guidelines, metal finishers added iron, lime and other chemicals to precipitate out or destroy pollutants such as chrome, zinc, copper and cyanide. The precipitate formed F006 sludge, which was then filtered and managed in compliance with RCRA regulations.

Current estimates of annual F006 generation in the United States range from 360,000 tons dry weight equivalent (F006 industry estimate) to 500,000 tons dry weight equivalent 1,252,072 tons/wet weigth (1989 EPA estimate). Most of this material is in the physical form of metal hydroxide sludges.[12]

F006 is subject to the full set of RCRA hazardous waste regulations (e.g., manifesting burden, training, emergency response plans). Metal finishers are also subject to OSHA and EPA worker health and safety regulations to protect workers from the potential effects of any toxic materials or other hazards in the workplace. Appendix C provides a list of the worker health and safety regulations and their applicability to metal finishers.

E. Reasons this Study was Conducted

The metal finishing industry believed that many metal finishers have significantly changed the way they operate since 1980, and that the chemical makeup of F006 is more amenable to recycling than it was in 1980. The strengthening of wastewater pretreatment, hazardous waste management, and hazardous waste minimization requirements since 1980 have had a positive impact on materials used, improved process operations, and better waste management practices in the metal finishing. These improvements have reduced the pollutants contained in F006.
The industry also believed that these changes may be substantial enough to warrant modification of regulatory controls. This report provides current information about the metal finishing industry in the U.S. and presents data characterizing F006.

The metal finishing industry responded to the strengthening of wastewater and hazardous waste regulations with improvements in alternative plating chemistries, production management practices, equipment, and waste management technology. For example, the installation of countercurrent flow, spray rinsing and drag out reduction methods are examples of techniques that reduce wastewater volumes and the amount of metals and other chemicals used. Some metal finishing companies installed pollution prevention methods which are targeted at further reducing or eliminating the use of specific toxic materials. The most notable have been: the replacement of traditional cyanide-based plating solutions (e.g., for zinc and copper plating) with alkaline-based plating solutions; the substitution of trivalent chromium for highly toxic hexavalent chromium for some applications; and the replacement of some single metal systems with alloy systems (e.g., replacing cadmium with zinc-nickel).

In 1980, EPA published regulations which set standards for permitting hazardous waste land disposal facilities, and in 1988, EPA promulgated land disposal restrictions regulations which require metal finishers to treat F006 to meet the treatment standards specified in this rule. The rule requires F006 to be treated to immobilize toxic constituents, mainly metals. Stabilization is one technology that may be utilized, however, other technologies may be used. methods before disposing of the waste in landfills.

The economics of waste disposal result in most F006 being land disposed rather than recycled because recycling is typically more expensive. This means potentially recoverable metals

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[12] Borst, Paul A. U.S. EPA, Office of Solid Waste. Recycling of Wastewater Treatment Sludges from Electroplating Operations, F006. 1997.

(i.e., those which are land disposed) are no longer available for commerce. Several of the more prominent metals (e.g., nickel and chromium) are strategic metals which are not available in the U.S.

The results of a 1993 study by the National Center for Manufacturing Sciences (NCMS) and the National Association of Metal Finishers (NAMF) show that 90 percent of the 318 facilities that responded (16% response rate of 1,971 facilities queried) use pollution prevention methods and benefitted from them.   Water conservation and in process recycling techniques were noted to be more frequently used than chemical recovery.   Approximately 60 percent of respondents attempted material substitution to reduce or eliminate one or more of the following materials: cadmium, chromium (hexavalent), cyanide, and chlorinated solvents.[13]

Some metal finishers recover precious or other metals on site (the number of facilities that conduct on-site recovery is not available). Other facilities ship F006 to recycling facilities to recover commercially valuable metals, or to RCRA permitted treatment and disposal facilities. Table 4 summarizes an array of pollution prevention measures that may be used in metal finishing operations.

Worker Health and Safety

As part of the benchmarking study, the workgroup collected information on F006 handling practices, identified the potential hazards to workers, and described possible hazard control methods. In addition, the workgroup developed a list of the current worker health and safety regulations and policies that may apply to on-site and off-site management of F006. This information is presented in Appendix C of this report. Beyond this information, the workgroup did not attempt to complete a comprehensive review of worker health and safety issues associated with F006 management.

This report presents data collected during the F006 Benchmarking Study as a foundation for further evaluation of F006. The CSI Workgroup did not attempt to analyze the data to determine the extent to which the characteristics of F006 have changed based on industry pollution prevention practices or other factors. In Phase 2 of this efort, the Workgroup will analyze the information presented in this report, and examine whether potential modifications of the current regulations applicable to F006 should be considered by EPA.

Table 4: Examples of Pollution Prevention Measures

Method	**Pollution Prevention Benefits**
Improved Operating Practices	

[13] NCMS/NAMF.   Pollution Prevention and Control Technology for Plating Operations. 1994.

Table 4: Examples of Pollution Prevention Measures	
Method	**Pollution Prevention Benefits**
Remove cadmium and zinc anodes from bath when it is idle. Anodes baskets can be placed on removable anode bars that are lifted from tank by an overhead hoist	• Eliminates cadmium/zinc buildup causing decanting of solution due to galvanic cell set up between steel anode basket and cadmium/zinc anodes • Maintains bath within narrow Cd/Zn concentration providing more predictable plating results
Eliminate obsolete processes and/or unused or infrequently used processes	• Reduces risks associated with hazardous chemicals • Creates floor space to add countercurrent rinses or other P2 methods • Creates safer and cleaner working environment
Waste stream segregation of contact and non-contact wastewaters	• Eliminates dilution of process water prior to treatment which can increase treatment efficiency • Reduces treatment reagent usage and operating costs
Establish written procedures for bath make-up and additions. Limit chemical handling to trained personnel. Keep tank addition logs	• Prevents discarding process solutions due to incorrect formulations or contamination • Improves plating solution and work quality consistency •Improves shop safety
Install overflow alarms on all process tanks to prevent tank overflow when adding water to make up for evaporative losses	• Minimizes potential for catastrophic loss of process solution via overflow • Prevents loss of expensive chemicals
Conductivity and pH measurement instruments and alarm system for detecting significant chemical losses	• Identifies process solution overflows and leaks before total loss occurs • Alerts treatment operators to potential upset condition • Reduces losses of expensive plating solutions
Control material purchases to minimize obsolete material disposal	• Reduces hazardous waste generation • Reduces chemical purchases
Use process baths to maximum extent possible before discarding. Eliminate dump schedules. Perform more frequent chemical analysis	• Prevents discarding of solutions prematurely • Reduces chemical costs • Chemical adjustments of baths will improve work quality
Reduce bath dumps by using filtration to remove suspended solids contamination	• Extends bath life • Reusable filter cartridges reduce solid waste generation • Improves bath performance
Deburring containment	• Segregates waste
Ultrafiltration, oil removal	• Removes contaminants from cleaning wastes, promotes recycling
Process/Chemical Substitution	
Substitute cyanide baths with alkaline baths when possible	• Eliminates use of CN
Substitute trivalent chromium for hexavalent chromium when product specifications allow.	• Reduces/eliminates use of hexavalent chromium

Table 4: Examples of Pollution Prevention Measures	
Method	**Pollution Prevention Benefits**
Eliminate use of cadmium plating if product specifications allow	• Eliminates the use of cadmium
Eliminate cyanide copper	• Eliminates use of CN
Introduce deposit substitutes: e.g., Zn-Ni alloy replaces cadmium	• Eliminates use of Cd
Drag-Out Reduction Methods that Reduce Waste Generation	
Install fog rinses or sprays over process tanks to remove drag out as rack/part exits bath	• Can inexpensively recover a substantial portion of drag out and does not require additional tankage
Minimize the formation of drag out by: redesigning parts and racks/barrels to avoid cup shapes, etc. that hold solution; properly racking parts; and reducing rack/part withdraw speed	•Reduces pollutant mass loading on treatment processes, treatment reagent usage, and resultant sludge generation • May improve treatment operation/removal efficiency • Reduces chemical purchases and overall operating costs
Introduction of barrel spray rinsing	• Reduces pollutant mass loading on treatment processes, treatment reagent usage, and resultant sludge generation
Automation control	• Reduces process error and process waste
Rinse Water Reduction Methods that Reduce Waste Generation	
Install flow restrictors to control the flow rate of water	• Reduces water use and aids in reducing variability in wastewater flow • Very inexpensive to purchase and install
Install conductivity or timer rinse controls to match rinse water needs with use	• Coordinates water use and production when properly implemented • Provides automatic control of water use
Use counter-current rinse arrangement with two to four tanks in series depending on drag out rate	• Major water reduction can be achieved • High impact on water bills • May reduce the size of needed recovery/treatment equipment
Track water use with flow meters and accumulators. Keep logs on water use for individual operations	• Identifies problem areas including inefficient processes or personnel • Helps management to determine cost for individual plating processes.
Install pulsed spray rinsing	• Reduced wastewater generation

Source: NCMS/NAMF. Pollution Prevention and Control Technology for Plating Operations. 1994

II. NATIONAL F006 BENCHMARKING STUDY APPROACH

A. Overview

The workgroup focused on three analytical questions to guide its work on characterizing current practices in the metal finishing industry, and the composition and management of F006:

1) What are the characteristics of F006?
2) What can metal finishers do to make F006 more recyclable, while optimizing pollution prevention? What pollution prevention measures are in place at metal finishing facilities?
3) What are the environmental impacts of F006 recycling?

While not an initial focus in this effort, the workgroup also examined worker health and safety impacts in this study.

The workgroup then designed a two year study methodology to address the three analytical objectives. The study methodology is discussed below.

The technical work required for this study was completed by Science Applications International Corporation under contract to EPA. The contract work was managed by an EPA workgroup member working in close coordination with the workgroup. The workgroup monitored progress and critiqued results throughout the analysis process.

B. Methodology

The workgroup designed a five part "benchmarking" study approach to address the three analytical questions identified above. A Quality Assurance Project Plan was developed and approved for this study and is available in a separate report[14]. The five portions of the study are summarized below and discussed in more detail in the remainder of this section. The five study portions include:

D. A "Regional Benchmarking Study" that involved site visits to 29 metal finishing shops in three cities to gather detailed data on plating processes, pollution prevention practices, F006 chemical analysis and F006 handling and management practices;

E. A "National Benchmarking Study" that used a mail survey to gather less detailed data on metal finishing operations, pollution prevention practices, F006 characteristics and management practices from a broad range of metal finishers;

[14] USEPA, Office of Solid Waste. Quality Assurance Project Plan For the Metal Finishing Industry. October, 1997.

- An analysis which evaluates the extent to which the regional and national benchmarking studies represent the universe of metal finishers.

- A Survey of Commercial Recycling Companies to gather data on the amount of F006 recycled and the chemical composition of F006 accepted for recycling, and

- A "Community Interest Group Phone Survey" to assess whether community groups in the vicinity of commercial recycling companies believe those companies are good environmental and/or economic neighbors.

Each of the above components of the study involved a series of analytical steps. The approach used to complete each study component is described below. The results are presented in Section III of this report.

1. Regional Benchmarking Study

The workgroup developed a method for identifying and gathering information from metal finishing companies that are judged to be "typical" facilities in the metal finishing universe.

The workgroup identified ten cities that are known to have high populations of metal finishing facilities. Milwaukee, Chicago, and Phoenix were chosen as cities which are representative of the metal finishing industry in terms of the processes they use and the industries they serve.

The workgroup agreed on a list of criteria for selecting facilities, and tried to include, as much as possible, a balanced distribution of the following criteria in making facility selections:

- Type of shop: captive/job,
- Size: number of employees,
- Type of deposition process in use,
- Pollution prevention technologies in use,
- In-house metal recovery technologies:
  -- counterflow rinse,
  -- ultrafiltration/microfiltration,
  -- other ion exchanges,
  -- electrolytic metal recovery,
  -- electrodialysis, or
  -- reverse osmosis; and
- F006 treatment technology:
  -- alkaline precipitation,
  -- offsite metals recovery,
  -- landfilling of F006,
  -- other.

The workgroup developed additional information regarding the third criteria listed above, "type of deposition process in use. The workgroup identified five plating processes which are among the most frequently used processes in the metal finishing industry. Studying facilities that operate these processes would provide the workgroup with key information about these common processes. The five processes included:

-Zinc (Zn) plated on steel,
-Nickel (Ni)/chromium (Cr) plated on steel, followed by plated on steel,
-Cu/Ni/Cr on non-ferrous alloys,
-Cu plating/stripping in the printed circuit industry, and
-Cr on steel.

These five processes are among the 25 most common processes identified in the NCMS/NAMF study (1994), and were the main criteria in selecting facilities in Milwaukee. Facility selection in Chicago began using the five processes, but resulted in a principal focus on facilities that operate copper/nickel/chromium electroplate on nonferrous processes, a plating process used by one-half of Chicago platers. Facility selection in Phoenix focused on obtaining data from metal finishers that serviced the printed circuit board and aerospace industries.

The workgroup identified a Point of Contact (POC) in each city. The POC and the workgroup identified 10 facilities and several alternates located in or near each of the three benchmarking cities that fit the criteria sought for each city and were willing to participate in the study. At their request, facilities remained anonymous to the workgroup throughout the selection and information gathering process. Facilities are identified as F1, F4, F11, etc.

A facility selection table was completed for each city (see Section IV), and the workgroup made its selections based on the criteria discussed above. An overview of facility selection for each city is discussed below.

Milwaukee: The POC gathered information on 15 facilities, from which the workgroup selected 10 facilities and three alternates. Each of the 10 facilities and three alternates was contacted to schedule a site visit for completing a profile of operations and waste sampling and analysis. Three of the 10 facilities were eliminated during the site visits because it was determined that their sludges are not F006, and the three alternates were added. The third alternate was subsequently eliminated because their sludge is excluded from the definition of F006. Consequently, only nine facilities were included in the Milwaukee benchmarking study.

Chicago: The POC in Chicago identified 14 metal finishers willing to participate in the study, from which the workgroup selected 10 and three alternates. Each of the ten facilities and alternates was contacted to schedule site visits.

Phoenix: The POC in Phoenix identified 13 metal finishers, from which the workgroup selected 10 facilities and three alternates. One facility was eliminated during the site visit because it plated every two months as a batch operation and no F006 sludge was available during the time of the study. An alternate site was added.

A survey was mailed to each facility to gather basic data from facility records (Appendix F contains a copy of the Regional Benchmarking Survey). On-site visits were completed to gather detailed data on metal finishing processes, pollution prevention practices, recycling practices, F006 quantities, and F006 handling and management practices (handling practices were recorded only in Chicago and Phoenix). The site visit information collection protocol is provided in Appendix D.

In addition to gathering information on plating processes, pollution prevention methods, F006 generation quantities and F006 management, a total of 46 composite samples of F006 were collected from the 29 facilities and transported to an EPA certified laboratory for chemical analysis and quality assurance methods. Two samples of F006 sludge were collected at some facilities (selected at random) as spot checks for variability in chemical content. All samples were analyzed for total concentrations of metals, TCLP metals, and general chemistry analytes. Four of the samples collected in Milwaukee were also analyzed for total volatile and semivolatile organic constituents, and TCLP volatile and semivolatile organic constituents, but since the results of the organic analysis in Milwaukee showed nondetectable levels in nearly all cases, no further organics testing was completed in the remaining two cities. See Appendix E for a list of all chemicals analyzed. The laboratory results were reviewed for accuracy and completeness and provided to each facility for review and comment.

2. National Benchmarking Study

The workgroup developed a survey for gathering data on metal finishing operations, pollution prevention practices, F006 characteristics and sludge management practices from a large sample of the universe of metal finishers. The data categories contained in the survey are similar to the regional benchmarking protocol, but less detailed. Appendix G contains the survey used for the National Benchmarking Study.

Nearly 2,000 surveys were distributed by mail using the mailing list of NAMF and AESF, and by hand at a metal finishers national technical conference. 186 responses (9 percent) were received. The data was compiled into a computer data base.

3. Statistical Analysis of the Regional and National Benchmarking Data

A chi-squares analysis was completed to determine the extent to which the facilities included in the regional and national benchmarking studies represent the universe of metal finishers for demographic parameters. Benchmarking results were compared to the universe of F006 generators in the Dunn & Bradstreet and EPA 1995 Biennial Report national databases. The results are presented in Section III.

4. Survey of Commercial Recyclers

The workgroup developed a survey to gather data from six commercial recycling companies believed to be representative of the commercial F006 recycling industry. The survey requested data on the amount and chemical composition of F006 they recycle. Few data were received. The results were inclusive and are not provided in this report. A copy of the Recyclers' Survey is contained in Appendix H.

5. Survey of Community Environmental Groups

A "community interest group phone survey" was developed by the workgroup to make a preliminary assessment of whether ten community groups community groups in the vicinity of commercial recycling companies believe those companies are good environmental and/or economic neighbors. In order to promote candid responses, the workgroup agreed that respondents could remain anonymous. Each group was asked the following questions:

- Is the group aware of environmental impacts from the recycling facility?
- Is the group aware of economic impacts from the recycling facility?
- Is the facility considered a "good neighbor?"

A summary of responses is provided in Section IV. Individual responses are provided in Appendix I.

III. RESULTS OF THE F006 BENCHMARKING STUDY

The Regional and National Benchmarking Studies produced a large body of current data concerning facility operations, pollution prevention activities, F006 generation and management, and F006 composition. Section A below presents summaries of the data. Section B presents the data in detail.

A. Summaries of Regional and National Benchmarking F006 Waste Characterization Data

1. Benchmarking Summary Tables

Table 5 summarizes the minimum, mean, median, and maximum analytical results for each chemical analyzed for each of the three cities. The values presented represent only clearly measurable laboratory results. Non-detected samples (i.e., samples below laboratory detection limits) and samples detected but below the laboratory quantitation limit (below the limit for accurate chemical measurement) are not included. Table 6 compares same statistics for the three cities to F006 waste composition data received in the National Benchmarking Survey. Table 7 summarizes the results of the National Survey.

2. Statistical Analysis: Does this Data Come from "Typical" Metal Finishers?

Statistical analyses are often used to determine the extent to which a sample selected from a population represents the larger population from a statistical perspective, require carefully designed sample selection and testing procedures, and are generally time consuming and expensive. Because of its specialized design (i.e., to provide the workgroup with a highly descriptive set of data from metal finishing facilities which run the most "typical" plating processes in the industry), the workgroup was limited in its abililty to compare Benchmarking data to other databases which contain information on the metal finishing universe. Notwithstanding the specialized design of the Benchmarking study, the workgroup completed a statistical comparison of Benchmarking results to two national databases which contain some information on the metal finishing universe.

The analysis used a chi-squares statistical method to compare the only three parameters (facility size and location, and the amount of F006 waste generated) contained in the benchmarking studies and in other national databases which contain information on metal finishing facilities, i.e., the Dun & Bradstreet (D&B) business/economic database and EPA's 1995 Biennial Reporting System (BRS) database. The analysis results show that the facilities participating are not necessarily representative of the universe of metal finishers. It is possible that a larger number of participants in the Benchmarking Studies or a different mix of participants could have provided results that show a more direct relationship between Benchmarking and national data (D&B and BRS). This result does not diminish the value of the Benchmarking study. The Benchmarking Study provides substantial additional data characterizing the industry's wastestream and provides a sound starting point for further discussion.

3. Results of Commercial Recyclers and Citizen Group Surveys

The workgroup received too few responses to the commercial recyclers survey to draw any conclusions. Responses to the citizen group brief phone interviews received nearly complete responses and revealed no significant adverse opinions regarding whether these facilities are perceived as good environmental and economic neighbors. The results of the citizen group phone survey is summarized Appendix I.

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Table 7: F006 Analytical Data from the National Survey: Excludes non-detects and includes only values above method quantitation limit. 70 of 186 respondents submitted characterization data.					
Constituent	**# of Reported Detections**	**Minimum**	**Mean**	**Median**	**Maximum**
Total Metals (mg/kg)					
Aluminum (Al)	34	0.59	13,387.89	1,725.00	76,100.00
Antimony (Sb)	22	1.80	2,188.23	67.40	34,800.00
Arsenic (As)	35	2.00	489.67	10.00	8,780.00
Barium (Ba)	38	6.00	199.27	73.70	1,080.00
Beryllium (Be)	20	0.59	12.55	8.50	37.00
Bismuth (Bi)	7	2.10	50.86	29.00	398.00
Cadmium (Cd)	39	2.10	6,122.32	22.00	71,300.00
Calcium (Ca)	28	682.00	37,239.28	17,250.00	143,000.00
Chromium (Cr)	60	10.00	39,601.20	13,900.00	206,000.00
Copper (Cu)	51	33.60	55,474.35	10,620.00	631,000.00
Iron (Fe)	38	364.00	82,420.74	48,950.00	560,000.00
Lead (Pb)	47	5.00	5,754.10	346.00	175,000.00
Magnesium (Mg)	14	187.00	48,798.09	10,800.00	336,000.00
Manganese (Mn)	28	13.00	830.91	563.00	3,300.00
Mercury (Hg)	30	0.05	0.39	0.30	2.00
Nickel (Ni)	44	51.00	23,456.33	5,935.00	180,000.00
Selenium (Se)	35	1.900	7.86	6.50	16.60
Silver (Ag)	30	1.50	169.64	87.50	1,190.00
Sodium (Na)	9	25.00	18,458.37	11,000.00	89,200.00
Tin (Sn)	28	9.00	20,906.06	1,100.00	467,000.00
Zinc (Zn)	48	57.00	88,692.44	24,600.00	460,000.00
TCLP (mg/l)					
Arsenic (As)	17	ND	ND	ND	ND
Barium (Ba)	16	0.26	1.29	1.45	2.20
Cadmium (Cd)	18	0.02	8.36	0.11	144.00
Chromium (Cr)	20	0.02	9.48	0.92	56.20
Lead (Pb)	18	0.06	113.97	0.13	1,630.00
Mercury (Hg)	15	0.001	0.005	0.005	0.011
Selenium (Se)	16	0.08	0.08	0.08	0.08
Silver (Ag)	17	0.01	0.67	0.06	3.80
General Chemistry (mg/kg)					
Chloride (Cl)	20	64	8,035.09	2,225.00	70,100.00
Fluoride (F)	13	1.2	719.06	161.00	4,240.00
Chromium, hex	15	0.1	108.89	11.00	1,190.00
Cyanide, Total (CN)	25	0.8	692.47	114.50	3,920.00
Cyanide, Am (CN)	11	2.6	609.56	51.00	5,340.00
Percent Solids		13.5	37.65	30.80	94.10

B. Detailed Results of the Regional and National Benchmarking Studies

This section provides the detailed results of data gathering for the Regional and National Benchmarking Studies.

1. The Milwaukee Benchmarking Study

This section provides a detailed presentation of data gathered in the Milwaukee Benchmarking Study (MBS), including a characterization of plating processes, pollution prevention and recycling practices, F006 characteristics, and site specific variations in the generation and management of F006 for nine facilities in Milwaukee. Table 8 is the facility selection matrix used to select 10 facilities from 13 candidates. Table 9 presents information collected for each facility in the study. Table 10 summarizes the results of the laboratory analyses of F006 data and Table 11 presents detailed laboratory analysis results for each facility.

Six of the nine facilities reported waste generation rates. The total reported waste quantity for Milwaukee is approximately 590.5 tons/year. Four facilities reported landfilling their F006 waste while four facilities reported recycling their F006 wastes. One facility sent half of its F006 waste to landfills, and the other half to commercial recycling. Sixteen laboratory samples were gathered from nine facilities. Four of these samples were for organic chemicals.

Table 8: Milwaukee Metal Finishing Facility Selection Matrix

Selection Criteria	Fac 1* (Selected)	Fac 2* (Selected)	Fac 3* (Alternate)	Fac 4 (Selected)	Fac 5 (Selected)	Fac 6	Fac 7	Fac 8 (Selected)	Fac 9 (Selected)
Type: Captive/Job	Job	Job	Job	Captive	Job	Captive	Job	Job	Job
Size	16	152	95	2000/20	50	900/30	160	35	180
Main Treatment Technology	Alk/ PPT	Other - Al reuse	Alk/ PPT	Alk/ PPT	Alk/ PPT Off IX	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT
Treatment Technology	CFR	CFR EMR	CFR	CFR Vacuum & Evp.	CFR	CFR	CFR	Other	Other CFR IX
Onsite Recycle	No	No	No	25%	No	No	60%	No	95%
Landfill	100%	No	100%	Yes	Yes	5%	40%	100%	5%
Main Mgmt. Method	LF	Recycle	LF	LF	LF	95% Rec	Recycle	LF	Recycle
Finishing Processes	Zn/Fe	Cu	Zn/Fe	Zn/Fe HCr/Al Ni/Cr	HCr Cu/Ni/Cr Ni/Cr Zn/Fe	Zn/Fe Zn/Br	Zn/Fe Cu/Ni/Cr/Fe	HCr & EN	Zn/Fe NiCr Cu/Ni/Cr HCr

* Eliminated because they do not generate F006.

Key:

Alk/PPT	Alkaline precipitation
IX	Ion exchanges
Ultra	Ultrafiltration/Microfiltration
CFR	Counterflow rinse
EMR	Electrolytic metal recovery
ED	Electrodialysis
RO	Reverse osmosis
Zn/Fe	Zinc electroplate on steel
Ni/Cr	Nickel chromium Electroplate on steel
Cu/Ni/Cr	Copper nickel chromium on nonferrous
Cu	Copper/PC bands
HCr	Hard chromium on steel

Milwaukee Metal Finishing Facility Selection Matrix (cont.)									
Selection Criteria	**Fac 10* (Alternate)**	**Fac 11 (Alternate)**	**Fac 12**	**Fac 13 (Selected)**	**Fac 14 (Selected)**	**Fac 15**	**Fac 16 (Selected)**	**Fac 17 (Selected)**	**Fac 18**
Type: Captive/Job	Job	Job	Job	Job	Job	Captive	Captive	Captive	Job
Size	40	50-60	15	70	110	700/14	500/90	1550/37	35
Main Treatment Technology	Alk/PPT	Alk/PPT	Offsite other	Offsite other	Alk/PPT	Alk/PPT offsite	Alk/PPT	Alk/PPT	Alk/PPT
Treatment Technology	CFR other	CFR Evap	CFR IX other	CFR IX other	CFR other	CFR EMR Ultra	IX CFR	CFR RO IX EMR Other	CFR IX
Onsite Recycle	No	Yes	Yes	Yes	95%	Yes	No	Yes	20%
Landfill	Yes	No	No	No	5%	Yes	Yes	Yes	20%
Main Mgmt. Method	LF	Recycle	Recycle	Recycle	Recycle	LF	LF	LF	80% Rec
Finishing Processes	Zn/Fe	Cu Ni Cr Zn Sn Ag	Ni/Cr	Ni/Cr	Zn/Fe	Dupl Ni Brite Ni Hex Cr	Ni/Cr /Br	Zn/Fe	HCr Ni

* Eliminated because they do not generate F006.

Key:

Alk/PPT	Alkaline precipitation
IX	Ion exchanges
Ultra	Ultrafiltration/Microfiltration
CFR	Counterflow rinse
EMR	Electrolytic metal recovery
ED	Electrodialysis
RO	Reverse osmosis
Zn/Fe	Zinc electroplate on steel
Ni/Cr	Nickel chromium Electroplate on steel
Cu/Ni/Cr	Copper nickel chromium on nonferrous
Cu	Copper/PC bands
HCr	Hard chromium on steel

Table 9: Facility-Specific Information for Milwaukee Facilities
Facility F4

Plating Process	F006 Quantity and Management	Sample Description
Nickel-chrome on Aluminum Zinc (non-CN) on Steel Decorative nickel-chrome on Steel	146 tons/yr Landfill	<u>F1-01</u> - Sludge sample collected directly from drop bin <u>F1-02</u> - Sludge collected from supersack dated the previous month

Pollution Prevention Practices

<u>SPENT PLATING SOLUTIONS</u>
Implementation of high temperature zinc baths to eliminate partial bath dumps
Replaced hexavalent Cr with Trivalent Cr on decorative Cr line
Elimination of all cyanide plating baths
Substitution of chromate and dichromate seal with non-chrome sealer
Constant development of alternative plating technologies
Filtration on nickel recovery unit
Electrolytic dummying
Precipitation and monitoring of spent plating solutions
Uses purer anodes and bags
Tooling attention/maintenance on scrubbers
Evaporation techniques on nickel portion of chrome line
Chemical usage reduction through substitution - replaced hard chrome with decorative chrome
Oil removal techniques

<u>DRAG-OUT REDUCTION</u>
Enhanced product hang times
Uses wetting agents occasionally
Drainage boards
Strategic workpiece positioning
Withdrawal and drainage time
Diking

<u>RINSEWATER</u>
Counter-current flow rinse systems for 1 plating line
Flow restrictors done with weirs
Use conductivity meters to monitor the quality of final rinses
Reuse electrocleaner rinse water as dilute plating bath solution
Reuse acid rinse waters for rinsing racks exiting soak cleaner
Evaporative recovery of Ni rinse waters
Closed-loop wastewater systems on Ni and Hex. Cr lines

<u>OTHER</u>
Chemical inventory and control
Conducts annual plant assessments and housekeeping
Preventive maintenance systems
Increased temperature of bath
Product longevity through specification alteration

Sample Characteristics (Dry wt.)

F1 - 01	**F1 - 02**
<u>Total</u> (mg/kg)	<u>Total</u> (mg/kg)
Al - 31,200	Al - 17,300
Sb - 5.5	Sb - 1.8
As - 9.9	As - 9.3
Ba - 41.9	Ba - 34.3
Be - ND	Be - ND
Bi - 2.7	Bi - 3.3
Cd - 7.5	Cd - 9.6
Ca - 24,800	Ca - 17,500
Cr - 59,500	Cr - 64,900
Hex. Cr - 0.6	Hex. Cr - 0.6
Cu - 130	Cu - 1,480
Fe - 25,000	Fe - 27,700
Pb - 297	Pb - 366
Mg - 15,800	Mg - 17,400
Mn - 1,710	Mn - 399
Hg - 2	Hg - ND
Ni - 19,900	Ni - 18,200
Se - 16.6	Se - 16
Ag - 267	Ag - 97.9
Na - 8,360	Na - 21,700
Sn - 404	Sn - 582
Zn - 336,000	Zn - 335,000
CN - ND	CN - ND
<u>TCLP</u> (mg/l)	<u>TCLP</u> (mg/l)
As - ND	As - ND
Ba - 0.3	Ba - 1.4
Cd - 0.04	Cd - 0.1
Cr - 40.6	Cr - 56.2
Pb - ND	Pb - 0.1
Hg - ND	Hg - ND
Se - ND	Se - ND
Ag - 0.05	Ag - ND

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities
Facility F5

Plating Process	**F006 Quantity and Management**	**Sample Description**
Zinc (non-CN) on steel Cu/Ni/Cr on steel Nickel chrome on steel Nickel plating Hard chrome on steel	42.5 tons/yr Recycle (Horsehead)	F5-01 - Collected from sludge drier F5-02 - Collected from rolloff bin accumulated ~1 month previously

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
SPENT PLATING SOLUTION	**F5 - 01**	**F5 - 02**
Copper and nickel strips are sent out in liquid form for recycling reducing quantity of F006	Total (mg/kg)	Total (mg/kg)
Filtration, carbon treatment, replenishment, and electrolytic dummying for bath life extension	Al - 3,690	Al - 1,710
Replaced cyanide zinc plating with zinc alkaline plating	Sb - 67.4	Sb - 45
Planning to change to non-cyanide copper plating in 1997.	As - 15.4	As - 18.3
Oil removal techniques on pre-cleaning line	Ba - 843	Ba - 157
Chemical usage reduction through automated addition of brightener	Be - 0.6	Be - 0.7
Product longevity through specification alteration	Bi - 2.1	Bi - 3.2
Alternate stripping methodologies - replaced cyanide solution with non-cyanide solution to strip nickel	Cd - 9.6	Cd - 13.4
	Ca - 21,400	Ca - 23,200
DRAG OUT REDUCTION/RECOVERY	Cr - 92,000	Cr - 71,000
Mesh pad Mist eliminators on 2 of 3 chrome lines for drag-out recovery	Hex. Cr - 0.6	Hex. Cr - 0.1
Enhanced product hang times	Cu - 39,900	Cu - 41,500
New plating barrel reduces drag out	Fe - 92,100	Fe - 105,000
Increase drain time over process tanks	Pb - 976	Pb - 556
Drag out tanks and counter-current flow used where feasible.	Mg - 13,000	Mg - 12,500
Increased withdrawal and drainage time	Mn - 1,200	Mn - 1,340
Uses wetting agents	Hg - 0.3	Hg - 0.26
Strategic workpiece positioning	Ni - 104,000	Ni - 105,000
Spray rinses	Se - 10.6	Se - 11.5
	Ag - 8.7	Ag - 3.4
RINSEWATER	Na - 5,950	Na - 6,830
Flow restrictors	Sn - 429	Sn - 337
Spray rinsing on 1 line	Zn - 126,000	Zn - 158,000
	CN - 700	CN - 900
OTHER		
Tooling attention/maintenance	TCLP (mg/l)	TCLP (mg/l)
Waste collection plumbing alterations or improvements	Ar - ND	As - ND
Diking	Ba - 1.7	Ba - 2.2
Energy savings techniques	Cd - 0.05	Cd - 0.1
Conducts annual plant assessments and plant housekeeping	Cr - 27.2	Cr - 12.1
	Pb - ND	Pb - ND
	Hg - ND	Hg - ND
	Se - ND	Se - ND
	Ag - ND	Ag - ND

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities
Facility F8

Plating Process	**F006 Quantity and Management**	**Sample Description**
Hard Chrome on Steel	unreported Landfill	F8-01 - Collected from supersack dated that week F8-02 - Collected from supersack dated the previous month

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
SPENT PLATING SOLUTION Ion exchange resin system - echo-tec DRAG OUT REDUCTION/RECOVERY Strategic workpiece positioning OTHER Annual plant assessments Diked tanks High efficiency lighting Plant Housekeeping Preventive Maintenance systems Installed waste collection hard piping to control chemicals Tooling maintenance once per year	**F8-01** Total (mg/kg) Al - 19,300 Sb - 161 As - 5.5 Ba - 83.4 Be - ND Bi - ND Cd - 10.1 Ca - 67,400 Cr - 193,000 Hex. Cr - 0.4 Cu - 24,500 Fe - 110,000 Pb - 858 Mg - 9,710 Mn - 1,360 Hg - ND Ni - 1,130 Se - ND Ag - ND Na - 19,600 Sn - 129 Zn - 3,790 CN - ND TCLP (mg/l) As - ND Ba - 0.3 Cd - 0.01 Cr - 54.1 Pb - 0.1 Hg - N D Se - ND Ag - ND	**F8-02** Total (mg/kg) Al - 8,560 Sb - 110 As - 11.8 Ba - 33.3 Be - ND Bi - ND Cd - 42.7 Ca - 50,800 Cr - 91,500 Hex. Cr - 0.2 Cu - 41,100 Fe - 279,000 Pb - 231 Mg - 11,100 Mn - 1,080 Hg - 1.2 Ni - 744 Se - ND Ag - ND Na - 49,400 Sn - 96.3 Zn - 9,610 CN - ND TCLP (mg/l) As - ND Ba - 0.7 Cd - 0.3 Cr - 12.8 Pb - ND Hg - 0.005 Se - ND Ag - ND

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities
Facility F9

Plating Process	F006 Quantity and Management	Sample Description
Chrome on aluminum Bright dip on brass Copper, nickel, chrome on steel Hard chrome on steel Nickel chrome on nonferrous Zinc (non-CN) on steel	150 tons/yr Recycle (Encycle/Horsehead 97%) Landfill (3%)	F9-01 - Collected from supersack loaded that day F9-02 - Collected by facility about 2 weeks later

Pollution Prevention Practices	Sample Characteristics (Dry wt.)	
SPENT PLATING SOLUTION Eliminated cadmium plating line Replace some hexavalent chrome lines with trivalent chrome Utilizes filtration carbon treatment, replenishment, and electrolytic dummying for general bath life extension Uses precipitation, monitoring, carbonate agitation, and electrowinning on spent solutions Uses evaporative techniques on nickel plating bath Chemical usage reduction through automation and substitution Increased temperature of bath DRAG OUT REDUCTION/RECOVERY Drag out and counter-current flow rinse systems Ion exchange systems Evaporation and Mesh pad mist eliminators for drag-out recovery Spray rinsing and drag-out tankage Enhanced product hang times Withdrawal and drainage time Uses wetting agents and drainage boards Spray rinses only on nickel boards Utilizes strategic workpiece positioning RINSEWATER Implemented a strict control program for monitoring incoming water to each separate production line Company-wide water conservation program (e.g., spray rinses, flow restrictors water meters, etc.) Use spent acid bath for pH adjustment in WWT Reuse treated wastewater in production lines Replaced solvent-based washers with aqueous systems (increasing sludge generation) Flow restrictors OTHER Use sludge dryer to reduce sludge volume and transportation costs Reduced cyanide use by 80% Conduct annual training for waste treatment operators on chemical use and how this affects sludge volumes Tooling attention/maintenance Chemical inventory and control Waste collection plumbing alterations or improvements Diking Incorporated energy savings techniques Conducts annual plant assessments and housekeeping Uses preventive maintenance systems	**F9-01** Total (mg/kg) Al - 27,000 Sb - 5.4 As - 4.8 Ba - 298 Be - ND Bi - 72.5 Cd - 2.1 Ca - 87,000 Cr - 28,200 Hex. Cr - 29 Cu - 20,700 Fe - 105,000 Pb - 439 Mg - 44,300 Mn - 1,070 Hg - 0.35 Ni - 14,800 Se - 1.9 Ag - 65 Na - 15,900 Sn - 1,100 Zn - 67,200 CN - 46 TCLP (mg/l) As - ND Ba - 1.1 Cd - ND Cr - 0.9 Pb - ND Hg - ND Se - ND Ag - ND	**F9-02** Total (mg/kg) Al - 13,200 Sb - 13.5 As - 3.1 Ba - 257 Be - ND Bi - 31.5 Cd - 17.3 Ca - 70,000 Cr - 94,000 Hex. Cr - 1,000 Cu - 15,000 Fe - 80,800 Pb - 410 Mg - 30,300 Mn - 1,170 Hg - 0.6 Ni - 18,700 Se - ND Ag - 230 Na - 39,000 Sn - 681 Zn - 83,900 CN - 74 TCLP (mg/l) As - ND Ba - 0.8 Cd - ND Cr - 13.1 Pb - ND Hg - ND Se - 0.04 Ag - ND

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities Facility F11		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Zinc (non-CN) on steel Tin on non-ferrous and steel Nickel-chrome plating Copper-nickel on steel	unreported Recycle (Encycle)	F11-01 - Collected from sludge drier F11-02 - Collected from supersack dated the previous month

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
SPENT PLATING SOLUTION	**F11 - 01**	**F11-02**
Eliminated cyanide cadmium plating	Total (mg/kg)	Total (mg/kg)
Replaced zinc cyanide plating with zinc alkaline plating	Al - 1,800	Al - 1,650
Spent alkaline baths are used for pH adjustment	Sb - 14.2	Sb - 11.1
Oil removal techniques	As - 13	As - 6.5
Chemical usage reduction through substitution	Ba - 227	Ba - 159
Utilizes filtration, carbon treatment, replenishment, and electrolytic dummying	Be - ND	Be - ND
	Bi - 1.7	Bi - 1.8
	Cd - 12.5	Cd - 7.3
DRAG OUT REDUCTION/RECOVERY	Ca - 16,100	Ca - 14,800
Drag out recovery on chrome and nickel lines	Cr - 31,100	Cr - 48,100
Enhanced product hang times	Hex. Cr - 26	Hex. Cr - 0.4
Installed atmospheric evaporators on automatic chrome line for drag out recovery	Cu - 8,980	Cu - 11,300
	Fe - 58,800	Fe - 69,300
Wetting agents and drainage boards	Pb - 527	Pb - 230
Strategic workpiece positioning	Mg - 13,500	Mg - 13,700
Increase in withdrawal and drainage time	Mn - 557	Mn - 707
	Hg - ND	Hg - 0.3
RINSEWATER	Ni - 180,000	Ni - 84,600
Counter-current flow rinse systems	Se - 7.3	Se - 5
Monitors solutions and uses purer anodes and bags	Ag - 163	Ag - 657
Utilizes exit spray rinse	Na - 22,700	Na - 84,300
Uses atmospheric and simple evaporation techniques	Sn - 3,550	Sn - 8,070
Flow restrictors	Zn - 129,000	Zn - 94,400
Conductivity controls	CN - 16	CN - 6.6
OTHER	TCLP (mg/l)	TCLP (mg/l)
Installed sludge drier to reduce sludge volume	As - ND	As - ND
Train staff on causes of increase in hazardous waste production	Ba -1.3	Ba - 0.11
Tooling attention/maintenance	Cd - 0.1	Cd - 0.64
Chemical inventory and control	Cr - 3.1	Cr - ND
Waste collection alterations or improvements	Pb - ND	Pb - ND
Diking	Hg - ND	Hg - ND
Product longevity through specification alteration	Se - ND	Se - ND
Energy saving techniques	Ag - ND	Ag - 0.08
Plant housekeeping and annual plant assessment		
Automatic leak detection system		
Preventive maintenance system		

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities Facility F13		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Nickel chrome on steel	15 tons/yr Recycle (Inmetco)	F13-01 - did not meet the regulatory definition of F006 F13-02 - Collected from sludge supersack
Pollution Prevention Practices		**Sample Characteristics** (Dry wt.)
SPENT PLATING SOLUTION Oil removal and filtration techniques Promote product longevity through specification alteration Uses alternate stripping methodologies - switched from cyanide to non-cyanide stripping Evaporation to concentrate plating by-products Substituted hexavalent chrome with trivalent chrome Set up pilot line to evaluate a liquid addition agent for cleaning Require operators to log plating parameters daily which improves their control Uses purer anodes and bags and fume suppressors DRAG OUT REDUCTION/RECOVERY Enhanced product hang times Wetting agents Air knives Spray or fog rinses Drainage boards Increased withdrawal and drainage time Strategic workpiece positioning RINSEWATER Other than cooling water and water used to process incoming water, this is a zero discharge facility (from the process units) Rinse water is recycled through filtration, carbon absorption in waste treatment section, replenishment and ion exchange Counter-current flow rinse systems Utilizes electrocoagulation for cleaning (and reusing) rinse waters Flow restrictors Reverse osmosis utilized on incoming water OTHER Tooling attention/maintenance, preventive maintenance systems Improved record keeping demonstrates areas to be considered for improvement Installed filter press and sludge drier to reduce sludge volume Chemical inventory and control Waste collection plumbing alterations or improvements Diking High efficiency lighting Conducts annual plant assessments and plant housekeeping		**F13-02** Total (mg/kg) Al - 311 Sb - 0.6 As - 2.3 Ba - 6 Be - ND Bi - ND Cd - ND Ca - 855 Cr - 193 Hex. Cr - 0.5 Cu - 33.6 Fe - 3,350 Pb - 0.6 Mg - 355 Mn - 3.8 Hg - ND Ni - 76,000 Se - ND Ag - ND Na - 16,400 Sn - 9.0 Zn - 6.1 CN - 2.0

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities Facility F14		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Zinc (CN) on Steel	196 tons/yr Recycle (Horsehead 58%) Landfill (42%)	F14-01 - Sludge from drier output
Pollution Prevention Practices		**Sample Characteristics** (Dry wt.)
SPENT PLATING SOLUTIONS Separated the process chemistry and wastewater treatment departments Cyanide bath carbonate freezing to prolong life Utilize bags on 1 chloride bath Oil removal techniques on 1 barrel DRAG-OUT REDUCTION Workpiece positioning Increase dwell (rinse) cycles Wetting Agents Prolonged withdrawal and drainage time Drainage boards RINSEWATER Counter-current flow rinse systems Flow restrictors Spray rinse and multiple rinses Evaporators and filters on 3 of 4 baths Larger hole barrels Use alkaline cleaner baths for wastewater pH adjustment Sludge dryer reduces volume by 65%. Assessed source by source water use to eliminate major changes in flow which upsets WWT performance Employed an environmental engineering company to assist in water control and reduction. OTHER Eliminated several plating services: cadmium, nickel, hard chrome, tin, copper, and brass plating and aluminum anodizing Replacing CN baths with alkaline baths by end of 1997. Diking of all 4 production lines Plant Housekeeping Annual plant assessments Hazardous waste leak detection system Preventive maintenance system Installed waste collection hard plumbing on every machine		**F14 - 01** Total (mg/kg) / TCLP (mg/l) Al -2,320 / As - ND Sb - 2 / Ba - 1.3 As - 13.4 / Cd - 0.03 Ba -29.2 / Cr - 0.2 Be - ND / Pb - ND Bi -ND / Hg - ND Cd - 3.9 / Se - ND Ca -18,000 / Ag - ND Cr -26,900 Hex. Cr - 2.6 Cu - 54.6 Fe - 194,000 Pb - 64.8 Mg - 9,990 Mn - 979 Hg - ND Ni - 57.1 Se - 5.7 Ag - 4.4 Na - 3,830 Sn - 19.5 Zn - 277,000 CN - 200

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities
Facility F16

Plating Process	F006 Quantity and Management	Sample Description
Nickel chrome on non-ferrous Gold plating	41 tons/yr Landfill	F16-01 - Collected from supersack dated that day F16-02 - Collected by facility about 2 weeks later

Pollution Prevention Practices	Sample Characteristics (Dry wt.)	
	F16-01	**F16-02**

Pollution Prevention Practices	F16-01	F16-02
SPENT PLATING SOLUTION	**F16-01**	**F16-02**
Filtration	Total (mg/kg)	Total (mg/kg)
Improved SOPs by tracking water flow reducing the level of chrome in the hot rinse >90%	Al - 3,940 Sb - 3.5	Al - 1,210 Sb - 2.7
Leak detection systems on plating bath	As - 9.4	As - 7
Metals recovery system via ion exchange reclaims Cr and Ni from rinse waters	Ba - 73.7 Be - ND	Ba - 24.5 Be - ND
Oil removal techniques on pre-cleaning line	Bi - 5.4	Bi - 2.2
	Cd - 1.3	Cd - 1.3
DRAG OUT REDUCTION/RECOVERY	Ca - 97,300	Ca - 105,000
Conductivity meters	Cr - 13,800	Cr - 5,520
Rack design eliminates drag out	Hex. Cr - 0.2	Hex. Cr - 0.1
Enhanced product hang times on pre-cleaning line	Cu - 13,600	Cu - 5,520
Wetting agents on chrome line	Fe - 114,000	Fe - 189,000
Spray rinses and drainage boards	Pb - 2,870	Pb - 778
	Mg - 10,400	Mg - 4,250
RINSEWATER	Mn - 671	Mn - 950
Counter-current flow rinsing on plating and pre-cleaning lines	Hg - 0.4	Hg - ND
Flow restrictors	Ni - ND	Ni - ND
Spray rinsing on some pre-cleaning lines	Se - 30,700	Se - 16,800
Replaced solvent-based washers with aqueous systems (increasing sludge generation)	Ag - 47.4 Na - 5,490	Ag - 20.2 Na - 7,900
Continually searching for new environmentally safe cleaners	Sn - 497	Sn - 50.8
	Zn - 14,200	Zn - 5,790
OTHER	CN - ND	CN - ND
Operators are certified and receive on-going training		
Tooling attention/maintenance	TCLP (mg/l)	TCLP (mg/l)
Chemical inventory and control	As - ND	As - ND
Diking	Ba - 0.9	Ba - 0.2
Utilize high efficiency motors	Cd - 0.03	Cd - ND
Conduct annual plan assessments	Cr - 14.5	Cr - 12.7
Ongoing plant housekeeping and chemical usage reduction	Pb - 0.3	Pb - 1.3
Preventive maintenance systems	Hg - 0.005	Hg - 0.01
Employ monitoring and utilize bags	Se - ND	Se - ND
	Ag - ND	Ag - 0.04

Table 9 (cont'd): Facility-Specific Information for Milwaukee Facilities Facility F17		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Zn (non-CN) on steel Chrome on nonferrous Copper-nickel on nonferrous Copper-nickel on steel Cadmium on steel	unreported Landfill	<u>F17-01</u> - Collected from sludge drier <u>F17-02</u> - Collected from supersack dated the previous month

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
<u>SPENT PLATING SOLUTION</u> Uses vapor recompression evaporation and carbonate removal system for recovery Employs filtration, carbon treatment, replenishment, and electrolytic dummying Utilizes cyanide bath carbonate freezing to extend life of solution Reduced 50% of cadmium to zinc Oil removal techniques on pre-cleaning line Alternate stripping methodologies - formerly used cyanide based stripper; but now outsourced <u>DRAG OUT REDUCTION/RECOVERY</u> Uses stagnant rinse tanks or drag out tanks Drag out waters replace drag in waters or added back to plating bath Spray rinses and diking Enhanced product hang times Utilizes wetting agents and drainage boards Increased temperature bath, withdrawal and drainage time <u>RINSEWATER</u> Segregate wastewater streams Counter-current flow rinse systems Flow restrictors Conductivity meters Uses reverse osmosis (3 units) and atmospheric and vacuum distillation evaporation to recycle rinse waters Ion exchange for water delivered to plating baths <u>OTHER</u> Planning to re-engineer the WWT to segregate the nickel sludge from the cadmium sludge to enable recycling of the nickel sludge to Encycle. Cadmium sludge will be landfilled. Chemical inventory and control Redesigned waste plumbing Utilizes energy saving techniques Conducts annual plant assessments and weekly plant housekeeping Preventive maintenance systems and leak detection on reverse osmosis equipment	**F17-01** <u>Total</u> (mg/kg) Al - 1,260 Sb - 0.6 As - 3.8 Ba - 29.4 Be - ND Bi - ND Cd - 39,300 Ca - 141,000 Cr - 14,000 Hex. Cr - 19 Cu - 21,900 Fe - 24,300 Pb - 221 Mg - 12,900 Mn - 244 Hg - ND Ni - 83,000 Se - 2.1 Ag - 0.5 Na - 11,700 Sn - 11.2 Zn - 35,500 CN - 380 <u>TCLP</u> (mg/l) As - ND Ba - 1.3 Cd - 13.3 Cr - ND Pb - ND Hg - ND Se - 0.01 Ag - ND	**F17-02** <u>Total</u> (mg/kg) Al - 1,360 Sb - 0.6 As - 4.1 Ba - 43.5 Be - ND Bi - ND Cd - 21,600 Ca - 140,000 Cr - 9,250 Hex. Cr - 3.7 Cu - 18,600 Fe - 17,400 Pb - 237 Mg - 12,300 Mn - 199 Hg - 0.12 Ni - 35,100 Se - 2.1 Ag - 1.5 Na - 17,700 Sn - 13.8 Zn - 44,600 CN - 99 <u>TCLP</u> (mg/l) As - ND Ba - 1.1 Cd - 5.7 Cr - ND Pb - ND Hg - ND Se - ND Ag - ND

Table 10: Overview of Milwaukee F006 Analytical Data: # of Samples Which Were: Not-Detected; "C" values (i.e., Statistically Estimated Values Above Instrument Detection Limit, but Below Method Quantitation Limit); Above MethodQuantitation Limit				
Constituent	# Samples	# Non Detects	# Samples Above Instrument Detection, Below Method Quantitation	# Samples Above Method Quantitation Limit
Total Metals Concentration (mg/kg)				
Aluminum	16	0(0%)	0(0%)	16(100%)
Antimony	16	0(0%)	6(37%)	10(63%)
Arsenic	16	0(0%)	2(12%)	14(88%)
Barium	16	0(0%)	3(19%)	13(81%)
Beryllium	16	14(87%)	0(0%)	2(13%)
Bismuth	16	6(37%)	3(19%)	7(44%)
Cadmium	16	1(6%)	2(12%)	13(82%)
Calcium	16	0(0%)	0(0%)	16(100%)
Chromium	16	0(0%)	0(0%)	16(100%)
Copper	16	0(0%)	0(0%)	16(100%)
Iron	16	0(0%)	0(0%)	16(100%)
Lead	16	0(0%)	1(6%)	15(94%)
Magnesium	16	0(0%)	0(0%)	16(100%)
Manganese	16	0(0%)	1(6%)	15(94%)
Mercury	16	6(37%)	4(25%)	6(37%)
Nickel	16	2(12%)	0(0%)	14(88%)
Selenium	16	2(12%)	0(0%)	12(75%)
Silver	16	3(37%)	1(6%)	12(75%)
Sodium	16	0(0%)	0(0%)	16(100%)
Tin	16	0(0%)	0(0%)	16(100%)
Zinc	16	0(0%)	1(6%)	15(94%)
TCLP (mg/l)				
Arsenic	16	16(100%)	0(0%)	0(0%)
Barium	16	0(0%)	12(75%)	4(25%)
Cadmium	16	4(25%)	4(25%)	8(50%)
Chromium	16	2(12%)	0(0%)	14(88%)
Lead	16	12(75%)	0(0%)	4(25%)
Mercury	16	13(81%)	0(0%)	3(19%)
Selenium	16	14(87%)	1(6%)	1(6%)
Silver	16	12(75%)	3(19%)	1(6%)
General Chemistry (mg/kg)				
Chloride	16	0(0%)	0(0%)	16(100%)
Fluoride	16	0(0%)	1(6%)	15(94%)
Chromium, hexavalent	16	0(0%)	0(0%)	16(100%)
Total Cyanide	16	4(25%)	0(0%)	12(75%)
Amenable Cyanide	16	4(25%)	0(0%)	12(75%)
Percent Solids	16	0(0%)	0(0%)	16(100%)

Table 11: Analytical Data for the Milwaukee Facilities.

Constituent	CAS No.	F1-01[1]	F9-01	F16-01	F17-01
Volatile Organics - Method 8260A µg/kg					
Acetone	67641	210	B 7,500	B 290	24
2-Butanone	78933	J	B 58	B 69	J
2-Hexanone	591786	ND	ND	JB	ND
Benzene	71432	ND	53	J	ND
Chloroform	67663	J	6	ND	ND
Chlorobenzene	108907	ND	J	ND	ND
Trichloroethene	79016	ND	ND	J	ND
4-Methyl-2-pentanone	108101	ND	16	64	ND
Toluene	108883	J	J	20	ND
Ethylbenzene	100414	ND	ND	J	ND
m,p-Xylenes	108383 / 106423	ND	ND	J	ND
o-Xylene	95476	ND	ND	J	ND
Semivolatile Organics - Method 8270B µg/kg					
bis(2-Ethylhexyl)phthalate	117817	59,000	55,000	180,000	28,000
Di-n-octylphthalate	117840	J	ND	ND	ND
Fluoranthene	206440	4,900	ND	ND	ND
Phenanthrene	85018	4,600	ND	ND	ND
Pyrene	129000	J	ND	ND	ND
Phenol	108952	3,600	3,600	ND	ND
Benzyl alcohol	100516	7,900	7,900	ND	ND

Notes: All results reported on a dry-weight basis.
1. Facility F4's F006 samples were designated as F1.
J Mass spectral data indicate the presence of a compound that meets the identification criteria for which the result is less than the laboratory detection limit, but greater than zero.
B Analyte also detected in the associated method blank analysis.
ND Non-detect
Volatiles analyzed for but not detected include: Chloromethane, Vinyl Chloride, Bromomethane, Chloroethane, Trichlorofluoromethane, 2-Chloroethyl vinyl ether, 1,1-Dichloroethene, Methylene Chloride, Carbon Disulfide, Vinyl Acetate, 1,1-Dichloroethane, trans-1,2-Dichloroethene, cis-1,2-Dichloroethene, 1,1,1-Trichloroethane, Carbon Tetrachloride, 1,2-Dichloroethane, Benzene, 1,2-Dichloropropane, Bromodichloromethane, cis-1,3-Dichloropropene, trans-1,3-Dichloropropene, 1,1,2-Trichloroethane, Dibromochloromethane, Tetrachloroethene (PCE), Styrene, Bromoform, 1,1,2,2-Tetrachloroethane, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, and 1,2-Dichlorobenzene.
Semivolatiles analyzed for but not detected include: bis(2-Chloroethyl)ether, 2-Chlorophenol, 2,3-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2-Dichlorobenzene, 2-Methylphanol, bis((2-Chloroisopropyl)ether, 4-Methyphenol, N-Nitroso-di-n-propylamine, Hexachloroethane, Nitrobenzene, Isophorone, 2-Nitrophenol, 2,4-Dimethylphenol, bis(2-Chloroethoxy)methane, Benzoic acid, 2,4-Dichlorophenol, 1,2,4-Trichlorobenzene, Naphthalene, 4-Chloroaniline, Hexachlorobutadiene, 4-Chloro-3-methylphenol, 2-Methylnaphthalene, Hexachlorocyclopentadiene, 2,4,6-Trichlorophenol, 2,4,5-Trichlorophenol, 2-Chloronaphthalene, 2-Nitroaniline, Dimethylphthalate, Acenaphthylene, 2,6-Dinitrotoluene, 3-Nitroaniline, Acenaphthene, 2,4-Dinitrophenol, 4-Nitrophanol, 4-Nitrophenol ,Dibenzofuran, 2,4-Dinitrotoluene, Diethyphthalate, 4-Chlorophenyl-phenylether, Fluorene, 4-Nitroaniline, 4,6-Dinitro-2-methylphenol, N-Nitrosodiphenylamine, 4-Bromophenyl-phenylether, Hexachlorobenzene, Pentachloropheno,l Anthraoene, Carbazole, Di-n-butylphthalate, Butylbenzylphthalate, 3,3'-Dichlorobenzidine, Benzo(a)anthracene, Chrysene, Din-octylphthalate, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, and Benzo(g,h,f)perylene

Table 11 (cont'd): Analytical Data for the Milwaukee Facilities.

Constituent	CAS No.	F1-01[1]	F1-02	F5-01	F5-02	F16-01	F16-02	F8-01	F8-02
Total Metals - Methods 6020, 7471 mg/kg									
Aluminum	7429905	31,200	17,300	3,690	1,710	3,940	1,210	19,300	8,560
Antimony	7440360	C 5.5	C 1.8	67.4	45.0	C 3.5	C 2.7	161	110
Arsenic	7440382	C 9.9	C 9.3	15.4	18.3	9.4	7.0	C 5.5	11.8
Barium	7440393	C 41.9	C 34.3	843	157	73.7	C 24.5	83.4	C 33.3
Beryllium	7440417	ND	ND	C 0.59	C 0.69	ND	ND	ND	ND
Bismuth	7440699	C 2.7	C 3.3	C 2.1	3.2	5.4	C 2.2	ND	ND
Cadmium	7440439	7.5	9.6	9.6	13.4	C 1.3	C 1.3	10.1	42.7
Calcium	7440702	24,800	17,500	21,400	23,200	97,300	105,000	67,400	50,800
Chromium	7440473	59,500	64,900	92,000	71,000	13,800	5,520	193,000	91,500
Copper	7440508	130	1,480	39,900	41,500	13,600	5,320	24,500	41,100
Iron	7439896	25,000	27,700	92,100	105,000	114,000	189,000	110,000	279,000
Lead	7439921	297	366	976	556	2,870	778	858	231
Magnesium	7439954	15,800	17,400	13,000	12,500	10,400	4,250	9,710	11,100
Manganese	7439965	1,710	399	1,200	1,340	671	950	1,360	1,080
Mercury	7439976	2.0	ND	C 0.33	C 0.26	C 0.40	ND	ND	C 1.2
Nickel	7440020	19,900	18,200	104,000	105,000	ND	ND	1,130	744
Selenium	7782492	16.6	16.0	10.6	11.3	30,700	16,800	ND	ND
Silver	7440224	267	97.9	8.7	3.4	47.4	20.2	ND	ND
Sodium	7440235	8,360	21,700	5,950	6,830	5,490	7,900	19,600	49,400
Tin	7440315	404	582	429	337	497	50.8	129	96.3
Zinc	7440666	336,000	335,000	126,000	158,000	14,200	5,790	3,790	9,610
TCLP Metals - Methods 1311, 6010, 7470 mg/L									
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	C 0.26	1.4	C 1.7	2.2	C 0.9	C 0.2	C 0.3	B 0.7
Cadmium	7440439	C 0.04	0.07	C 0.05	0.08	C 0.03	ND	C 0.01	0.3
Chromium	7440473	40.6	56.2	27.2	12.1	14.5	12.7	54.1	12.8
Lead	7439921	ND	0.11	ND	ND	0.3	1.3	0.1	ND
Mercury	7439976	ND	ND	ND	ND	0.005	0.009	ND	0.005
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	C 0.05	ND	ND	ND	ND	C 0.04	ND	ND

Table 11 (cont'd): Analytical Data for the Milwaukee Facilities.																	
Constituent	CAS No.		F1-01[1]		F1-02		F5-01		F5-02		F16-01		F16-02		F8-01		F8-02
General Chemistry mg/kg																	
Chloride	16887006		2,400		13,000		1,000		1,200		2,200		190		8,800		8,000
Fluoride	16984488		300		1,600		82		120		61		120		48		17
Hex. Chromium	18540299	C	0.66	C	0.60		0.66	C	0.10	C	0.18	C	0.10	C	0.43	C	0.19
Total Cyanide	57125		ND		ND		700		900		ND		ND		ND		ND
Amenable Cyanide	E-10275	**	12	**	18	**	2,700	**	1,300		ND		ND		ND		ND
Percent Solids			14.8		16.5		43.5		45.9		25.1		31.3		19.9		18.8

Notes: All results reported on a dry-weight basis

1. Facility F4's F006 samples were designated as F1.

B Analyte also detected in the associated method blank analysis.

C Reported value is less than the method quantitation limit (QL) but greater than the instrument detection limit (IDL).

** Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.

ND Non-detect

Table 11 (cont'd): Analytical Data for the Milwaukee Facilities.									
Constituent	CAS No.	F17-01	F17-02	F11-01	F11-02	F13-02	F14-01	F9-01	F9-02
Total Metals - Methods 6020, 7471 mg/kg (cont.)									
Aluminum	7429905	1,260	1,360	1,800	1,650	311	2,320	27,000	13,200
Antimony	7440360	C 0.62	C 0.63	14.2	11.1	C 0.57	C 2.0	5.4	13.5
Arsenic	7440382	3.8	4.1	13.0	6.5	C 2.3	13.4	4.8	3.1
Barium	7440393	29.4	43.5	227	159	C 6.0	29.2	298	257
Beryllium	7440417	ND	ND	ND	ND	ND	ND	ND	ND
Bismuth	7440699	ND	ND	C 1.7	C 1.8	ND	ND	72.5	31.5
Cadmium	7440439	39,300	21,600	12.5	7.3	ND	3.9	2.1	17.3
Calcium	7440702	141,000	140,000	16,100	14,800	855	18,000	87,000	70,000
Chromium	7440473	14,000	9,250	31,100	48,100	193	26,900	28,200	94,000
Copper	7440508	21,900	18,600	8,980	11,300	33.6	54.6	20,700	15,000
Iron	7439896	24,300	17,400	58,800	69,300	3,350	194,000	105,000	80,800
Lead	7439921	221	237	527	230	C 0.59	64.8	439	410
Magnesium	7439954	12,900	12,300	13,500	13,700	355	9,990	44,300	30,300
Manganese	7439965	244	199	557	707	C 3.8	979	1,070	1,170
Mercury	7439976	ND	C 0.12	ND	C 0.29	ND	ND	0.35	0.58
Nickel	7440020	83,000	35,100	180,000	84,600	76,000	57.1	14,800	18,700
Selenium	7782492	2.1	2.1	7.3	5.0	ND	5.7	1.9	ND
Silver	7440224	C 0.52	1.5	163	657	ND	4.4	65.0	230
Sodium	7440235	11,700	17,700	22,700	84,300	16,400	3,830	15,900	39,000
Tin	7440315	11.2	13.8	3,550	8,070	9.0	19.5	1,100	681
Zinc	7440666	35,500	44,600	129,000	94,400	C 6.1	277,000	67,200	83,900
TCLP Metals - Methods 1311, 6010, 7470 mg/L									
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	C 1.3	C 1.1	C 1.3	C 0.7	C 0.4	C 1.3	C 1.1	C 0.8
Cadmium	7440439	13.3	5.7	0.06	0.11	ND	C 0.03	ND	ND
Chromium	7440473	ND	ND	3.1	0.64	1.9	0.2	0.9	13.1
Lead	7439921	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	7439976	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	7782492	0.08	ND	ND	ND	ND	ND	ND	C 0.04
Silver	7440224	ND	ND	ND	C 0.08	ND	ND	ND	ND

Table 11 (cont'd): Analytical Data for the Milwaukee Facilities.										
Constituent	CAS No.	F17-01	F17-02	F11-01	F11-02	F13-02	F14-01	F9-01	F9-02
General Chemistry mg/kg									
Chloride	16887006	5,500	13,000	690	30,000	17,000	2,700	12,000	23,000
Fluoride	16984488	C 0.7	1.2	99	48	120	250	200	1,400
Chromium, hexavalent	18540299	19	C 3.7	26	0.43	0.50	2.6	29	1,000
Total Cyanide	57125	380	99	16	6.6	2.0	200	46	74
Amenable Cyanide	E-10275	** 940	** 180	3.0	3.3	** 11	30	12	51
Percent Solids		65.9	77.4	38.2	54.9	54.1	37.7	74.3	69.1

Notes:
* All results reported on a dry-weight basis.
B Analyte also detected in the associated method blank analysis.
C Reported value is less than the method quantitation limit (QL) but greater than the instrument detection limit (IDL).
** Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.
ND Non-detect

2. Chicago Benchmarking Study

This section provides a detailed presentation of data gathered in the Chicago Benchmarking Study, including a characterization of plating processes, pollution prevention and recycling practices, F006 characteristics, and site specific variations in the generation and management of F006 for ten facilities in Milwaukee. Table 12is the facility selection matrix used to select 10 facilities from 13 candidates. Table 13 presents information collected for each facility in the study. Table 14 summarizes the results of the laboratory analyses of F006 data and Table 15 presents detailed laboratory analysis results for each facility.

All Chicago facilities reported an annual quantity of waste generated. The total amount generated from all 10 facilities is approximately 1712 tons/year. Nine of the facilities recycle their F006 waste. One facility landfills its F006 waste. Fifteen F006 laboratory samples gathered.

Table 12: Chicago Metal Finishing Facility Selection Matrix														
Selection Criteria	**C1 Selected**	**C2 Selected**	**C3 Selected**	**C4 Selected**	**C5 Selected**	**C6 Selected**	C7 Alternate	**C8 Selected**	**C9 Selected**	C10 Alternate	C11 Alternate	C12 Eliminated	**C13 Selected**	**C14 Selected**
Type: Captive/Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job
Size	80	150	37	43	70	30		60	50		35	120		150
Main Treatment Technology	Alk/ PPT	Alk/ PPT	Alk/ PPT/IX	Alk/ PPT/ Cr	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT	Alk/ PPT
Treatment Technology	CFR	CFR/IX	CFR	CFR	CFR/IX	CFR	CFR	CFR	CFR	CFR	CFR	CFR	CFR	CFR
Onsite Recycle	No	Yes	Yes	Electro-winning	Au/Ag Closed System	No		No	No		Yes	No	Au/Ag IX System	No
Landfill	No	No	No	No	No	No		Yes	Yes		Yes	Yes	No	Yes
Main Management Method	Recycle	Recycle	Recycle	Recycle	Reclaim	Recycle		LF	LF		Lf/Recycle	LF	Reclaim	LF
Finishing Processes	Cu/Ni/Cr	Cu/Ni/Cr E-Ni HCr Zn(nCN)/ Fe	CdCN Zn(nCN)/ Fe	Cu/Ni/Cr Zn(CN)/ Fe	AuCN AgCN Nickel Copper	Cu/Ni Zn(nCN)/ Fe	CdCN Zn(nCN)/ Fe	Cu/Ni/Cr	Zn/Fe Cu/Ni/Cr	CuCN/Ni BrassCN E-Ni Zn/Fe	Cu/Ni/Cr E-Ni HCr Zn(nCN)/ Fe	Electro-polish	AuCN AgCN	Zn(CN)/ Fe Zn (nCN)
SURVEY?	Y	N	Y	Y	Y	N	N	Y-SAIC	Y-SAIC	N	Y-SAIC	Y	N	Y

Table 13: Facility-Specific Information for Chicago Facilities
Facility C1

Plating Process		**F006 Quantity and Management**	**Sample Description**
Cu-CN Cu-Tin-Zn Bright dip of Cu alloy Ni/Cr on steel Electroless Ni Tins Tin-Zn	Cd-CN Au-CN Ag-CN Acid-Cu Chrome Tin-Ni Tin-acid	24 - 28 tons/yr Recycle (World Resources)	C1-01 - sludge collected from supersack at drier output; slightly warm; gray-green color

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
<u>SPENT PLATING SOLUTIONS</u> Filtration - E-Ni, Ni, Cu, Cd, Au, Sn, Ag Carbon treatment - occasional use for Ni/as needed Replenishment - complete change for E-Ni only/soap dumped periodically Purified water - DI treated on-site Electrolytic dummying - as needed - Ni - primary Cyanide bath carbonate freezing - Na-CN every winter, Cd Precipitation - combined with bath filtration of carbon Monitor pH daily Drag-in Reduction - pre-rinse with DI water High purity anodes (some tanks bagged) Non-chelated process chemistries in Tin-Zn bath Non-CN process chemicals - approx. 1/3 of chemicals non-CN Solvent degreasing alternatives - mineral spirits and limited ultrasonic. Alkaline Cleaners - skimming, chrome reducers Have written procedures for bath make-up and additions Use process baths to maximum extent possible (no dump schedule) Remove anodes from bath when they are idle Perform regular maintenance of racks/barrels Pre-inspect parts to prevent processing of obvious rejects <u>DRAG-OUT REDUCTION/RECOVERY</u> Process Bath Operating Conc. - checked every other week Process Bath Operating Temp. - automated; daily Wetting agents - some Workpiece positioning Withdrawal and Drainage Time - manual (operators trained) Drainage boards between all baths returned to bath Drag-out tanks on some tanks returned to bath Electrowinning on Au only Meshpad Mist Eliminators - chrome <u>RINSE WATER</u> Spray or Fog Rinse/Rinse Water Agitation Increased Contact Time/Multiple Rinses Countercurrent rinsing and flow restrictors Recycling/Recovery of rinsewater Manually turning off rinsewater when not in use Air agitation in rinse tanks <u>OTHER</u> Established a formal policy statement with regard to P2 and control Established a formal P2 program Conduct employee education for P2 Establish a preventative maintenance program for tanks	**C1 - 01** <u>Total</u> (mg/kg) Al - 4,390 Sb - ND As - ND Ba - 1,080 Be - ND Bi - ND Cd - 17,300 Ca - 47,400 Cr - 83,000 Hex. Cr - 1,190 Cu - 40,000 Fe - 27,800 Pb - 10,300 Mg - 51,100 Mn - 332 Hg - ND Ni - 98,800 Se - ND Ag - 280 Na - 22,100 Sn - 13,800 Zn - 17,100 CN - 1,800	 <u>TCLP</u> (mg/l) As - ND Ba - ND Cd - 1.0 Cr - 2.8 Pb - ND Hg - 0.001 Se - ND Ag - 3.8

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C2

Plating Process	F006 Quantity and Management	Sample Description
Mg Anodizing Gold-CN Cu/NiCr Electroless Ni Zn (nCN) on Fe Chromic acid Cu plating (nCN) Ag-CN	~347 tons/yr Recycle (Horsehead)	C2-01 - Sludge from roll-off bin; not dried; ambient temp. cool; consistency of fudge; chunky; orange-brown; moist C2-02 - Sludge from drier; consistency of dirt; chocolate color

Pollution Prevention Practices

SPENT PLATING SOLUTIONS
Filtration - some continuous
Carbon treatment to remove organic contaminants on some baths
Purified water - DI
Precipitation combined with filtration on certain baths
Monitoring - daily with on-site lab
Purer Anodes and Bags - depends on bath
Nonchelated Process Chemistries
Non-CN process chemicals except Au/Ag
Solvent Degreasing Alternatives including Hot alkaline cleaning and Electrocurrent
Alkaline Cleaners including Skimming and Coalescer on barrel lines
Acid Purification - Ion exchange removes metals

DRAG-OUT REDUCTION/RECOVERY
Wetting Agents - required
Workpiece positioning
Withdrawal and Drainage Time
Drainage boards between tanks
Drag-out tanks
Ion Exchange chrome rinses (off-site)

RINSE WATER
Increased Contact Time/ Multiple Rinses - manual rinse with DI water
Countercurrent Rinsing - some but limited space for more
Flow controls - Flow restrictors
Recycle rinse water
Recycle solvents via Safety Kleen

Sample Characteristics (Dry wt.)

C2 - 01	**C2-02**
Total (mg/kg)	Total (mg/kg)
Al - 45,900	Al -27,900
Sb -ND	Sb - ND
As -ND	As - ND
Ba -65	Ba - 76
Be -ND	Be - ND
Bi - 66	Bi - 19
Cd -3,740	Cd - 4,440
Ca -32,900	Ca - 26,400
Cr -9,300	Cr - 18,700
Hex. Cr - 53	Hex. Cr - 11
Cu -1,210	Cu - 1,600
Fe - 29,500	Fe - 40,400
Pb - 170	Pb - 161
Mg -161,000	Mg - 111,000
Mn -1,240	Mn - 1,010
Hg - ND	Hg - ND
Ni - 1,640	Ni - 7,390
Se - ND	Se - ND
Ag -27	Ag - 88
Na -29,600	Na - 33,100
Sn -1,270	Sn - 2,090
Zn -62,000	Zn - 89,200
CN - 3.3	CN - 0.8
TCLP (mg/l)	TCLP (mg/l)
As -ND	As - ND
Ba -ND	Ba - ND
Cd -0.19	Cd - 0.16
Cr - 0.08	Cr - 0.09
Pb - ND	Pb - ND
Hg -ND	Hg - ND
Se - ND	Se - ND
Ag -ND	Ag - ND

<table>
<tr><th colspan="3">Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C3</th></tr>
<tr><th>Plating Process</th><th>F006 Quantity and Management</th><th>Sample Description</th></tr>
<tr><td>Cd-CN
Zn(non CN) on Steel</td><td>~90 tons/yr

Recycle (Horsehead)</td><td><u>C3-01S</u> - Sludge from left filter press; mix of wet/soft and wet/hard sludge; brown color; fudge consistency</td></tr>
<tr><th colspan="2">Pollution Prevention Practices</th><th>Sample Characteristics (Dry wt.)</th></tr>
<tr><td colspan="2"><u>SPENT PLATING SOLUTIONS</u>
General Bath Life Extensions
Carbon Treatment - as needed
Monitoring - 3-4 times / day
Housekeeping - 1 person in charge of bath chemistry
Nonchelated Process Chemistries
Solvent Degreasing Alternatives - Hot Alkaline Cleaning and Electrocurrent
Alkaline Cleaners - Skimming

<u>DRAG-OUT REDUCTION</u>
Process Bath Operating Concentration
Process Bath Operating Temperature - in the process of installing temp. controls
Withdrawal and Drainage Time
Drainage Boards
Drag-Out Tanks - Cd line has dead rinse and is returned to plating bath

<u>RINSE WATER</u>
Improved Rinsing Efficiency - Countercurrent Rinsing
Flow Restrictors</td><td>C3 - 01S
<u>Total</u> (mg/kg): Al -597; Sb -ND; As -39; Ba -167; Be -ND; Bi - ND; Cd -788; Ca -30,200; Cr -10,700; Hex. Cr - 33; Cu -86; Fe - 156,000; Pb - 581; Mg -27,200; Mn -3,300; Hg - ND; Ni - 106; Se - ND; Ag -ND; Na -8,200; Sn -68; Zn -262,000; CN - 3,240

<u>TCLP</u> (mg/l): As -ND; Ba -0.7; Cd -1.57; Cr - ND; Pb - ND; Hg -ND; Se - ND; Ag -ND</td></tr>
</table>

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C4

Plating Process	F006 Quantity and Management	Sample Description
Cu/Ni/Cr on brass Cu (Alkaline) Dull and Bright Ni Ni/Cr on steel Bright dip of Cu Zn phosphate Chromating of Al 60/40 (Sn/Pb) solder Zn-CN Cd-CN Sn-acid	~73 tons/yr Recycle (Horsehead)	C4-01S - Sludge from lugger box under filter press: fudge consistency, cool, chocolate-brown color, cake formed into 1 ½ inch thick layers, estimated at 75% water

Pollution Prevention Practices	Sample Characteristics (Dry wt.)
SPENT PLATING SOLUTIONS Filtration on the Tin, Ni, and Cu baths Carbon Treatment in the Ni and Cu baths Replenishment Electrolytic Dummying for Ni, Cu, Cd, Zn, Cr Cyanide Bath Carbonate Freezing Precipitation - occasionally on tins Monitoring - once/wk at minimum Purer Anodes and Bags Hexavalent for trivalent Chrome in clear chromate conversion coating Solvent Degreasing alternatives: hot alkaline cleaning, electrocurrent, & ultrasonic Alkaline Cleaners - skimming Waste reduction study conducted Pre-inspect parts to prevent processing of obvious rejects Perform regular maintenance of racks/barrels Remove anodes from bath when they are idle Use process baths to maximum extent possible Have written procedures for bath make-up and additions Waste stream segregation of contact and non-contact wastewaters Strict chemical inventory control Evaluation of recycling alternatives DRAG-OUT REDUCTION/RECOVERY Process Bath Operating Concentration and Temperature Wetting Agents - add to Ni baths Workpiece Positioning Withdrawal and Drainage Time and Boards Drag-Out Tanks Electrowinning for Cd RINSE WATER Spray Rinse/Rinse Water Agitation - some tin Countercurrent Rinsing - 2 and 3-stage Recycle/Recovery of Rinse Water Recycle/Recovery of Solvents Eliminate rinsewaters to waste treatment Manually turning off rinsewater when not in use Flow restrictors OTHER Conduct employee education for P2 Housekeeping - QA manager controls bath chemistry	**C4 - 01S** Total (mg/kg): Al -41,000; Sb -ND; As -ND; Ba -715; Be -37; Bi - ND; Cd -6,040; Ca -63,500; Cr -50,800; Hex. Cr - 28; Cu -9,940; Fe - 124,000; Pb - 2,320; Mg -49,500; Mn -1,690; Hg - ND; Ni - 11,300; Se - ND; Ag -110; Na -4,440; Sn -36,200; Zn -176,000; CN - 3,740 TCLP (mg/l): As -ND; Ba -ND; Cd -1.26; Cr - ND; Pb - ND; Hg -ND; Se - ND; Ag -ND

<table>
<tr><th colspan="3">Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C6</th></tr>
<tr><th>Plating Process</th><th>F006 Quantity and Management</th><th>Sample Description</th></tr>
<tr><td>Electroless Ni
Cu-CN
Zn
Au-CN
Ni
Sn
Ag-CN</td><td>~15 tons/yr

Recycle (World Resources)</td><td><u>C6-01</u> - Sludge from plant 1; sludge mixed with absorbent called Absorbex; black and greenish-gray; sludge is 2 days old
<u>C6-02</u> - Sludge from superbag in plant 2; green/gray and brown; clay consistency; sludge generated the previous week</td></tr>
<tr><th colspan="2">Pollution Prevention Practices</th><th>Sample Characteristics (Dry wt.)</th></tr>
<tr><td colspan="2"><u>SPENT PLATING SOLUTIONS</u>
Filtration - continuous
Carbon Treatment - periodically
Purified Water - for Ni
Electrolytic Dummying - for Ni
Cyanide Bath Carbonate Freezing - annually
Precipitation - periodically
Monitoring - weekly to outside labs/daily-weekly internally
Housekeeping - lab controls bath chemistry
Purer Anodes and Bags - Silver 99.998%; Gold 99.999%; Nickel 98%
Hexavalent Chrome Alternatives - Trivalent chrome for clear/blue bright conversion coatings
Solvent Degreasing Alternatives - Hot Alkaline Cleaning and Electrocurrent
Alkaline Cleaners - Skimming

<u>DRAG-OUT REDUCTION/RECOVERY</u>
Wetting Agents - present in formula from vendor
Withdrawal and Drainage Time - Training
Drainage Boards
Drag-Out Tanks (Dead Rinse)
Electrowinning - Gold (periodic); Silver (continuous)
Nickel drag out sent back to plating bath

<u>RINSE WATER</u>
Improved Rinsing Efficiency
Spray Rinse/Rinse Water Agitation (Air Spargers)
Countercurrent Rinsing - 2-stage
Flow Restrictors</td><td>C6 - 01
<u>Total</u> (mg/kg)
Al -5,350
Sb -207
As -ND
Ba -119
Be -20
Bi - ND
Cd -51
Ca -63,000
Cr -698
Hex. Cr - 7
Cu -37,500
Fe - 24,600
Pb - 326
Mg -53,400
Mn -799
Hg - ND
Ni - 77,100
Se - ND
Ag -272
Na -37,200
Sn -9,740
Zn -24,400
CN - 373

<u>TCLP</u> (mg/l)
As -ND
Ba -ND
Cd -ND
Cr - ND
Pb - ND
Hg -0.002
Se - ND
Ag - 0.29

C6-02
<u>Total</u> (mg/kg)
Al - 1,740
Sb - ND
As -ND
Ba - 54
Be - 10
Bi - 35
Cd - ND
Ca - 13,000
Cr - 59,400
Hex. Cr - 174
Cu - 21,900
Fe - 47,000
Pb - 109
Mg - 6,100
Mn - 746
Hg - ND
Ni - 21,500
Se - ND
Ag - 32
Na - 89,200
Sn - 12,100
Zn - 81,400
CN - 240

<u>TCLP</u> (mg/l)
As - ND
Ba - ND
Cd - ND
Cr - 0.08
Pb - ND
Hg - ND
Se - ND
Ag - ND</td></tr>
</table>

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities Facility C7		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Plant 1: Ag (CN) Cu-CN Acid-Sn Electroless Ni Cu-acid Plant 2: Sn (Dull) Ni (Sulfamate) Cu-CN Sn (Bright Acid) Solder	~ 65 tons/yr Recycle (World Resources)	C7-01S - From supersack; reddish-brown and some greenish-gray, muddy/clayey consistency C7-02S - from supersack, big chunks, very hard but breakable, red-brown, ambient temperature, smells like paint -Plant 2
Pollution Prevention Practices		**Sample Characteristics** (Dry wt.)
SPENT PLATING SOLUTIONS Filtration - removes organics Carbon Treatment Purified Water - DI Electrolytic Dummying Precipitation Monitoring - at least weekly Purer Anodes and Bags - 99.9% Solvent Degreasing Alternatives - Hot Alkaline Cleaning and Electrocurrent Alkaline Cleaners - Skimming for oil DRAG-OUT REDUCTION/RECOVERY Process Bath Operating Concentration Process Bath Operating Temperature Wetting Agents - in Brightener Workpiece Positioning Withdrawal and Drainage Time Silver rinse - Either electrowinning or electrodialysis RINSE WATER Spray Rinse/Rinse Water Agitation - Air agitation Countercurrent Rinsing - 2-stage on most lines Flow Restrictors		**C7 - 01S** Total (mg/kg) Al -4,510 Sb -ND As -ND Ba -20 Be -ND Bi - ND Cd -9 Ca -11,000 Cr -161 Hex. Cr. - ND Cu -21,400 Fe - 1,510 Pb - 47 Mg -336,000 Mn -103 Hg - ND Ni - 27,100 Se - ND Ag -253 Na -1,060 Sn -9,680 Zn -1,070 CN - 2,480 TCLP (mg/l) As -ND Ba -ND Cd -ND Cr - ND Pb - ND Hg -ND Se - ND Ag -0.07 **C7-02S** Total (mg/kg) Al -493 Sb - ND As - ND Ba - 27 Be - ND Bi -54 Cd - ND Ca - 16,100 Cr - 127 Hex. Cr - ND Cu - 23,800 Fe - 131,000 Pb - 2,080 Mg - 242,000 Mn - 523 Hg - ND Ni - 10,100 Se - ND Ag - ND Na - 1,230 Sn - 36,600 Zn - 2,060 CN - 725 TCLP (mg/l) As - ND Ba - ND Cd - ND Cr - ND Pb - ND Hg - ND Se - ND Ag - ND

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C8

Plating Process	F006 Quantity and Management	Sample Description
Zn plating Acid Chloride Alkaline - non CN Chromating	~135 tons/yr BFI landfill	C8-01 - Sludge from supersack at continuous filter press; soft and moist; waxy; green/gray C8-02 - Sludge from batch tank filter press; clay consistency; green/gray; outer layer has rust color probably due to iron oxidation.

Pollution Prevention Practices	Sample Characteristics (Dry wt.)	
SPENT PLATING SOLUTIONS	**C8 - 01**	**C8-02**
Continuous Filtration	Total (mg/kg)	Total (mg/kg)
Carbon Treatment - intermittently	Al -204	Al -153
Replenishment - bleed off growth	Sb -ND	Sb - ND
Electrolytic Dummying - as needed	As -ND	As - ND
Monitoring - daily	Ba -58	Ba - 45
Purer Anodes and Bags - 99.99% Zinc	Be -ND	Be - ND
Hexavalent Chrome Alternatives - Trivalent clear chrome	Bi - ND	Bi - ND
Nonchelated Process Chemistries	Cd -11	Cd - ND
Non-Cyanide Process Chemicals - Dropped Cyanide plating in 1993	Ca -15,000	Ca - 4,040
Solvent Degreasing Alternatives: Hot alkaline cleaning and Electrocurrent	Cr -11,000	Cr - 59,000
Alkaline Cleaners - Skimming	Hex. Cr -160	Hex. Cr - 29
	Cu -401	Cu - 120
DRAG-OUT REDUCTION/RECOVERY	Fe - 24,600	Fe - 56,300
Process Bath Operating Concentration	Pb - 30	Pb - 49
Process Bath Operating Temperature	Mg -10,800	Mg - 1,340
Wetting Agents	Mn -438	Mn - 569
Workpiece Positioning	Hg - ND	Hg - ND
Withdrawal and Drainage Time	Ni - 452	Ni - 257
Spray or Fog Rinses	Se - ND	Se - ND
Drainage Boards	Ag -109	Ag - 112
Drag-Out Tanks - plating baths	Na -10,400	Na - 56,400
Portion of drag out returned to plating bath	Sn -ND	Sn - ND
	Zn -460,000	Zn - 345,000
RINSE WATER	CN - 3	CN - 285
Improved Rinsing Efficiency: Spray Rinse/Rinse Water Agitation		
Countercurrent Rinsing where feasible	TCLP (mg/l)	TCLP (mg/l)
Flow Restrictors	As -ND	As - ND
	Ba -ND	Ba - 0.80
	Cd -0.02	Cd - ND
	Cr - 0.04	Cr - ND
	Pb - ND	Pb - ND
	Hg -ND	Hg - ND
	Se - ND	Se - ND
	Ag -ND	Ag - ND

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C9

Plating Process	F006 Quantity and Management	Sample Description
Zn-acid plating Cd-acid plating Cu/Ni Chromating Phosphating	230-300 tons/yr Recycle (Envirite)	C9-01 - Dried sludge from supersack after sludge drier, warm, dark chocolate-brown color, granular to powdery consistency C9-02 - Sludge from a supersack dated the previous week, dry/moist mix, reddish-brown, chunky and powdery, ambient air temp

Pollution Prevention Practices	Sample Characteristics (Dry wt.)	
SPENT PLATING SOLUTIONS	**C9 - 01**	**C9-02**
Filtration - Zn baths as needed	Total (mg/kg)	Total (mg/kg)
Carbon Treatment - as needed	Al -298	Al -311
Purified Water - DI for chromates	Sb -ND	Sb - ND
Precipitation - Fe removal in Zn baths, combined with filtration	As -ND	As - ND
Monitoring - daily	Ba -578	Ba - 789
Housekeeping - manager authorizes bath additions/changes	Be -ND	Be - ND
Purer Anodes and Bags - min. 99.9%	Bi - ND	Bi - ND
Hexavalent Chrome Alternatives - Trivalent chrome for clear chromates	Cd - 27,600	Cd - 13,800
Nonchelated Process Chemistries	Ca - 8,630	Ca - 17,000
Non-Cyanide Process Chemicals - No CN	Cr - 40,400	Cr - 32,200
Solvent Degreasing Alternatives: Hot alkaline cleaning and Electrocurrent	Hex. Cr -6	Hex. Cr -11
	Cu - 388	Cu - 4,230
DRAG-OUT REDUCTION	Fe - 185,000	Fe - 257,000
Wetting Agents	Pb - 5	Pb - 9
Workpiece Positioning	Mg -2,120	Mg - 4,190
Withdrawal and Drainage Time	Mn -2,130	Mn - 2,950
Drainage Boards	Hg - ND	Hg - ND
Drag out Tanks - on rinses only	Ni - 707	Ni - 2,730
	Se - ND	Se - NA
RINSE WATER	Ag -225	Ag - 173
Countercurrent Rinsing - 2 - 3-stage	Na -7,840	Na - 11,600
Flow Restrictors	Sn -ND	Sn - ND
Recycle/Recovery Rinse Water	Zn -115,000	Zn - 175,000
	CN - 2.6	CN - 1.6
	TCLP (mg/l)	TCLP (mg/l)
	As -ND	As - ND
	Ba -ND	Ba - ND
	Cd -144	Cd - 15.8
	Cr - 0.14	Cr - 0.02
	Pb - ND	Pb - ND
	Hg -ND	Hg - ND
	Se - ND	Se - ND
	Ag -ND	Ag - ND

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities Facility C13		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Cu-CN Ni Au-CN Ag-CN Sn	3 tons/yr Recycle (United Refining)	C13-01 - Sludge from filter press bag; 30-day old sludge; consistency of cookies; chocolate-brown in color
Pollution Prevention Practices		**Sample Characteristics** (Dry wt.)
SPENT PLATING SOLUTION Filtration - as needed Carbon Treatment - as needed (rarely) Purified Water Electrolytic Dummying - Silver uses Monitoring - once a month/ weekly additions Housekeeping - QC program to calculate usage Purer Anodes and Bags - Silver 99.99% Solvent Degreasing Alternatives - Electrocurrent DRAG-OUT REDUCTION/RECOVERY Wetting Agents Withdrawal and Drainage Time - Training Drag-Out Tanks (Dead Rinse) Ion Exchange for Gold Electrowinning for Silver - commercial unit RINSE WATER Countercurrent Rinsing - 2-stage for tin Flow Restrictors Recycling/Recovery of Solvents (sent to off-site recovery)		**C13 - 01** Total (mg/kg): Al -564, Sb -90, As -ND, Ba -143, Be -7, Bi - ND, Cd -22, Ca -83,900, Cr -73, Hex. Cr -4, Cu -91,600, Fe - 69,000, Pb - 189, Mg -10,800, Mn -343, Hg - ND, Ni - 9,010, Se - ND, Ag -351, Na -1,420, Sn -41,200, Zn -3,590, CN - 3,310 TCLP (mg/l): As -ND, Ba -ND, Cd -ND, Cr - ND, Pb - ND, Hg - 0.011, Se - ND, Ag -0.85

Table 13 (cont'd): Facility-Specific Information for Chicago Facilities
Facility C14

Plating Process	F006 Quantity and Management	Sample Description
Zn-CN Zn-Ni (CN) Zn Ni (Alkaline?)	730 tons/yr Recycle (Horsehead and Envirite)	C14-01 - Sludge from the luggerbox; orange-brown; dry; chunks the size of dimes and smaller. Carbonate from carbonate freezing of Ni bath combined with dewatered sludge sent to driers

Pollution Prevention Practices	Sample Characteristics (Dry wt.)
SPENT PLATING SOLUTIONS Filtration - continuous (paper/cartridges) for alkaline-Zn-Ni and alkaline-Zn Purified Water - for some applications Cyanide Bath Carbonate Freezing for Zn-CN and Zn-alkaline-Ni Monitoring - daily or every-other day Housekeeping - use assigned personnel for chemical additions Purer Anodes and Bags Hexavalent Chrome Alternatives - Cr^{+3} in blue dip process Nonchelated Process Chemistries - no chelated cleaners Solvent Degreasing Alternatives - hot alkaline cleaning and electrocurrent (no solvents in process) Alkaline Cleaners - Skimming grease and oil (investigating filtration and centrifuging) Stricter conformance with line preventative maintenance schedule Stricter conformance with SPC procedures Strict chemical inventory control Perform routine bath analysis Maintain bath analysis/addition logs Have written procedures for bath make-up and additions Remove anodes from bath when they are idle Regularly retrieve fallen parts/racks from tanks Perform regular maintenance of racks/barrels Pre-inspect parts to prevent processing of obvious rejects Evaluate recycling alternatives Research alternative plating technologies DRAG-OUT REDUCTION/RECOVERY Process Bath Operating Concentration and Temperature - Daily Wetting Agents - rinsate chemicals; acid-inhibitor in pickling acids Workpiece Positioning Withdrawal and Drainage Time Electrodialysis for black chromate RINSE WATER Spray Rinse/Rinse Water Agitation Countercurrent Rinsing - 2-stage in most processes Flow Restrictors Recycle rinse waters - treated wastewaters recycled as needed Drip shields between tanks Lower bath concentration Manually turning off rinsewater when not in use Establish a preventative maintenance program for tanks	**C14 - 01** Total (mg/kg): Al -390; Sb -ND; As -ND; Ba -48; Be -ND; Bi - ND; Cd -31; Ca -18,200; Cr -24,200; Hex. Cr -18; Cu -220; Fe - 129,000; Pb - 149; Mg -5,360; Mn -858; Hg - ND; Ni - 128; Se - ND; Ag -87; Na -16,500; Sn -ND; Zn -375,000; CN - 3,920 TCLP (mg/l): As -ND; Ba -ND; Cd -0.06; Cr - 0.02; Pb - ND; Hg -ND; Se - ND; Ag -ND

Table 14: Summary of Chicago F006 Analytical Data			
Constituent	**# Samples**	**# Non Detects**	**# Samples Above Method Quantitation Limit**
Total Metals Concentration (mg/kg)			
Aluminum	15	0(0%)	15(100%)
Antimony	15	13(87%)	2(13%)
Arsenic	15	1(7%)	14(93%)
Barium	15	0(0%)	15(100%)
Beryllium	15	11(73%)	4(27%)
Bismuth	15	11(73%)	4(27%)
Cadmium	15	3(20%)	12(80%)
Calcium	15	0(0%)	15(100%)
Chromium	15	0(0%)	15(100%)
Copper	15	0(0%)	15(100%)
Iron	15	0(0%)	15(100%)
Lead	15	0(0%)	15(100%)
Magnesium	15	0(0%)	15(100%)
Manganese	15	0(0%)	15(100%)
Mercury	15	10(67%)	5(33%)
Nickel	15	0(0%)	15(100%)
Selenium	15	15(100%)	0(0%)
Silver	15	2(13%)	13(87%)
Sodium	15	0(0%)	15(100%)
Tin	15	5(33%)	10(67%)
Zinc	15	0(0%)	15(100%)
TCLP (mg/l)			
Arsenic	15	15(100%)	0(0%)
Barium	15	14(93%)	1(7%)
Cadmium	15	6(40%)	9(60%)
Chromium	15	7(47%)	8(53%)
Lead	15	15(100%)	0(0%)
Mercury	15	12(80%)	3(20%)
Selenium	15	15(100%)	0(0%)
Silver	15	11(7%)	4(93%)
General Chemistry (mg/kg)			
Chloride	15	0(0%)	15(100%)
Fluoride	15	5(33%)	10(67%)
Chromium, hexavalent	15	2(13%)	13(87%)
Total Cyanide	15	0(0%)	15(100%)
Amenable Cyanide	15	0(0%)	15(100%)
Percent Solids	15	0(0%)	15(100%)

Table 15: Detailed Chicago Analytical Data								
Constituent	CAS No.	C1-01	C2-01	C2-02	C3-01S	C4-01S	C6-01	C6-02
Total Metals - Methods 6010A, 7471A, 7060A, 7421, 7740 mg/kg								
Aluminum	7429905	4,390	45,900	27,900	597	41,000	5,350	1,740
Antimony	7440360	ND	ND	ND	ND	ND	207	ND
Arsenic	7440382	ND	ND	ND	39	ND	ND	ND
Barium	7440393	1,080	65	76	167	715	119	54
Beryllium	7440417	ND	ND	ND	ND	37	20	10
Bismuth	7440699	ND	66	19	ND	ND	ND	35
Cadmium	7440439	17,300	3,740	4,440	788	6,040	51	ND
Calcium	7440702	47,400	32,900	26,400	30,200	63,500	63,000	13,000
Chromium	7440473	83,000	9,300	18,700	10,700	50,800	698	59,400
Copper	7440508	40,000	1,210	1,600	86	9,940	37,500	21,900
Iron	7439896	27,800	29,500	40,400	156,000	124,000	24,600	47,000
Lead	7439921	10,300	170	161	581	2,320	326	109
Magnesium	7439954	51,100	161,000	111,000	27,200	49,500	53,400	6,100
Manganese	7439965	332	1,240	1,010	3,300	1,690	799	746
Mercury	7439976	ND	ND	0	ND	0	0	0
Nickel	7440020	98,800	1,640	7,390	106	11,300	77,100	21,500
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	280	27	88	ND	110	272	32
Sodium	7440235	22,100	29,600	33,100	8,200	4,440	37,200	89,200
Tin	7440315	13,800	1,270	2,090	68	36,200	9,740	12,100
Zinc	7440666	17,100	62,000	89,200	262,000	176,000	24,400	81,400
TCLP Metals - Methods 1311, 6010A, 7470A mg/L								
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	ND	ND	ND	0.7	ND	ND	ND
Cadmium	7440439	1.0	0.19	0.16	1.57	1.26	ND	ND
Chromium	7440473	2.8	0.08	0.09	ND	ND	ND	0.08
Lead	7439921	ND	ND	ND	ND	ND	ND	ND
Mercury	7439976	0.001	ND	ND	ND	ND	0.002	ND
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	3.8	ND	ND	ND	ND	0.29	ND

Table 15: Detailed Chicago Analytical Data								
Constituent	CAS No.	C1-01	C2-01	C2-02	C3-01S	C4-01S	C6-01	C6-02
General Chemistry - Methods 300.0, 335.2, 335.1, 7195/6010A mg/kg								
Chloride	16887006	2,720	7430	59,800	5,980	959	2,140	322
Fluoride	16984488	166	4210	1180	ND	96.5	128	347
Chromium, hex	18540299	1,190	53	11	33	28	7	174
Total Cyanide	57125	1,800	3.3	0.8	3,240	3,740	373	240
Amen. Cyanide	E-10275	110	** 6.2	** 2.6	** 4,940	** 5,340	** 471	** 354
Percent Solids		57.0	13.5	44	15.3	14.7	25	30.3

Notes: * All results reported on a dry-weight basis.
** Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.
ND = Not detected

Table 15: Detailed Chicago Analytical Data									
Constituent	CAS No.	C7-01S	C7-02S	C8-01	C8-02	C9-01	C9-02	C13-01	C14-01
Total Metals - Methods 6010A, 7471A, 7060A, 7421, 7740 mg/kg									
Aluminum	7429905	4,510	493	204	153	298	311	564	390
Antimony	7440360	ND	ND	ND	ND	ND	ND	90	ND
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	20	27	58	45	578	789	143	48
Beryllium	7440417	ND	ND	ND	ND	ND	ND	7	ND
Bismuth	7440699	ND	54	ND	ND	ND	ND	ND	ND
Cadmium	7440439	9	ND	11	ND	27,600	13,800	22	31
Calcium	7440702	11,000	16,100	15,000	4,040	8,630	17,000	83,900	18,200
Chromium	7440473	161	127	11,000	59,000	40,400	32,200	73	24,200
Copper	7440508	21,400	23,800	401	120	388	4,230	91,600	220
Iron	7439896	1,510	131,000	24,600	56,300	185,000	257,000	69,600	129,000
Lead	7439921	47	2,080	30	49	5	9	189	149
Magnesium	7439954	336,000	242,000	10,800	1,340	2,120	4,190	10,800	5,360
Manganese	7439965	103	523	438	569	2,130	2,950	343	858
Mercury	7439976	ND	ND	ND	ND	ND	ND	0	ND
Nickel	7440020	27,100	10,100	452	257	707	2,730	9,010	128
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	253	ND	109	112	225	173	351	87
Sodium	7440235	1,060	1,230	10,400	56,400	7,840	11,600	1,420	16,500
Tin	7440315	9,680	36,600	ND	ND	ND	ND	41,200	ND
Zinc	7440666	1,070	2,060	460,000	345,000	115,000	175,000	3,590	375,000
TCLP Metals - Methods 1311, 6010A, 7470A mg/L									
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	ND	ND	ND	0.80	ND	ND	ND	ND
Cadmium	7440439	ND	ND	0.02	ND	144	15.8	ND	0.06
Chromium	7440473	ND	ND	0.04	ND	0.14	0.02	ND	0.02
Lead	7439921	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	7439976	ND	ND	ND	ND	ND	ND	0.011	ND
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	0.07	ND	ND	ND	ND	ND	0.85	ND
General Chemistry - Methods 300.0, 335.2, 335.1, 7195/6010A mg/kg									
Chloride	16887006	421	594	11,300	70,100	2,380	7,250	2,380	1,270

Table 15: Detailed Chicago Analytical Data									
Constituent	CAS No.	C7-01S	C7-02S	C8-01	C8-02	C9-01	C9-02	C13-01	C14-01
Fluoride	16984488	42.4	17.5	ND	ND	343	ND	ND	416
Chromium, hex.	18540299	ND	ND	160	29	6	11	4	18
Total Cyanide	57125	2,480	725	3	285	2.6	1.6	3,310	3,920
Amen. Cyanide	E-10275	** 4,050	** 1,100	** 4.3	285	** 3.5	** 3.1	250	830
Percent Solids		47.4	41.1	15.8	23.5	45.7	41.4	32.8	40.4

Notes: * All results reported on a dry-weight basis.
** Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.
ND = Not detected

3. Phoenix Benchmarking Study

This section provides a detailed presentation of data gathered in the Phoenix Benchmarking Study, including a characterization of plating processes, pollution prevention and recycling practices, F006 characteristics, and site specific variations in the generation and management of F006 for ten facilities in Phoenix. Table 16 is the facility selection matrix used to select 10 facilities from 13 candidates. Table 17 presents information collected for each facility in the study. Table 18 summarizes the results of the laboratory analyses of F006 data and Table 19 presents detailed laboratory analysis results for each facility.

The 10 Phoenix facilities generate approximate 1428 tons of F006 per year. Eight facilities recycle their waste and two facilities send their waste to be landfilled. Fifteen F006 laboratory samples were gathered.

Table 16: Phoenix Metal Finishing Facility Selection Matrix

Selection Criteria	P 1	P 2	P 3	P 4	P 5	P 6	P 7*	P8	P 9	P 10	P 11	P 12*	P13
Status	Selected	Selected	Selected	Selected	Selected	Selected	Alternate	Selected	Selected	Eliminated	Selecte d	Alternate	Selected
Type: Captive/Job	Captive	Job	Job	Captive	Captive	Job	Job	Job	Captive	Job	Job	Job	Captive
Size	35	200	75	10	24	175	105	150	75-100	165	47	450	70
Treatment Technology	CFR, IX, Diagn.	IX, CFR	CFR, IX, RO	CFR, ED	CFR, DOR	CFR	IX for Ag	CF2, DOR	IX, MS	CFR, MS, FM	CFR, IX	IX, MS	ER
Onsite Recycle	water	water reuse	No	No	No	Off-spec process foil	No	No	water	No	IX closed loop	Cu-bearing from IX; EW	water in drag-out tanks
Landfill	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No
Main Mgmt. Method	Filter Press	Filter Press	Filter Press	Filter Press	Filter Press	Filter Press; Drier (not in use)	Filter Press	Filter Press	Filter Press	Filter Press	Filter Press	Filter Press	Filter Press
Finishing Processes	Cu, Ni, Au, Tin	Cr Cu-CN Cd-CN Anodiz, Phosphat. CC, Ni	Cu, Ag, Cr, E-Ni, Anodiz, Cu/Ag/ Ni	Cu-CN, Cu strip, Etching, E-Ni, Ni	Cr, Ag, Ni, Cu on steel/Ni/ Cr	Cu-foil, hard CR plating, brass-CN (produces Cu-foil)	Anodize, Chem-Film-Cr on Ti, Al, Fe, Cr, Ag, Ni	E-Cu; Cu; black oxide; Au-CN; Ni	Cu/Ag/ Ni	Cu, Tin, Tin-Pb, Ni, Au-CN	Acid-Cu, Tin, Tin-Pb, Tin-Ni, Ni-Au(CN)	HCl-Cu etching	Acid-Cu, Ni, Au-CN

* Facility operates as a metal finisher and not an electroplater but manages sludge as F006.

Key:

MS	Material Substitution	ER	Electrowinning	Ni/Cr	Nickel chromium Electroplate on steel
Alk/PPT	Alkaline precipitation	FM	Flow Meter	Cu/Ni/Cr	Copper nickel chromium on nonferrous
IX	Ion exchanges	DOR	Drag-Out Reduction	Cu	Copper/PC bands
Ultra	Ultrafiltration/Microfiltration	CC	Chrome conversions	HCr	Hard chromium on steel
CFR	Counterflow rinse	Ni	Nickel electroplating	Cu-CN	Copper cyanide electroplating
EMR	Electrolytic metal recovery	Au	Gold electroplating	Cd-CN	Cadmium cyanide electroplating
ED	Electrodialysis	E-Ni	Electroless-Nickel electroplating	Ag	Silver electroplating
RO	Reverse osmosis	Zn/Fe	Zinc electroplate on steel		

Table 17: Facility-Specific Information for Phoenix Facilities
Facility P1

Plating Process	F006 Quantity and Management	Sample Description
Acid Cu Au-CN Tin-Pb Electroless Ni Electroless Cu	~445 tons/yr Recycle (World Resources)	P1-01 - collected from roll-off, includes sludge generated from separate alkaline etch batch treatment press P1-02 - composite of sludge collected from two roll-offs containing sludge.

Pollution Prevention Practices

SPENT PLATING SOLUTIONS
Filtration
Carbon treatment
Bath replenishment
Purified water - utilize Reverse Osmosis (RO) and Electrodialytic Removal (EDR)
Electrolytic dummying
Monitoring - 90% of baths changed via throughput - some constant feed/bleed
Housekeeping via checklists
Drag-in reduction - drip boards/rack orientation
Purer anodes and bags - currently using purest level per specifications
Facility has explored electrowinning Cu
Solvent degreasing alternatives - currently use alkaline/aqueous

DRAG-OUT REDUCTION/RECOVERY
Wetting agents - contained in some chemistries
Workpiece positioning - some racks set at angle
Withdrawal and drainage time - increased hang time
Spray or fog rinses - all horizontal equipment
Drainage boards - automated line equipped w/drainage boards that move w/racks
Drag-out tanks - replenish baths with drag-out tanks
Replenish plating baths with drag-out tanks

RINSEWATER
Spray rinse/rinse water agitation - air agitation in most cases
Increased contact time/multiple rinses
Countercurrent rinsing
Flow restrictors - horizontal flow sensors - flow restrictors on most rinses
Conductivity-actuated flow control - rinse after micro-etch on oxide line
Recycling of rinse water via a closed loop system for etch rinses

Sample Characteristics (Dry wt.)

P1 - 01	**P1 - 02**
Total (mg/kg)	Total (mg/kg)
Al - 3,420	Al - 44,700
Sb - ND	Sb - ND
As - 2	As - 8
Ba - 6	Ba - 22
Bi - ND	Bi - ND
Cd - ND	Cd - ND
Ca - 15,100	Ca - 15,300
Cr - 10	Cr - 23
Hex. Cr - ND	Hex. Cr - ND
Cu - 7,690	Cu - 28,100
Fe - 5,050	Fe - 4,020
Pb - 2,590	Pb - 194
Mg - 319,000	Mg - 245,000
Mn - 101	Mn - 288
Hg - ND	Hg - ND
Ni - 3,080	Ni - 4,450
Se - ND	Se - ND
Ag - 8	Ag - 22
Na - 4,050	Na - 4,780
Sn - 2,370	Sn - 1,710
Zn - 57	Zn - 190
CN - ND	CN - ND
TCLP (mg/l)	TCLP (mg/l)
As - ND	As - ND
Ba - ND	Ba - ND
Cd - ND	Cd - ND
Cr - ND	Cr - ND
Pb - 0.12	Pb - 0.08
Hg - ND	Hg - ND
Se - ND	Se - ND
Ag - ND	Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P2

<table>
<tr><th>Plating Process</th><th>F006 Quantity and Management</th><th>Sample Description</th></tr>
<tr><td>Hard chrome
Sulfuric acid anodizing
chromic Acid anodizing
Hard anodizing
Electroless Ni
Sulfamate Ni
Cd-CN
Zinc phosphating
Manganese phosphating
Chromate conversion coatings
passivation
Cu-CN</td><td>~40 tons/yr

Recycle (World Resources)</td><td><u>P2-01</u> - collected directly from roll-off, brownish-green mixed with a white and green layer</td></tr>
</table>

<table>
<tr><th>Pollution Prevention Practices</th><th>Sample Characteristics (Dry wt.)</th></tr>
<tr><td><u>SPENT PLATING SOLUTIONS</u>
Filtration - seals, anodize, sulfamate/electroless Ni, Cu, Cd
Carbon Treatment on CN rinses, periodically on sulfamate nickel
Replenishment - process tanks have drag-out w/ replenishment of Cd, Cu, Cr, anodize
Purified Water - RO/DI, not all rinse tanks use purified water
Electrolytic Dummying - Woods Ni, strike, sulfamate Ni, Cr anodize, Cr plate, Cu
Precipitation - hard Cr - BaCl2 precipitates sulfate
Monitoring - wet lab/computerized cleaners-chronological
Drag-in Reduction - training on rinsing, minimum of 2 counterflow rinses
Purer Anodes and Bags - already employed (Cd 99.999%) - all highest grade
Ventilation/Exhaust Systems - Cr scrubber reused for evaporation losses
Solvent Degreasing Alternatives - use vapor degreaser - not using perchloroethylene, but instead a brominated solvent
Acid Purification - chromic acid purification (hard chrome). Uses EcoTech system

<u>DRAG-OUT REDUCTION/RECOVERY</u>
Process Bath Operating Concentration - chromic acid concentrations have been looked at to reduce drag-out - limitations due to specs
Workpiece positioning - racking
Withdrawal and Drainage Time - spraying over bath
Spray or Fog Rinses over drag-out tanks
Spent Plating Solutions - Replenishment

<u>RINSE WATER</u>
Spray Rinse/RinseWater Agitation - air agitation in some tanks
Increased Contact Time/Multiple Rinses
Countercurrent Rinsing
Flow Restrictors in all cases
Conductivity-Actuated Flow Control - all rinses are conductivity/pH controlled via lab
Rinse Water - recycling/recovery of CN rinses</td><td>P2 - 01
<u>Total</u> (mg/kg)
Al -72,300
Sb - ND
As - 12
Ba - 67
Bi - 71
Cd - 77
Ca -15,800
Cr - 25,700
Hex. Cr - 5
Cu -2,660
Fe - 13,600
Pb - 1,160
Mg - 198,000
Mn - 116
Hg - 0.3
Ni - 4,480
Se - ND
Ag -7
Na - 15,800
Sn -171
Zn - 251
CN - ND

<u>TCLP</u> (mg/l)
As - ND
Ba - ND
Cd - ND
Cr - 0.1
Pb - 0.12
Hg - ND
Se - ND
Ag - ND</td></tr>
</table>

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P3

Plating Process	F006 Quantity and Management	Sample Description
Hard chrome Cu-CN Ag-CN Sulfuric anodizing Chrome anodizing Sulfamate Ni Electroless Ni Bright Ni	37 tons/yr Recycle (Word Resources)	P3-01 - taken from roll-off, blue-greenish color P3-02 - taken from same roll-off, sample collected from obviously different press load - brownish-green in color

Pollution Prevention Practices	Sample Characteristics (Dry wt.)	
SPENT PLATING SOLUTIONS Filtration on all process tanks Carbon treatment used in regular filters Replenishment Purified water - RO/DI Electrolytic Dummying - Ag/Nickel baths Cyanide Bath Carbonate Freezing - precipitate AgCN from bath Precipitation - precipitate Al out of anodize bath Monitoring - most tanks weekly - either scheduled or monitored replacements Housekeeping - tank covers, clean anode/cathode bars Drag-in Reduction - Counter Flow rinses Purer Anodes and Bags - already using high purity Ni/Cu/Ag Hexavalent Chrome Alternatives - MILSPEC, etc. limits options Non-cyanide Process Chemicals - MILSPEC limitations, also would need to redo permit to use these chemistries Solvent Degreasing Alternatives - used to use Vapor degreaser (perchloroethylene) switched ~1995 to aqueous-based Alkaline Cleaners - skimming on semi-aqueous cleaners (alkaline based) Acid Purification - chrome baths - constant ion exchange, after 8 days, baths are "dead" and are diluted by half and run through ion exchange, then evaporated to working concentration (can recover ~98% of original bath) DRAG-OUT REDUCTION/RECOVERY Wetting Agents - some tanks have agents (Cu, Ni, fume suppressant-mist control) Workpiece Positioning - incorporated (optimization between drag-out and throwing power) Withdrawal and Drainage Time - operator subjective (training) Spray or Fog Rinses in chrome baths - RO water spray Drag-out Tanks - Ag tanks, chromic anodize, 3 rinse on chrome tank, replenish bath RINSE WATER Spray Rinse/Rinse Water Agitation - some rinses have air agitation Increased Contact Time/Multiple Rinses Countercurrent Rinsing	**P3 - 01** Total (mg/kg) Al - 76,100 Sb - ND As - 11 Ba - 686 Bi - 19 Cd - 5 Ca - 35,300 Cr - 205,000 Hex. Cr - 8 Cu - 5,670 Fe - 6,450 Pb - 191 Mg - 15,500 Mn - 183 Hg - ND Ni - 4,400 Se - ND Ag -23 Na -15,600 Sn -382 Zn - 7,390 CN - 2.4 TCLP (mg/l) As - ND Ba - ND Cd - ND Cr - 0.92 Pb - 0.06 Hg - 0.003 Se - ND Ag - ND	**P3 - 02** Total (mg/kg) Al - 74,500 Sb - ND As - 12 Ba - 371 Bi - 29 Cd - 30 Ca - 63,300 Cr - 118,000 Hex. Cr - 11 Cu - 11,500 Fe - 7,990 Pb - 500 Mg - 30,300 Mn - 184 Hg - ND Ni - 4,390 Se - ND Ag - 1,190 Na - 19,800 Sn - 182 Zn - 29,100 CN - 579 TCLP (mg/l) As - ND Ba - ND Cd - 0.02 Cr - 0.56 Pb -ND Hg - ND Se - ND Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P4

Plating Process	F006 Quantity and Management	Sample Description
Ni-Cr on steel Hard chrome on steel Cu-CN Sulfuric acid anodizing	85 tons/yr Subtitle C Landfill	P4-01 - collected directly from roll-off, reddish-brown in color

Pollution Prevention Practices	Sample Characteristics (Dry wt.)
SPENT PLATING SOLUTIONS Replenishment on all tanks Purified Water - DI water Electrolytic Dummying - hard chrome (regeneration automatically in tank) Monitoring once a week Housekeeping - training for drag-out, air drying Ventilation/Exhaust Systems Nonchelated Process Chemistries - segregate chelating chemistries, investigated material substitutions Solvent Degreasing Alternatives - all cleaning is aqueous based DRAG-OUT REDUCTION/RECOVERY Wetting Agents - exploring with vendor Workpiece Positioning Withdrawal and Drainage Time - procedures set guideline Drainage boards and drag-out tanks Drag-out used as make-up in baths RINSE WATER Spray Rinse/Rinse Water Agitation - air and water agitation Increased Contact Time/Multiple Rinses Countercurrent Rinsing Rinse Water - counterflow recycling/recovery Spent Process Baths - a portion of FeCl is used in Waste water treatment for flocculation	**P4 - 01** Total (mg/kg): Al - 2,180; Sb - ND; As - 10; Ba - 49; Bi - ND; Cd - ND; Ca -15,700; Cr - 5,680; Hex. Cr - 75; Cu - 417; Fe - 560,000; Pb - 80; Mg - 6,310; Mn - 2,070; Hg - ND; Ni - 1,530; Se - ND; Ag - ND; Na - 6,700; Sn - 38; Zn - 258; CN - ND TCLP (mg/l): As - ND; Ba - ND; Cd - ND; Cr - ND; Pb - ND; Hg - ND; Se - ND; Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities Facility P5		
Plating Process	**F006 Quantity and Management**	**Sample Description**
Hard chrome Sulfamate Ni Cu-CN Ag-CN Aluminum anodizing	50 tons/yr Subtitle C Landfill	P5-01 - composited a variety of different press loads into a single sample, colors ranged from dark brown to light brown to greenish-brown
Pollution Prevention Practices		**Sample Characteristics** (Dry wt.)
SPENT PLATING SOLUTIONS Filtration of most baths Replenishment of most baths Purified Water - RO/DI Electrolytic Dummying - hard chrome Cyanide Bath Carbonate Freezing for all CN plating ($CaCO_3$ drops out) Monitoring - wet chemistry - all changes are based on testing Housekeeping - designated bath maintenance person Ventilation/Exhaust Systems - scrubbers segregated as well Nonchelated Process Chemistries - segregated (electroless Ni) Solvent Degreasing Alternatives - all cleaning aqueous based Alkaline Cleaners - coalesce/disk filter to remove contaminants DRAG-OUT REDUCTION/RECOVERY Wetting Agents Workpiece positioning Withdrawal and Drainage Time - SOP's Air Knives - some used for drying Spray or Fog Rinses - some drag-out tanks have spray rinse Drainage boards and drag-out tanks Sent back for replenishment of plating baths RINSE WATER Spray Rinse/Rinse Water Agitation - air agitation Increased Contact Time/Multiple Rinses Countercurrent Rinsing Flow restrictors set at 5 gpm (timed) Spent Process Baths - copper alkaline strip recycled/recovered off-site at a smelter Solvents - oil based wax removal sent off site for fuel blending		**P5 - 01** Total (mg/kg) / TCLP (mg/l) Al - 2,270 / As - ND Sb - ND / Ba - ND As - 160 / Cd - ND Ba - 387 / Cr - 1.06 Bi - ND / Pb - ND Cd - 806 / Hg - ND Ca - 29,300 / Se - ND Cr - 206,000 / Ag - ND Hex. Cr - 77 Cu - 23,500 Fe - 35,200 Pb - 377 Mg - 31,300 Mn - 556 Hg - ND Ni - 10,300 Se - ND Ag - 457 Na - 15,300 Sn - 546 Zn - 291 CN - 102

Table 17 (cont’d): Facility-Specific Information for Phoenix Facilities
Facility P6

Plating Process	**F006 Quantity and Management**	**Sample Description**
Cu sulfate Hard chrome Cyanide-based brass	~590 tons/yr Recycle (World Resources)	P6-01 - “fresh” sludge sample from roll-off currently in use(sludge dropped that day), sludge was a mixture of bluish and dark brown P6-02 - “old” sludge from hopper accumulated the previous week, appeared brownish

Pollution Prevention Practices
SPENT PLATING SOLUTIONS Filtration on all baths - cartridge, bags, and diatomaceous earth filters Carbon Treatment - electroforming Replenishment - continuous circulation Purified Water - RO Monitoring - on-line XRF, wet lab Drag-in Reduction - multiple rinses, squeegees Ventilation/Exhaust Systems Non-cyanide Process Chemicals - looking at material substitutions Caustic Etch Solution Regeneration - plate-out removes all copper Acid Purification - filtration DRAG-OUT REDUCTION/RECOVERY Spray or Fog Rinses - some replenish to prior tank All Drag-Out to Waste Water Treatment RINSE WATER Spray Rinse/Rinse Water Agitation Increased Contact Time/Multiple Rinses Flow Restrictors - some used but operators can adjust flow manually Conductivity-Actuated Flow Control Spent Process Baths - Recycling/Recovery of electroforming bath - Solvent Extraction of copper off-site

Sample Characteristics (Dry wt.)

P6 - 01	**P6 - 02**
Total (mg/kg)	Total (mg/kg)
Al - 511	Al - 233
Sb - 221	Sb - 153
As - 8,780	As - 5,600
Ba - 67	Ba - 11
Bi - ND	Bi - ND
Cd -3	Cd - ND
Ca -1,440	Ca - 1,980
Cr -10,000	Cr - 7,820
Hex. Cr - 548	Hex. Cr - 466
Cu -552,000	Cu - 463,000
Fe - 6,650	Fe - 2,670
Pb - 19,800	Pb - 14,800
Mg - 1,320	Mg - 1,590
Mn - 72	Mn - 24
Hg - ND	Hg - ND
Ni - 99	Ni - 51
Se - ND	Se - ND
Ag -3	Ag - ND
Na - 60	Na - 25
Sn - 3,570	Sn - 3,850
Zn - 31,600	Zn - 24,600
CN - 169	CN - 127
TCLP (mg/l)	TCLP (mg/l)
As - ND	As - ND
Ba - ND	Ba - ND
Cd - 0.02	Cd - 0.03
Cr - ND	Cr - ND
Pb - 35.40	Pb - 39.80
Hg - ND	Hg - ND
Se - ND	Se - ND
Ag - ND	Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P8

Plating Process	**F006 Quantity and Management**	**Sample Description**
Electroless Cu Acid Cu Ni sulfamate Au-CN Tin-lead-copper	64 tons/yr Recycle (World Resources)	P8-01 - sample collected directly from hopper, appeared brownish in color and was dropped that day

Pollution Prevention Practices	**Sample Characteristics** (Dry wt.)	
SPENT PLATING SOLUTIONS Filtration on acid Cu, Au, Ni, black oxide, pre-cleaning lines Carbon Treatment on acid Cu/Sn-Pb/Au, Ni Purified Water - RO/UV/ion exchange - incoming water Electrolytic Dummying - acid Cu primarily (Sn) Monitoring - lab does chemical maintenance - computer controlled (staff monitors) Housekeeping - drip trays, daily inspection Drag-in Reduction - manual lines - training Ventilation/Exhaust Systems - fume scrubbers on roof, ventilation on tanks that are heated Alkaline cleaners - Filtration and Skimming DRAG-OUT REDUCTION/RECOVERY Process Bath Operating Concentration - standard and well addressed Process Bath Operating Temperature - already optimized Air Knives and squeegee rollers Spray or Fog Rinses Drainage Boards - drip pads between tanks Drag-Out Tanks RINSE WATER Spray Rinse/Rinse Water Agitation - air agitation on a few tanks Countercurrent Rinsing - used in all processes Flow restrictors isolated and operator controlled Spent Process Baths - ammonium hydroxide etching recycled off site	**P8 - 01** Total (mg/kg) Al - 60,800 Sb - ND As - 3 Ba - 125 Bi - ND Cd - ND Ca - 9,710 Cr - 248 Hex. Cr - ND Cu - 124,000 Fe - 50,900 Pb - 3,610 Mg - 6,620 Mn - 496 Hg - 0.3 Ni - 2,900 Se - ND Ag - 835 Na - 2,050 Sn - 14,700 Zn - 782 CN - ND	 TCLP (mg/l) As - ND Ba - 1.5 Cd - ND Cr - 0.02 Pb - 0.64 Hg - ND Se - ND Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P9

Plating Process	F006 Quantity and Management	Sample Description
Copper sulfate Nickel sulfate Au immersion (CN) Tin Electrolytic Au (CN) Electroless nickel	109 tons/yr Recycle (World Resources)	P9-01 - chelate sludge sampled directly from small hopper prior to moving to final storage roll-off where commingled with non-chelate sludge P9-02 - non-chelate sludge sampled directly from final storage hopper avoiding chelate sludge (some minor mixing of the two occurred)

Pollution Prevention Practices
SPENT PLATING SOLUTIONS Particulate filtration Carbon treatment Replenishment Purified Water - RO/DI Electrolytic Dummying - Ni/Cu Monitoring - AA testing, titrations, and microetch Cu testing Housekeeping Drag-in Reduction Purer Anodes and Bags are already implemented (function of industry) Ventilation/Exhaust Systems Nonchelated Process Chemistries - chelating chemistries are segregated Solvent Degreasing Alternatives - removed vapor degreaser Caustic Etch Solution Regeneration - Cu Ammonium chlorite recycled off site DRAG-OUT REDUCTION/RECOVERY Process Bath Operating Concentration - optimized Process Bath Operating Temperature - optimized Wetting Agents - Ni and Cu bath Workpiece Positioning - looking at positioning sheets at 10° drip angle Withdrawal and Drainage Time - automatic lines are programmed with dwell and rate of removal Air Knives and squeegees on conveyors Spray or Fog Rinses Drainage Boards - used some in electrolytic gold and used in conveyors Drag-Out Tanks Evaporation - Ni drag-out replenished to Ni plate bath RINSE WATER Spray Rinse/Rinse Water Agitation Increased Contact Time/Multiple Rinses Countercurrent Rinsing Flow Restrictors Conductivity-Actuated Flow Control - used on large Cu-Tin line Rinse Water - approximately 30 to 35% of total flow is recycled Spent Process Baths - Au recovered on site

Sample Characteristics (Dry wt.)

P9 - 01	**P9 - 02**
Total (mg/kg)	Total (mg/kg)
Al - 4,110	Al - 59
Sb - 44	Sb - ND
As - 26	As - 9
Ba - 40	Ba - 9
Bi - 21	Bi - ND
Cd - ND	Cd - ND
Ca - 6,880	Ca - 682
Cr - 100	Cr - 34
Hex. Cr - ND	Hex. Cr - 31
Cu - 48,700	Cu - 631,000
Fe - 204,000	Fe - 364
Pb - 1,660	Pb - ND
Mg - 10,700	Mg - 230
Mn - 191	Mn - 104
Hg - ND	Hg - ND
Ni - 1,990	Ni - 10,800
Se - ND	Se - ND
Ag - 38	Ag - 12
Na - 36,900	Na - 41,600
Sn - 37,200	Sn - 402
Zn - 389	Zn - 2.750
CN - 9.1	CN - ND
TCLP (mg/l)	TCLP (mg/l)
As - ND	As - ND
Ba - ND	Ba - ND
Cd - ND	Cd - ND
Cr - ND	Cr - ND
Pb - ND	Pb - 0.08
Hg - ND	Hg - ND
Se - ND	Se - ND
Ag - ND	Ag - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P11

Plating Process	F006 Quantity and Management	Sample Description
Acid Cu Ni sulfate Tin-Pb Acid Tin Au -CN	~4 tons/yr Recycle (World Resources)	P11-01 - sludge from supersack

Pollution Prevention Practices	Sample Characteristics (Dry wt.)
SPENT PLATING SOLUTIONS Filtration on all process baths Carbon treatment on acid-Cu quarterly and others periodically Replenishment of baths with drag-out Purified water - use deionized water Electrolytic dummying periodically Monitoring via wet lab (pH, titration); baths replaced based on sq. ft. plated Drag-in reduction - drain times/dwell times Segregate chelating process chemistries (magnesium sulfate used on a batch-by-batch basis) Solvent degreasing alternatives - all cleaners are aqueous-based Alkaline cleaners - resist strip is filtered DRAG-OUT REDUCTION/RECOVERY Workpiece positioning - racks are coated Optimize withdrawal and drainage time Use squirt bottles for rinsing Au/Ni solution back into bath Utilize Drag-out tanks Some drag-out tanks are used to replenish hot plating baths RINSE WATER Spray rinse/rinse water agitation Increased contact time/multiple rinses Countercurrent rinsing Flow restrictors Conductivity-actuated flow control Recycling/recovery of rinse water - closed-loop on metal-bearing rinses	**P11 - 01** Total (mg/kg) — TCLP (mg/l) Al - 819 — As - ND Sb - ND — Ba - ND As - ND — Cd - ND Ba - 17 — Cr - ND Bi - ND — Pb - 0.13 Cd -ND — Hg - ND Ca -11,400 — Se - ND Cr - 119 — Ag - ND Hex. Cr - ND Cu - 125,000 Fe - 75,800 Pb - 6,080 Mg - 72,600 Mn - 2,080 Hg - ND Ni - 1,030 Se - ND Ag - 14 Na - 13,400 Sn - 131,000 Zn - 820 CN - ND

Table 17 (cont'd): Facility-Specific Information for Phoenix Facilities
Facility P13

Plating Process	F006 Quantity and Management	Sample Description
Copper (CN) Au-CN Ni	~4 tons/yr Recycle (World Resources)	P13-01 - "old" sample collected from top of superbag, appeared dry, and dense P13-02 - "fresh" sample collected directly from small hopper under filter press

Pollution Prevention Practices

SPENT PLATING SOLUTIONS
Filtration
Carbon Treatment for alkaline rinse
Purified Water - DI system
Electrolytic Dummying - Ni baths
Monitoring via in-house lab - conductivity on rinse tanks, going to add turbidity monitor to alkaline rinse
Housekeeping - process tanks are covered at end of the day and also replace baths chronologically visually
Drag-in Reduction - spray rinses with double dipping
Ventilation/Exhaust Systems
Nonchelated Process Chemistries - electrowinning helps, and add reducing agents

DRAG-OUT REDUCTION/RECOVERY
Workpiece Positioning - looking into new racks
Withdrawal and Drainage Time - subject to plater on manual lines (Au racks are left to sit ~10 minutes)
Spray or Fog Rinses - stagnant spray rinses (with water)
Drag-Out Tanks
Electrowinning - Ni, Cu

RINSE WATER
Spray Rinse/RinseWater Agitation - air agitation
Increased Contact Time/Multiple Rinses
Countercurrent Rinsing
Flow Restrictors - spray rinses
Conductivity-Actuated Flow Control - conductivity meters, but not controlled because generate too much water
Rinse Water - Ni rinse with ion exchange is recycled

Sample Characteristics (Dry wt.)

P13 - 01	**P13 - 02**
Total (mg/kg)	Total (mg/kg)
Al - 1,370	Al - 2,860
Sb - 34,800	Sb - 1,250
As - ND	As - 10
Ba - 253	Ba - 198
Bi - 398	Bi - 32
Cd - ND	Cd - 3
Ca - 2,690	Ca - 143,000
Cr - 29	Cr - 170
Hex. Cr - ND	Hex. Cr - ND
Cu -3,660	Cu - 6,430
Fe - 3,500	Fe - 17,100
Pb - 175,000	Pb - 13,000
Mg - 187	Mg - 2,640
Mn - 13	Mn - 92
Hg - 0.5	Hg - 0.4
Ni - 2,420	Ni - 71,900
Se - ND	Se - ND
Ag - 113	Ag - 40
Na - 310	Na - 5,660
Sn - 467,000	Sn - 15,300
Zn - 672	Zn - 357
CN - ND	CN - ND
TCLP (mg/l)	TCLP (mg/l)
As - ND	As - ND
Ba - ND	Ba - ND
Cd - 0.1	Cd - ND
Cr - ND	Cr - ND
Pb - 1,630	Pb - 1.26
Hg - ND	Hg - ND
Se - ND	Se - ND
Ag - ND	Ag - ND

Table 18: Summary of Phoenix F006 Analytical Data: # of Samples Which Were: Not Detected; Above Method Quantitation Limit			
Constituent	**# Samples (%)**	**# Non Detects (%)**	**# Samples Above Method Quantitation Limit (%)**
Total Metals Concentration (mg/kg)			
Aluminum	15	0(0%)	15(100%)
Antimony	15	10(67%)	5(33%)
Arsenic	15	2(13%)	13(87%)
Barium	15	0(0%)	15(100%)
Beryllium	0	0	0
Bismuth	15	9(60%)	6(40%)
Cadmium	15	9(60%)	6(40%)
Calcium	15	0(0%)	15(100%)
Chromium	15	0(0%)	15(100%)
Copper	15	0(0%)	15(100%)
Iron	15	0(0%)	15(100%)
Lead	15	1(7%)	14(93%)
Magnesium	15	0(0%)	15(100%)
Manganese	15	0(0%)	15(100%)
Mercury	15	11(73%)	4(27%)
Nickel	15	0(0%)	15(100%)
Selenium	0	0	0
Silver	15	2(13%)	13(87%)
Sodium	15	0(0%)	15(100%)
Tin	15	0(0%)	15(100%)
Zinc	15	0(0%)	15(100%)
TCLP (mg/l)			
Arsenic	0	0	0
Barium	8	7(87%)	1(13%)
Cadmium	15	11(73%)	4(27%)
Chromium	15	10(67%)	5(33%)
Lead	15	4(27%)	11(73%)
Mercury	7	6(86%)	1(14%)
Selenium	0	0	0
Silver	0	0	0
General Chemistry (mg/kg)			
Chloride	15	0(0%)	15(100%)
Fluoride	15	1(7%)	14(93%)
Chromium, hexavalent	15	7(46%)	8(54%)
Total Cyanide	15	8(54%)	7(46%)
Amenable Cyanide	15	1(7%)	14(93%)
Percent Solids	15	0(0%)	15(100%)

Table 19: Detailed Analytical Data for the Phoenix Facilities

Constituent	CAS No.	P1-01	P1-02	P2-01	P3-01	P3-02	P4-01	P5-01
Total Metals - Methods 6010A, 7471A, 7060A, 7421, 7740 mg/kg								
Aluminum	7429905	3,420	44,700	72,300	76,100	74,500	2,180	2,270
Antimony	7440360	ND	ND	ND	ND	ND	ND	ND
Arsenic	7440382	2	8	12	11	12	10	16
Barium	7440393	6	22	67	686	371	49	387
Beryllium	7440417	ND	ND	ND	ND	ND	ND	ND
Bismuth	7440699	ND	ND	71	19	29	ND	ND
Cadmium	7440439	ND	ND	77	5	30	ND	806
Calcium	7440702	15,100	15,300	15,800	35,300	63,300	15,700	29,300
Chromium	7440473	10	23	25,700	205,000	118,000	5,680	206,000
Copper	7440508	7,690	28,100	2,660	5,670	11,500	417	23,500
Iron	7439896	5,050	4,020	13,600	6,450	7,990	560,000	35,200
Lead	7439921	2,590	194	1,160	191	500	80	377
Magnesium	7439954	319,000	245,000	198,000	15,500	30,300	6,310	31,300
Manganese	7439965	101	288	116	183	184	2,070	556
Mercury	7439976	ND	ND	0.3	ND	ND	ND	ND
Nickel	7440020	3,080	4,450	4,480	4,400	4,390	1,530	10,300
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	8	22	7	23	1,190	ND	457
Sodium	7440235	4,050	4,780	15,800	15,600	19,800	6,700	15,300
Tin	7440315	2,370	1,710	171	382	182	38	546
Zinc	7440666	57	190	251	7,390	29,100	258	291
TCLP Metals - Methods 1311, 6010A, 7470A mg/L								
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND
Cadmium	7440439	ND	ND	ND	ND	0.02	ND	ND
Chromium	7440473	ND	ND	0.1	0.92	0.56	ND	1.06
Lead	7439921	0.12	0.08	0.12	0.06	ND	ND	ND
Mercury	7439976	ND	ND	ND	0.003	ND	ND	ND
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	ND	ND	ND	ND	ND	ND	ND
General Chemistry - Methods 300.0, 335.2, 335.1, 7195/6010A mg/kg								
Chloride	16887006	542	3,950	451	430	566	8,120	4,790
Fluoride	16984488	49.5	804	782	3,090	4,240	ND	161
Hex. Chromium	18540299	ND	ND	5	8	11	75	77
Total Cyanide	57125	ND	ND	1.1	2.4	579	ND	102
Amen. Cyanide	E-10275	**13.3	**89.7	**8.4	**7	**809	ND	**156
Percent Solids		60.1	30.1	27.3	27.8	20.9	28	28.5

Notes: ND - not detected *All results reported on a dry-weight basis.
**Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.

Table 19 (con't): Detailed Analytical Data for the Phoenix Facilities									
Constituent	CAS No.	P6-01	P6-02	P8-01	P9-01	P9-02	P11-01	P13-01	P13-02
Total Metals - Methods 6010A, 7471A, 7060A, 7421, 7740 mg/kg									
Aluminum	7429905	511	233	60,800	4,110	59	819	1,370	2,860
Antimony	7440360	221	153	ND	44	ND	ND	34,800	1,250
Arsenic	7440382	8,780	5,600	3	26	9	ND	ND	10
Beryllium	7440417	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	67	11	125	40	9	17	253	198
Bismuth	7440699	ND	ND	ND	21	ND	ND	398	32
Cadmium	7440439	3	ND	ND	ND	ND	ND	ND	3
Calcium	7440702	1,440	1,980	9,710	6,880	682	11,400	2,690	143,000
Chromium	7440473	10,000	7,820	248	100	34	119	29	170
Copper	7440508	552,000	463,000	124,000	48,700	631,000	125,000	3,660	6,430
Iron	7439896	6,650	2,670	50,900	204,000	364	75,800	3,500	17,100
Lead	7439921	19,800	14,800	3,610	1,660	ND	6,080	175,000	13,000
Magnesium	7439954	1,320	1,590	6,620	10,700	230	72,600	187	2,640
Manganese	7439965	72	24	496	191	104	2,080	13	92
Mercury	7439976	ND	ND	0.3	ND	ND	ND	0.5	0.4
Nickel	7440020	99	51	2,900	1,990	10,800	1,030	2,420	71,900
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	3	ND	835	38	12	14	113	40
Sodium	7440235	60	25	2,050	36,900	41,600	13,400	310	5,660
Tin	7440315	3,570	3,850	14,700	37,200	402	131,000	467,000	15,300
Zinc	7440666	31,600	24,600	782	389	2,750	820	672	357
TCLP Metals - Methods 1311, 6010A, 7470A mg/L									
Arsenic	7440382	ND	ND	ND	ND	ND	ND	ND	ND
Barium	7440393	ND	ND	1.5	ND	ND	ND	ND	ND
Cadmium	7440439	0.02	0.03	ND	ND	ND	ND	0.1	ND
Chromium	7440473	ND	ND	0.02	ND	ND	ND	ND	ND
Lead	7439921	35.4	39.8	0.64	ND	0.08	0.13	1,630	1.26
Mercury	7439976	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	7782492	ND	ND	ND	ND	ND	ND	ND	ND
Silver	7440224	ND	ND	ND	ND	ND	ND	ND	ND
General Chemistry - Methods 300.0, 335.2, 335.1, 7195/6010A mg/kg									
Chloride	16887006	1,630	1,490	590	2,250	24,000	4,110	64	905
Fluoride	16984488	ND	ND	100	3,090	ND	ND	ND	ND
Hex. Chromium	18540299	548	466	ND	ND	31	ND	ND	ND
Total Cyanide	57125	169	127	ND	9.1	ND	ND	ND	ND
Amen. Cyanide	E-10275	**359	**369	**3.9	**75.1	**20.8	**16.6	**14.7	**39.4
Percent Solids		27.5	29.3	34.4	34.9	27.2	45.2	94.1	41.1

Notes: ND - not detected *All results reported on a dry-weight basis.
**Reported value is the concentration of cyanide after chlorination. Since this value is greater than the total cyanide result, a value for the cyanide amenable to chlorination cannot be calculated.

4. Detailed Results of the National Benchmarking Study

Tables 20- 32 present detailed results of the National Benchmarking Study. The data gathered is similar in type but is often less detailed than the data gathered in the Regional Benchmarking Study. Data categories include: metal finishing operations, pollution prevention practices, F006 characteristics and sludge management practices from a broad range of metal finishers (Appendix G contains the survey instrument). The survey was distributed by mail to member companies of NAMF and AESF, and at a metal finishers national technical conference (SURFIN 97). In all, nearly 2,000 surveys were distributed. One hundred eighty-six (186) responses were received and compiled into a computer data base. A variety of firms responded. The number of employees of respondents ranged from 4 to 7,250 with an average of 229. The survey question number is indicated in the summaries below in [brackets].

a. Characterization of the Survey Respondents

Average number of employees responding:	229
Maximum number of employees responding:	7,250
Minimum number of employees responding:	4

A total of 186 surveys were received.

Number of respondents to this question: 171 / 186 = 92 %

b. Product and Waste Stream Characterization [C1]

Respondents reported product weight using different units:
Average of the responses reported in cubic yards : 60,867 tons
Average of the responses reported in barrel loads: 150,000 barrel loads

Number of responses to this question: 88 / 186 = 47%

c. Total quantity of F006 waste generated in 1996 [C4]

Average of reponses reported in tons: 1016 tons

Number of responses to this question: 161 / 186 = 87%

d. F006 segregation [C2]

Facilities reporting that F006 wastes are combined in the wastewater:	139
Facilities reporting that F006 wastes are process-specific:	22

Number of responses to this question: 161 / 186 = 87%

e. Cyanide sludge segregation [C3]

Facilities reporting that cyanide-bearing F006 sludges are segregated:	33
Facilities reporting that cyanide-bearing F006 sludges are not segregated:	151

Number of responses to this question: 184 / 186 = 99%

f. Quantity of F006 waste generated by process [C5]

Respondents reported generating an average 1,016 tons of F006 sludge annually. As noted in the statistical analysis section, larger companies tended to respond more than smaller companies. A summary of F006 sludge generated by groups of plating processes is provided in Table 20. Table 21 presents the estimates of process-specific F006 waste generation for 1996. The quantities assume that all units are equivalent (e.g., cubic yards and dry tons).

Table 20: Summary of F006 Sludge Generation by Plating Category

Plating Category	Quantity (dry tons)
Mixed Acids	118750.47
Anodizing	19.05
Bright Dip of Copper/alloy	74.82
Cadmium	6373.50
All Chrome	55467.93
Cleaner	122.65
All Copper	7419.35
All Cyanide	8328.32
All Electroless Nickel	14.88
All Ion Exchange	14.42
All Nickel	23019.36
Silver Plate	75.65
Stainless Electropolish	68.63
Tin	51.45
All Zinc	15938.36

Table 21. Process-Specific F006 Waste Generation for 1996

Facility	Process	Quantity	Measure
027	Not available	1.00	Cubic Yards
064	Not available	30.30	Dry Tons
022	Not available		Dry Tons
016	Not available	0.56	Dry Tons
016	Not available	0.14	Dry Tons
078	ABS/Steel Chromium plating	78.47	Dry Tons
123	acid	80.00	Cubic Yards
037	acid batch treat	0.13	Dry Tons
090	acid copper	6.04	Dry Tons
037	acid rinses	26.50	Dry Tons
083	acid-alkali wastewater	118388.00	Dry Tons
145	acid-chloride zinc	90.00	Dry Tons
075	acid/alkaline	141.84	Long Tons
023	acid/alkaline rinses	17.97	Metric Tons
001	alum treating	8.00	Dry Tons
036	anodizing	0.50	Cubic Yards
148	anodizing	1.00	Cubic Yards
146	anodizing	7.50	Dry Tons
144	sulfuric acid anodizing	0.05	Dry Tons
174	Sulfuric Anodize/Hardcoat	2.00	Dry Tons
144	bright dip of copper/alloys	6.00	Dry Tons
035	black oxide	25.00	Cubic Yards
112	brass plating	0.50	Dry Tons

Table 21. Process-Specific F006 Waste Generation for 1996			
Facility	**Process**	**Quantity**	**Measure**
138	brass waste treatment	40.60	Dry Tons
057	bright dip of copper/alloy	0.13	Dry Tons
156	bright dip of copper/alloy	2.60	Dry Tons
155	bronze line cleaner side overflowing rinse	10.00	Dry Tons
027	cadmium	1.00	Cubic Yards
026	barrel cadmium	3126.00	Dry Tons
173	cadmium	1.00	Dry Tons
066	cadmium	26.00	Cubic Yards
057	cadmium plating	0.50	Dry Tons
120	cadmium plating	14.00	Dry Tons
114	cadmium and other processes	14.00	Dry Tons
133	cyanide cadmium plating	55.00	Cubic Feet
026	rack cadmium	3126.00	Dry Tons
119	chelate	20.00	Dry Tons
048	chromating	3.22	Dry Tons
119	chrome	15.00	Dry Tons
096	chrome	8.10	Dry Tons
075	chrome	54.75	Long Tons
065	chrome anodize	1.50	Dry Tons
080	chrome hydroxide	55.70	Dry Tons
183	chrome plate	10245.00	Dry Tons
038	chrome plating	1.00	Dry Tons
051	chrome plating	10.92	Dry Tons
059	chrome plating and chromating	61.00	Cubic Yards
082	chrome plating and chromating	43.75	Dry Tons
023	chrome rinses	5.39	Metric Tons
134	chrome rinses	46.50	Dry Tons
085	chrome/nickel	155.50	Dry Tons
054	chromic anodize	16.00	Dry Tons
174	chromic anodize	0.25	Dry Tons
090	chromium	9.98	Dry Tons
058	chromium	0.99	Dry Tons
083	chromium contaminated wastewater	35687.00	Dry Tons
049	hard chrome	7508.00	Dry Tons
046	hard chrome	7.38	Dry Tons
034	hard chrome	7.00	Dry Tons
039	hard chrome plating	1500.00	Cubic Feet
174	Conversion Coating	0.25	Dry Tons
148	conversion coatings	2.00	Cubic Yards
156	Chromate conversion on aluminum	1.75	Dry Tons
116	cleaner tank bottoms	0.15	Dry Tons
141	cleaning	5.00	Dry Tons
104	cleaning (soap and acid); aluminum cleaning	10.00	Dry Tons
004	cleaning rinses	93.50	Dry Tons
185	batch treats(cleaners & Microetch)	14.00	Dry Tons

Table 21. Process-Specific F006 Waste Generation for 1996			
Facility	**Process**	**Quantity**	**Measure**
110	copper nickel plating	75.00	Dry Tons
042	copper	5.51	Dry Tons
021	copper & brass	2.60	Dry Tons
112	copper nickel chrome plating on non ferrous	40.00	Dry Tons
112	copper nickel chrome plating on steel	0.50	Dry Tons
183	copper plate	657.00	Dry Tons
061	copper plate	40.00	Dry Tons
036	copper plate	0.50	Cubic Yards
057	copper plating	0.13	Dry Tons
082	copper plating	27.50	Dry Tons
136	copper, nickel, chromium on steel	23.00	Dry Tons
145	copper-nickel-chrome	9.00	Dry Tons
053	copper/ni/chrome on ABS	140.00	Dry Tons
027	copper/nickel/chrome	2.00	Cubic Yards
016	copper/nickel/chrome	6.30	Dry Tons
049	copper/nickel/chrome	6000.00	Dry Tons
170	copper/nickel/chrome decorative plating	42.00	Cubic Yards
157	copper/nickel/chrome plating on plastic	300.00	Dry Tons
014	Cu, Ni, Cr	23.50	Dry Tons
137	Cu/Ni/Cr on non-ferrous	5.55	Dry Tons
090	cyanide copper	4.03	Dry Tons
147	cyanide copper plating on zinc die cast	0.24	Dry Tons
086	cyanide copper/cyanide brass	15.00	Cubic Yards
083	cyanide contaminated wastewater	7930.00	Dry Tons
123	cyanide	200.00	Cubic Yards
119	cyanide	7.50	Dry Tons
075	cyanide	52.26	Long Tons
010	cyanide bearing rinse waters	1.37	Dry Tons
031	Cyanide destruction	3.70	Dry Tons
085	cyanide processes	93.30	Dry Tons
023	cyanide rinses	8.99	Metric Tons
134	cyanide rinses	11.00	Dry Tons
037	cyanide rinses	3.45	Dry Tons
029	misc cyanide wastes	16.75	Dry Tons
055	electroless nickel	1.10	Dry Tons
048	electroless nickel and gold plating	12.88	Dry Tons
038	electroless nickel plating	0.90	Dry Tons
140	hot dip galv	21.00	Dry Tons
117	ion exchange	10.14	Dry Tons
050	ion exchange regen	4.28	Dry Tons
038	iron plating	1.75	Dry Tons
041	lead plating	14.85	Cubic Yards
019	Mn & zinc phosphate	7.00	Dry Tons
137	Ni/Cr on steel	9.25	Dry Tons
096	nickel	0.90	Dry Tons

Table 21. Process-Specific F006 Waste Generation for 1996			
Facility	**Process**	**Quantity**	**Measure**
042	nickel	63.31	Dry Tons
035	nickel	10.00	Cubic Yards
021	nickel	2.00	Dry Tons
173	nickel	2.00	Dry Tons
050	nickel	6.42	Dry Tons
090	nickel	8.42	Dry Tons
010	nickel bearing-acid/alkali rinses	3.00	Dry Tons
036	nickel plate	3.00	Cubic Yards
183	nickel plate(incl. Electroless Nickel)	684.00	Dry Tons
004	nickel plating	25.00	Dry Tons
038	nickel plating	0.40	Dry Tons
033	nickel plating	3.00	Dry Tons
082	nickel plating	37.50	Dry Tons
059	nickel plating	60.00	Cubic Yards
146	nickel plating	0.50	Dry Tons
047	nickel plating	3.00	Dry Tons
065	nickel plating	1.00	Dry Tons
175	nickel plating	21.00	Dry Tons
051	nickel plating	10.49	Dry Tons
012	nickel plating (all types)	30.25	Dry Tons
147	nickel plating on zinc die cast	0.21	Dry Tons
029	nickel plating treatment	11.92	Dry Tons
132	nickel, silver, chrome, tin, and E-coat	1.00	Dry Tons
054	nickel/chrome	10.00	Dry Tons
026	automatic nickel/chrome	18756.00	Dry Tons
173	nickel/chrome	0.50	Dry Tons
100	nickel/chrome plating	1.00	Dry Tons
105	nickel/chrome plating	23.69	Dry Tons
073	nickel/chromium plating	7.05	Dry Tons
080	nickel/copper hyd.	51.80	Dry Tons
071	nickel chromium plating	55.00	Dry Tons
026	barrel nickel	3126.00	Dry Tons
146	passivation	2.00	Dry Tons
066	phosphate	100.00	Cubic Yards
183	Silver Plate	71.00	Dry Tons
111	silver plating operations	2.65	Long Tons
148	silver, tin, electroless nickel	2.00	Cubic Yards
105	stainless electropolish	3.38	Dry Tons
144	stainless steel passivation	0.25	Dry Tons
180	Steel	65.00	Dry Tons
141	stripping	5.00	Dry Tons
021	tin	0.30	Dry Tons
019	tin plating	1.00	Dry Tons
004	tin plating	50.00	Dry Tons
041	tin/lead plating	0.15	Cubic Yards

Table 21. Process-Specific F006 Waste Generation for 1996			
Facility	**Process**	**Quantity**	**Measure**
071	titanium	5.00	Dry Tons
014	zinc	20.00	Dry Tons
084	zinc	15.00	Dry Tons
072	zinc	224.00	Dry Tons
071	zinc	20.00	Dry Tons
066	zinc	126.00	Cubic Yards
027	zinc	1.00	Cubic Yards
021	zinc	76.50	Dry Tons
180	zinc	5.00	Dry Tons
042	zinc	206.44	Dry Tons
148	zinc and cadmium plating	15.00	Cubic Yards
095	zinc cyanide	1.00	Dry Tons
104	zinc cyanide plating and chromate conversion	30.00	Dry Tons
094	zinc electroplating	300.00	Cubic Yards
125	zinc electroplating, zinc nickel alloy electropl.	575.00	Cubic Yards
109	zinc electrotherapy on steel	148.00	Dry Tons
080	zinc hydroxide	57.30	Dry Tons
137	zinc on steel	18.50	Dry Tons
136	zinc on steel	19.50	Dry Tons
144	zinc phosphate	0.05	Dry Tons
061	zinc plate	70.00	Dry Tons
008	zinc plating	5507.20	Dry Tons
140	zinc plating	175.00	Dry Tons
003	zinc plating	5507.20	Dry Tons
065	zinc plating	25.00	Dry Tons
001	zinc plating	5.00	Dry Tons
132	zinc plating	19.00	Dry Tons
082	zinc plating	16.25	Dry Tons
004	zinc plating	150.00	Dry Tons
045	zinc plating	1040.00	Cubic Yards
070	zinc plating	80.00	Cubic Yards
105	zinc plating	40.62	Dry Tons
059	zinc plating	235.00	Cubic Yards
019	zinc plating	300.00	Dry Tons
048	zinc plating	144.90	Dry Tons
100	zinc plating	11.40	Dry Tons
035	zinc plating	200.00	Cubic Yards
012	zinc plating (all types)	60.50	Dry Tons
088	zinc plating on steel	155.00	Dry Tons
120	zinc plating on steel	140.00	Dry Tons
156	zinc plating on steel	83.00	Dry Tons
145	zinc-phosphate	1.00	Dry Tons
098	ZnNi alloy plating & chromating of Zn & ZnNi	7.00	Dry Tons
102	chloride zinc on steel	23.00	Cubic Yards
118	all zinc plating	84.00	Cubic Yards

g. On-site recycling techniques prior to discharge [C6]

Number of responses to this question: 36/186 = 19%

On-site recycling techniques that were mentioned by more than one company:
- Electrowinning
- Counter flow rinsing
- Drag out rinses returned to plating tank
- Electrodialysis
- Evaporation
- Precipitation

Metals that are recovered: brass, cadmium, chrome, copper, nickel, gold, silver.

Table 22 contains individual responses.

Table 22. On-Site Recycling Techniques

Facility	Description	Quantity	Measure
023	BEWT Chemelec Unit, Reverse Cn Stip, Jaynor Units	1.70	Dry Tons
018	brass	0.10	Dry Tons
018	cadmium	0.10	Dry Tons
075	cadmium electrowinning	0.25	Dry Tons
001	chrome recovery	2.00	Dry Tons
110	chromic acid through demineralizes	50.00	Dry Tons
018	copper	0.15	Dry Tons
160	copper grinding swarf	2.50	Dry Tons
157	Corning Evaporators for Chrome Drag-out	75.00	Dry Tons
038	counter flow rinsing chrome plate	1.00	Dry Tons
038	counter flow rinsing nickel plating	0.75	Dry Tons
141	drag out rinses	1.00	Dry Tons
095	drag out tanks used for tank replenishment	1.00	Cubic Yards
098	drag out from plating tanks returned to bath	6.50	Dry Tons
106	electrodialysis of rinsewater	0.25	Dry Tons
124	electroless nickel directly reduced	0.05	Dry Tons
168	electrowinning of gold solutions	500.00	Dry Tons
168	electrowinning of silver solutions	3000.00	Dry Tons
168	electrowinning of solder and tin solutions	1.00	Dry Tons
010	electrowinning-plating cells	0.06	Dry Tons
116	evaporating recovery	0.20	Dry Tons
180	evaporators	30.00	Dry Tons
180	ion exchangers	10.00	Dry Tons
138	metal recovery systems	3.50	Dry Tons
075	nickel evaporation	0.75	Dry Tons
055	nickel plate out from electroless nickel solution	0.05	Dry Tons
157	nickel precipitation as carbonate	35.00	Dry Tons
008	precipitation, filtration, & drying	5507.20	Dry Tons
160	re-sell copper turnings	7.50	Dry Tons

Table 22. On-Site Recycling Techniques			
Facility	**Description**	**Quantity**	**Measure**
041	reclaim tanks (dead rinse) used some solution	104.00	Cubic Feet
009	silver electrowinning	0.25	Dry Tons
093	silver reclaim using plate out unit	0.08	Dry Tons
163	six Eco-tec ion exchange units	4.20	Dry Tons
055	sulfuric acid reclamation from anodize tank		Dry Tons
155	use rinse water from plating side for bath makeup	1.40	Dry Tons
034	washdown from fume scrubbers returned to tank	1.00	Dry Tons

h. Off-site recycling companies [C7]

Number of respondents: 15/186 = 8%

The following processes were used to recycle F006 wastes:
- Blending
- High temperature incineration
- Hydro metallurgical
- Pyrometallurgical
- Smelting
- Thermo concentration and compounding

Off-site recycling companies:
- World Resources Corp
- Horsehead Resource Development Corp
- Encycle/Texas Inc
- 21st Century EMI
- Republic Environmental

Table 23 contains individual responses.

Table 23. Off-Site Recycling Techniques					
Facility	**Process**	**Quantity**	**Measure**	**Name**	**Location**
023	Blending	47.00	Cubic Yards	World Resources	Pottsville, PA
136	high temp incineration	42.50	Dry Tons	Horsehead	Chicago, Il
070	high temp incineration	60.00	Cubic Yards	Horsehead	Chicago, IL
014	high temp incineration	43.50	Dry Tons	Horsehead	Chicago, IL
137	Hydro Metallurgical	37.00	Dry Tons	Encycle/Texas Inc	Corpus Christi, TX
134	Pyrometallurgical	61.80	Dry Tons	Horsehead	Chicago, IL
075	Pyrometallurgical	248.84	Dry Tons	World Resources	Pottsville, PA
050	Pyrometallurgical	14.85	Dry Tons	21st century EMI	Fernly, NV
043	Pyrometallurgical	13.20	Dry Tons	World Resources	Phoenix, AZ
020	Pyrometallurgical	36.00	Dry Tons	Republic Environmental	Hamilton, Ontario
008	Pyrometallurgical	5507.20	Dry Tons	World Resources	Phoenix, AZ

Table 23. Off-Site Recycling Techniques					
Facility	Process	Quantity	Measure	Name	Location
003	Pyrometallurgica	22.00	Long Tons	World Resources	Pheonix, AZ
051	smelting	22.40	Dry Tons	World Resources	Phoenix, AZ
031	thermo concentration and compounding	18.53	Dry Tons	World Resources	Phoenix, AZ
024	thermo concentration and compounding	55.00	Dry Tons	World Resources	Phoenix, AZ

i. Management methods for F006 wastes [C8]

Number of responses: 57

Management methods:
- Incineration
- Neutralization
- Recycling
- Solidification
- Stabilization, landfilling
- Subtitle C landfill

Receiving facilities:
- Envirite
- Wayandot Landfill
- LWD
- Cynochem
- Envotech
- Stablex Canada
- Heritage Environmental
- Threamionic
- Romic Environmental
- Chemical Waste Management
- Peoria Disposal
- LESI
- USPCI
- Cycle Chem
- Northland Environment
- Phillips Environmental
- Chief Supply

Table 24 contains individual responses.

Table 24. Waste Management Methods F006 Wastes					
Mgt	Facility	Quantity	Measure	Name	Location
delisted facility	002	26.00	Cubic Yards	Envirite	Thomaston, CT
delisted facility	170	42.00	Cubic Yards	Wayandot Landfill	Carey, OH 43316
delisted facility	115	24.00	Cubic Yards	Envirite	Canton, OH
delisted facility	125	575.00	Cubic Yards	Envirite of Illinois	Harvey, IL
delisted facility	052	320.20	Dry Tons	Envirite Corporation	Canton, OH
delisted facility	066	100.00	Dry Tons	Envirite	
incineration	029	16.75	Dry Tons	LWD	Calventy City, KY
incineration	133	55.00	Cubic Feet	Cynochem	Detroit, MI
neutralization	152	4850.00	gal	Cyanokem	Detroit, MI
recycle	063	274.50	Dry Tons		
recycle	179	35.01	Dry Tons	World Resource Co.	Pheonix, AZ
Solidification	100	11.50	Dry Tons	Envirite Corp.	Canton, OH
Solidification	108	28.00	Dry Tons	Envotech (EQ)	Belleville, MI

Table 24. Waste Management Methods F006 Wastes					
Mgt	**Facility**	**Quantity**	**Measure**	**Name**	**Location**
Solidification	098	7.00	Dry Tons	Envirite	Canton, OH
Stabilization & fixation	048	154.00	Dry Tons	Stablex Canada, Inc.	Blainville, Quebec, Canada
Stabilization, landfilling	065	1.50	Dry Tons	Heritage- nickel sludge	Indianapolis, IN
Stabilization, landfilling	090	311.95	Dry Tons	Heritage Environmental	Indianapolis, IN
Stabilization, landfilling	065	25.00	Dry Tons	Heritage- zinc hydroxide sludge	Indianapolis, IN
Stabilization, landfilling	065	1.00	Dry Tons	Heritage- chrome sludge	Indianapolis, IN
Stabilization, landfilling	064	30.30	Dry Tons	Envirite Corp.	Canton, OH
Subtitle C Landfill	083	2.20	Dry Tons	Stablex	Canada
Subtitle C Landfill	004	293.00	Dry Tons	Stablex Canada Inc., solidification and C landfill	Canada
Subtitle C Landfill	005	11.50	Dry Tons	Stablex Canada Inc.	Canada
Subtitle C Landfill	093	20.00	Cubic Yards	Envirite	Canton, OH
Subtitle C Landfill	026	38100.00	Dry Tons	Envirite	Canton, OH
Subtitle C Landfill	041	3.00	Dry Tons	Envirite Corp.	Harvey, IL
Subtitle C Landfill	071	44.00	Dry Tons	Threamionic	Canada
Subtitle C Landfill	054	29.00	Dry Tons	Romic Environmental	
Subtitle C Landfill	074	131.00	Dry Tons	Chemical Waste Management (Adams Center)	Fort Wayne, IN
Subtitle C Landfill	071	36.00	Dry Tons	Stablex	Canada
Subtitle C Landfill	062	12.00	Dry Tons	Heritage Env. Service	Charlotte, NC
Subtitle C Landfill	066	146.00	Dry Tons	Peoria Disposal	
Subtitle C Landfill	034	8.00	Dry Tons	Waste Management	Indiana
Subtitle C Landfill	157	227.00	Dry Tons	Heritage Environmental	Indianapolis, IN
Subtitle C Landfill	063	30.50	Dry Tons		
Subtitle C Landfill	179	62.21	Dry Tons	Stablex	Quebec, Canada
Subtitle C Landfill	165	50.60	Dry Tons	LESI - Lone Mt	Waynoka, OK
Subtitle C Landfill	164	863.00	Dry Tons	LESI - Lone Mt.	Waynoka, OK
Subtitle C Landfill	163	1330.00	Dry Tons	LESI - Lone Mt Facility	Waynoka, OK
Subtitle C Landfill	162	505.00	Dry Tons	LESI - Lone Mt.	Waynoka, OK
Subtitle C Landfill	161	945.00	Dry Tons	USCPI - Laidlaw	Lone Mountain, OK
Subtitle C Landfill	113	58.00	Dry Tons	Envirosafe Services of Idaho, Inc.	Boise, ID
Subtitle C Landfill	041	11.00	Dry Tons	Heritage Environmental Ser.	Indianapolis, IN
Subtitle C Landfill	094	300.00	Cubic Yards	hydroxide sludge non-hazardous	So. Elgin, IL
Subtitle C Landfill	157	73.00	Dry Tons	USPCI	Lone Mountain, OK
Subtitle C Landfill	155	320.00	Dry Tons	USPCI Lone Mountain	Oklahoma
Subtitle C Landfill	151	9.35	Dry Tons	Envirite Corp.	North Canton, OH
Subtitle C Landfill	147	0.60	Dry Tons	Cycle Chem	Elizabeth, NJ
Subtitle C Landfill	146	10.00	Dry Tons	Northland Environmental	Providence, RI
Subtitle C Landfill	134	4.90	Dry Tons	Chemical Waste Management Inc	Menomonee Falls, WI

Table 24. Waste Management Methods F006 Wastes					
Mgt	**Facility**	**Quantity**	**Measure**	**Name**	**Location**
Subtitle C Landfill	132	20.00	Dry Tons	Envirite of Ohio	Canton, OH
Subtitle C Landfill	131	4.10	Dry Tons	chromic, muratic acid	NV
Subtitle C Landfill	119	64.00	Dry Tons	Phillips Environmental	Canada
Subtitle C Landfill	118	84.00	Cubic Yards	Envirite Corporation	Canton, OH
Subtitle C Landfill	156	87.35	Dry Tons	USPCI	Lone Mountain, OK 73860
thermal treatment	029	4.53	Dry Tons	Northeast Environmental	Wompsville, NY
thermal treatment	029	6.03	Dry Tons	Chief Supply	Haskl, OK

j. Exported Waste [C9]

Ten respondents reported exporting their F006 wastes, the responses are presented in Table 25 The other 174 respondents are not exporting F006 waste.

Table 25. Export Quantities of F006	
Facility No.	**Exported Waste (dry tons)**
004	293.0
005	11.5
009	32.0
048	154.0
071	80.0
083	2.2
114	39
119	64
169	30
179	64.7

k. Wastewater Treatment [C10]

Table 26 summarizes the number of respondents who are conducting wastewater treatment prior to discharge.

Table 26. Facilities Conducting Wastewater Treatment Prior to Discharge	
PROCESS	**NUMBER OF RESPONDENTS ANSWERING "YES"**
Waste stream segregation	92
Hexavalent chrome reduction	119
Cyanide oxidation	69
Neutralization, flocculation, clarification, effluent polishing	143
Sludge blending to achieve desired concentration	20

l. Plating Operations [B]

Table 27 summarizes responses to question B, “what type of plating operations are conducted by your facility?”.

Table 27. Types of Plating Conducted by Respondents		
PROCESS	**NUMBER OF RESPONDENTS ANSWERING “YES”**	**NUMBER OF RESPONDENTS ANSWERING “NO”**
Zinc plating on steel	92	92
Zinc plating on steel - cyanide	23	161
Zinc plating on steel – non-cyanide	57	127
Nickel chromium	82	102
Copper/nickel/chrome	62	122
Copper plating/stripping	7	177
Hard chromium	36	148
Copper plating	85	99
Tin	57	127
Cadmium	45	139
Sulfuric acid	45	139
Silver	56	128
Gold	48	136
Bright dip	56	128
Other	95	89

m. Pollution Prevention Waste Minimization Activities [E]

The respondents were asked to complete a checklist of 59 individual waste minimization techniques broken into three main categories (i.e., reduce drag out losses, reduce rinse water, and various operating practices). Table 28 presents the total number of positive responses for each of 59 waste minimization technique broken into three main categories (i.e. reduce drag out losses, reduce rinse water, and various operating practices). Three groups of facilities were identified: small, medium, and large. Each group contained an equal number of facilities (i.e., 61) to enable a comparison of techniques by facility size. Based on the analysis, it appears as though facility size is not a deciding factor in determining the number or type of waste minimization techniques implemented. This may be because the techniques included in the survey are relatively low cost and easy to implement. Larger facilities may be able to afford more sophisticated waste minimization improvements (e.g., process changes) that were not included in the survey. Table 29 identifies pollution prevention measures by technique.

Table 28: Summary of Techniques Used by Facility Size*			
Technique	**Small Facilities (<30 employees)**	**Medium Facilities (> 31 and < 65 employees)**	**Large Facilities (> 65 employees)**
Reduce drag-out losses Total	182	175	232
Allow rack/part to drip over plating tank	33	27	38
Using drag-out rinse tanks and returning chemicals to the process bath	27	30	33
Drip shields between tanks	18	22	29
Reduce rinse water use Total	151	166	285
Flow restrictors	26	39	58
Countercurrent rinses	30	38	61
Manually turn-off rinse waters	22	28	47
Air agitation in rinse tanks	22	22	37
Various operating practices Total	586	659	781
Training and programs subtotal	120	114	152

Table 28: Summary of Techniques Used by Facility Size*			
Technique	**Small Facilities (<30 employees)**	**Medium Facilities (≥ 31 and ≤ 65 employees)**	**Large Facilities (> 65 employees)**
Conduct employee education	21	22	30
Establish preventive maintenance program	15	22	28
Use specifically assigned personnel	27	35	40
Procedures subtotal	200	213	271
Perform routine bath analysis	34	33	41
Maintain bath analysis logs	33	33	39
Use process baths to maximum	29	30	31
Have written procedures	25	28	37
F006 volume reduction subtotal	58	88	86
Sludge dewatering	28	47	50
Closed loop recycling	16	15	10
Use control method	6	14	10
Inspections / maintenance subtotal	60	66	73
Perform regular maintenance of racks/barrels	26	24	29
Pre-inspect parts	22	23	24
Research / evaluations subtotal	60	73	91
Evaluation of recycling alternatives	16	21	27
Increase drain time	19	20	22
Research of alternative plating technologies	13	18	21
Elimination / Replacement / Substitutions subtotal	88	105	108
Eliminate obsolete processes	20	19	22
Replace cyanide based plating	14	21	23
Eliminate plating service	16	17	1

* number of positive responses by facility

Table 9.0 summarizes the results of the responses to each of the 59 individual techniques.

Table 29. Pollution Prevention Benefits by Technique								
Technique	**Number of "Yes" Responses**	**Number of "No" Responses**	**Number of Manual Vs. Automatic Responses**	**P2 BENEFIT** **1 = low success, 5 = high success**				
				1	2	3	4	5
Reduce Drag-out Losses								
Using drag-out rinse tanks and returning chemicals to the process bath	87	94	Manual: 57 Automatic: 22	3	4	17	20	27
Using drip tanks and returning chemicals to the process bath	36	145	Manual: 27 Automatic: 6	3	0	10	8	6
Reducing speed of rack/part withdrawal	63	118	Manual: 43 Automatic: 20	5	9	20	11	6
Allowing rack/part to drip over plating tank	96	85	Manual: 63 Automatic: 33	3	10	33	19	15
Using a drag-in/drag-out arrangement (i.e., use of same rinse tank before and after plating also referred to as a double-dip or double-use rinse)	40	141	Manual: 26 Automatic: 14	3	2	8	6	10
Fog or spray rinses installed over process bath	36	145	Manual: 21 Automatic: 12	1	2	6	9	7
Air knives that blow off drag-out	16	165	Manual: 1 Automatic: 15	1	1	3	7	3
Drip shields between tanks	66	115	Manual: 34 Automatic: 52	3	5	18	15	16
Lower bath concentration	35	146	Not applicable	2	5	14	6	4
Increasing solution temperature (reduces viscosity)	13	168	Not applicable	4	0	4	4	0
Using a wetting agent (reduces viscosity)	48	133	Not applicable	5	1	18	13	4
Positioning work piece to minimize solution holdup	65	116	Not applicable	2	2	17	13	20
Other, specify	4	3	Not applicable	0	0	0	1	2
Reduce Rinse Water Use								
Manually turning off rinse water when not in use	73	108	Not applicable	4	8	20	10	20

Table 29. Pollution Prevention Benefits by Technique								
Technique	**Number of "Yes" Responses**	**Number of "No" Responses**	**Number of Manual Vs. Automatic Responses**	**P2 BENEFIT** **1 = low success, 5 = high success**				
				1	2	3	4	5
Conductivity or pH rinse controls	22	159	Not applicable	1	2	8	4	3
Timer rinse controls	24	157	Not applicable	1	4	3	8	5
Flow restrictors	103	78	Not applicable	1	3	17	26	21
Counter current rinses	113	68	Not applicable	0	3	13	26	33
Spray rinses	59	122	Not applicable	2	4	9	15	11
Air agitation in rinse tanks	73	86	Not applicable	1	3	20	17	20
Use flow meters/accumulators to track water use at each rinse tank or plating line	23	136	Not applicable	1	0	8	3	5
Reactive rinsing or cascade rinsing	22	136	Not applicable	1	1	2	5	9
Other, specify	7	4	Not applicable	0	0	0	1	2
Various Operating Practices								
Training and Programs								
Established a formal policy statement with regard to pollution prevention and control	60	99	Not applicable	11	6	11	12	11
Established a formal pollution prevention program	64	95	Not applicable	7	6	23	6	12
Conduct employee education for pollution prevention	73	86	Not applicable	4	9	22	13	12
Establish a preventive maintenance program for tanks	66	93	Not applicable	2	6	22	14	13
Use specifically assigned personnel for chemical additions	99	60	Not applicable	2	6	12	24	34
Procedures								
Stricter conformance with Line Preventive Maintenance Schedule	31	127	Not applicable	3	1	7	9	7
Stricter conformance with SPC Procedures	26	133	Not applicable	3	2	8	6	5
Waste stream segregation of contact and non contact wastewater	38	121	Not applicable	0	1	8	8	16

Table 29. Pollution Prevention Benefits by Technique								
Technique	**Number of "Yes" Responses**	**Number of "No" Responses**	**Number of Manual Vs. Automatic Responses**	**P2 BENEFIT 1 = low success, 5 = high success**				
				1	2	3	4	5
Strict chemical inventory control	59	100	Not applicable	4	4	12	11	20
Perform routine bath analyses	99	60	Not applicable	0	2	17	30	32
Maintain bath analyses/addition logs	96	63	Not applicable	2	6	24	19	28
Have written procedures for bath make-up and additions	83	76	Not applicable	3	4	19	22	22
Use process baths to maximum extent possible (no dump schedule)	83	76	Not applicable	0	3	13	24	26
Remove anodes from bath when they are idle (e.g., cadmium, zinc)	36	123	Not applicable	2	1	9	6	11
Regularly retrieve fallen parts/racks from tanks	80	79	Not applicable	3	2	30	12	20
F006 Volume Reduction Methods								
Closed-loop recycling	34	124	Not applicable	2	0	1	3	9
Use control method for adding water to process tanks	29	130	Not applicable	1	2	6	5	8
Sludge dewatering (Vacuum filter, Solid bowl centrifuge, Imperforate basket centrifuge, belt filter press, Recessed plate filter press, sludge drying beds, sludge lagoons, sludge dryers, etc.)	113	46	Not applicable	0	0	10	17	37
Install overflow alarms on process tanks	19	140	Not applicable	3	0	6	3	5
Install other spill/leak detection system, specify	15	144	Not applicable	3	0	1	3	5
Inspections / Maintenance								
Perform regular maintenance of racks/barrels	73	86	Not applicable	3	8	24	20	7
Pre-inspect parts to prevent processing of obvious rejects	64	95	Not applicable	1	7	14	16	15
Waste Reduction Study conducted	48	111	Not applicable	2	5	14	14	7
Research / Evaluation								

Table 29. Pollution Prevention Benefits by Technique								
Technique	**Number of "Yes" Responses**	**Number of "No" Responses**	**Number of Manual Vs. Automatic Responses**	**P2 BENEFIT** **1 = low success, 5 = high success**				
				1	2	3	4	5
Evaluation of recycling alternatives	59	100	Not applicable	4	7	16	13	8
Increasing drain time over process tanks	55	104	Not applicable	4	7	16	13	8
Research of alternative plating technologies	51	108	Not applicable	6	7	10	6	13
Development of tracking system for monitoring flow from different areas	19	140	Not applicable	4	0	7	1	3
Monitoring of incoming water with strict control program	26	133	Not applicable	3	0	4	6	4
Two separate labs for process chemistry	2	157	Not applicable	0	0	1	1	0
Elimination / Replacement / Substitutions								
Eliminate obsolete processes and/or unused or infrequently used processes	57	102	Not applicable	1	2	16	14	14
Replace cyanide-based plating solution with alkaline-based solutions	56	103	Not applicable	3	2	6	7	24
Elimination of rinse waters to waste treatment (nickel, chrome)	25	134	Not applicable	3	2	4	5	3
Substitution of chromate and dichromate sealer with non-chromate sealer	2	157	Not applicable	0	0	2	0	0
Elimination of plating services (cadmium, tin, nickel, copper, brass, and hard chrome)	48	111	Not applicable	1	3	7	8	15
Elimination of vapor degreasing	46	113	Not applicable	1	1	4	3	29
Implementation of a multi-stage cyanide destruct system	30	129	Not applicable	2	1	3	5	14
Elimination of chelated cleaners	34	125	Not applicable	0	1	5	9	10
Other, specify	5	6	Not applicable	0	0	0	3	3

Table 29. Pollution Prevention Benefits by Technique								
Technique	**Number of "Yes" Responses**	**Number of "No" Responses**	**Number of Manual Vs. Automatic Responses**	**P2 BENEFIT 1 = low success, 5 = high success**				
				1	2	3	4	5
E - Additional	3	156	Not applicable	n/a	n/a	n/a	n/a	n/a

n. Waste Minimization Techniques by Generating Process

Table 30 summarizes the types of waste minimization techniques reported by facilities that conducted only one type of plating. The four processes were selected for analysis because they are most representative of the plating industry and the most problematic from a regulatory perspective. A handful of facilities only performed tin plating, bright dip, and sulfuric acid anodizing.

Table 30. Summary of Waste Minimization Techniques

TECHNIQUE	NICKEL	COPPER	CHROME	ZINC	CADMIUM
Reduce drag-out losses	55	47	23	62	30
Reduce rinse water use	67	52	25	78	36
Training and programs subtotal	53	41	21	78	28
Procedures subtotal	52	43	20	55	26
F006 volume reduction subtotal	68	52	33	54	36
Inspections / maintenance subtotal	42	34	15	72	23
Research / evaluations subtotal	41	34	13	45	20
Elimination / Replacement / Substitutions	54	41	20	63	26
Various operating practices Total	310	245	122		159

o. Impact of Waste Minimization Projects on Wastewater Discharge Rates [E2]

Number of positive responses: 63
Number of negative responses: 156

p. Recycle and Recovery Technologies [E3]

Table 31 summarizes the use of recycle and recovery technologies.

Table 31. Summary of Recycling and Recovery Technologies

TECHNIQUE	Number of Positive Responses	Number of Negative Responses
Electrodialysis	7	152
Electrowinning	26	133
Evaporator	39	120
Ion flotation	1	158
Ion exchange	28	131
Mesh pad mist eliminator/recycle	15	144
Reverse osmosis	8	151
Ultrafiltration	5	154
Other	11	2

q. Solution Maintenance Techniques [E4]

Table 32 summarizes the solution maintenance techniques.

Table 32. Summary of Solution Maintenance Techniques

TECHNIQUE	# of Positive Responses	# of Negative Responses
Acid retardation	1	158
Carbon treatment (batch)	46	113
Carbon treatment (continuous)	40	119

Table 32. Summary of Solution Maintenance Techniques		
TECHNIQUE	**# of Positive Responses**	**# of Negative Responses**
Dummying of metal contaminants	56	103
Electrodialysis for inorganic contaminants	56	155
Carbonate freezing	24	135
Filtration, in-tank	53	106
Filtration, external	51	108
High pH treatment	16	143
Precipitation	20	139
Liquid/ Liquid extraction	2	157
Microfiltration	1	158
Ultrafiltration	1	158
Other, specify	0	1

Appendix A:
Summary of the 10 Issue Areas Identified for the Metal Finishing Sector

Issue 1. *Operational Flexibility*

Industry performance leaders would receive operational flexibility (i.e., less burdensome permitting, monitoring, and reporting requirements) in recognition of their good performance and as an incentive to seek the ambitious performance goals.

Issue 2: *Waste Minimization and Recovery*

The first phase of this project was a bench marking analysis of F006 constituents, using national and regional sampling data. The data generated in the bench marking study will be used by the RCRA Project Team to develop and assess options for reducing barriers to pollution prevention and on-site and off-site metal recovery requirements.

Issue 3: *Reporting and Right-to-Know*

This project applies business process reengineering techniques to examine federal, state, and local reporting requirements for metal finishers across all environmental media.

Issue 4: *Compliance Tools and Assistance*

This project is designed to overcome barriers to improved compliance and pollution prevention by combining pollution prevention assistance and enforcement relief policies as an incentive for improved environmental performance by metal finishers.

Issue 5: *Research and Technology*

The National Metal Finishing Environmental R&D Plan is a customer-oriented R&D strategy for risk characterization, exposure assessment, and technology transfer for metal finishers, communities, and other stakeholders.

Issue 6: *Industrial Pretreatment*

The POTW Pretreatment Project is designed to identify ways to improve the capabilities of POTW manage their industrial users by reducing mass pollutant loadings without limiting industry activity, and to provide the most effective POTW with increased managerial flexibility to achieve higher environmental quality at lower cost.

Issue 7: *Environmentally Responsible Site Transition*

This project develops a government sponsored "exit strategy" for metal finishers who wish to get out of the business that reduces future contaminated "orphan industrial sites."

Issue 8: *Enforcement for Chronic Non-Complier*

This project develops a sector-based, targeted enforcement program for government at all level to identify chronic non-complier and take appropriate action against them.

Issue 9: *Access to Capital*

This project focuses on developing innovative approaches for improving access to capital for metal finishers and electronics firms.

Appendix B:
F006 Management Contained in EPA's 1995 Biennial Report Database

Waste Management Facilities: This appendix lists the names of hazardous waste landfill facilities contained in EPA's 1995 Biennial Report that reported accepting and /or managing F006 waste. The table includes the quantities of F006 waste managed by each facility, the facility's EPA ID, and the number of shipments the facility received.

Table 1: F006 Waste Managed in Landfills

Number of RCRA large quantity generators (greater than 1000kg/month) who sent F006 waste off-site to a RCRA landfill in 1995 = 283

Volume of F006 generated on-site and shipped off-site to a landfill = 80,298.370 tons

Volume of F006 generated on-site and managed in a landfill on-site = 18,782.832 tons (2 facilities, not including TSDs)

Total volume generated and managed in landfills = 99,081.202 tons

Landfills that Accept/Manage F006 Waste, by State:

Number	EPA ID	Company	Qty "Generated" & Managed On-site	Qty Rcvd & Managed On-site	# of Shpmts Rcvd	GM/WR Form
1	ALD000622464	Chemical Waste Management, Inc.		496.179	15	WR
2	CAD000633164	Laidlaw Environmental Services, Inc.		94.800	4	WR
3	CAT000646117	Chemical Waste Management, Inc.	260.000			GM
4	COD991300484	Highway 36 Land Development Co.		4,319.438	7	GM,WR
5	IDD073114654	Envirosafe Services of Idaho		138.955	20	WR
6	ILD000805812	Peoria Disposal Co.	5,208.628			GM
7	IND016584641	Midwest Steel Division	17,308.400			GM
8	IND078911146	Chemical Waste Management, Inc.	118.300	3,015.950	34	GM,WR
9	IND980503890	Heritage Environmental Services, Inc.		68,213.625	1	WR
10	KSD057889313	Ashland Chemical Co.		1.800	1	WR
11	LAD000777201	Chemical Waste Management, Inc.		44,939.950	45	WR
12	MID000724831	Michigan Disposal Waste Treatment	43,259.000			GM
13	MID048090633	Wayne Disposal Site #2 Landfill		45,070.380	9	WR
14	NJD002385730	E. I. DuPont de Nemours & Co. Inc.	10,030.000			GM
15	NYD049836679	CWM Chemical Services		60.170	4	WR
16	OHD045243706	Envirosafe Services of Ohio Inc.	236.490	13,558.665	54	GM,WR
17	OKD065438376	U.S. Pollution Control Inc.		3,403.746	17	WR
18	ORD089452353	Chemical Waste Management, Inc.	121.602	3,810,086.0	20	GM,WR
19	SCD070375985	Laidlaw Env. Svs. of SC Inc.	0.530	2,843.1	491	GM,WR
20	TND980847024	Excel TSD Inc.	1.310			GM
21	TXD069452340	Texas Ecologists, Inc.		1,800.2	3	WR
22	UTD982598898	Envirocare of Utah		4,431.8	7	WR
23	UTD991301748	USPCI Grassy Mountain Facility		6,859.9	7	WR
24	WAD041337130	Boeing - Auburn		115,193.0	2	WR
25	WAD041585464	Boeing Commercial Airplane Group Everett				WR
		Totals	78,018.7	47,026.0	2	

GM = Reported on Biennial Report GM form: identifies generators who manage F006 in an onsite landfill.

WR = Reported on WR form: identifies off-site facilities that receive and manage F006 in a landfill.

Table 2 lists recycling facilities contained in EPA's 1995 Biennial Report that reported accepting and/or managing F006 waste in 1995. The table includes the quantities of F006 waste managed by each facility, the facility's EPA ID, the number of shipments the facility received, recovery system used, and a system description.

Table 2: F006 Waste Managed by Metals Recovery

Number of generators who send F006 waste off-site to metals recovery = 824

Volume of F006 generated on-site and shipped off-site for metals recovery = 64,670.462 tons

Volume of F006 generated on-site and managed on-site by metals recovery = 217,292.304 tons (9 facilities)

Therefore, total volume of F006 generated and managed by metals recovery = 281,962.766 tons

Quantities and Number of Facilities/Streams that Shipped F006 Off-site for Metals Recovery

System	System Description	Qty Shipped Off-site	# of Facilities	# of Streams
M011	High temperature metals recovery	18,252.113	159	179
M012	Retorting	295.301	4	12
M013	Secondary smelting	11,958.071	74	89
M014	Other metals recovery for reuse (iron exchange, etc.)	16,707.303	278	320
M019	Metals recovery - type unknown	17,457.674	309	370
	Totals	64,670.462	824	970

Metals Recovery Facilities that Accept/Manage F006 Waste

Number	EPA ID	Company	Qty Generated & Managed On-site	Qty Rcvd & Managed On-site	# of Shpmts Rcvd	Recovery System	System Description	GM/WR Form
1	CAD981695729	Pacific Circuit Services	74.000			M014	Other metals recovery for reuse	GM
2	CAT000612150	Engelhard West, Inc.	25.314			M011	High temp. metals recovery	GM
3	COD082657420	Schlage Lock Company	0.616			M014	Other metals recovery for reuse	GM
4	ILD005087630	United Refining & Smelting Co.		87.186	2	M011	High temp. metals recovery	WR
5	ILD984766279	Hydromet Environmental Inc.		138.880	3	M014	Other metals recovery for reuse	WR
6	LAD058472721	Amax Metals Recovery Inc.		27.300	3	M014	Other metals recovery for reuse	WR
7	MID047153077	Production Plated Plastics, Inc.	192,351.977			M014	Other metals recovery for reuse	GM
8	MID981099435	Lacks - Airplane	24,603.837			M014	Other metals recovery for reuse	GM
9	NYD001325661	Lea Ronal Inc.		0.864	1	M011	High temp. metals recovery	WR
10	NYD086225596	AT&T Nassau Metals		0.741	4	M011	High temp. metals recovery	WR
11	OHD061614673	Dayton Water Systems		57.700	17	M014	Other metals recovery for reuse	WR
12	PAD087561015	Inmetco Inc.		4,839.448	97	M011	High temp. metals recovery	WR
13	RID062309299	Hallmark Healy Group Inc.	207.745			M013	Secondary smelting	GM
14	RID063890214	Boliden Metech Inc.		95.120	3	M014	Other metals recovery for reuse	WR
15	RID981886104	Gannon & Scott Inc.		1.455	4	M011	High temp. metals recovery	WR
16	TXD008117186	Encycle/Texas, Inc.		7,938.630	244	M014	Other metals recovery for reuse	WR
17	TXD072181969	Metal Coatings Corp.	5.930			M011	High temp. metals recovery	GM
18	TXD981514383	Alpha Omega Recycling Inc.	15.460	1,028.440	67	M014	Other metals recovery for reuse	GM,WR
19	WID006129522	Krueger International	7.425			M014	Other metals recovery for reuse	GM
		Totals	217,292.304	14,215.763	445			

GM = Reported on Biennial Report GM form: identifies generators who manage F006 in an onsite landfill.

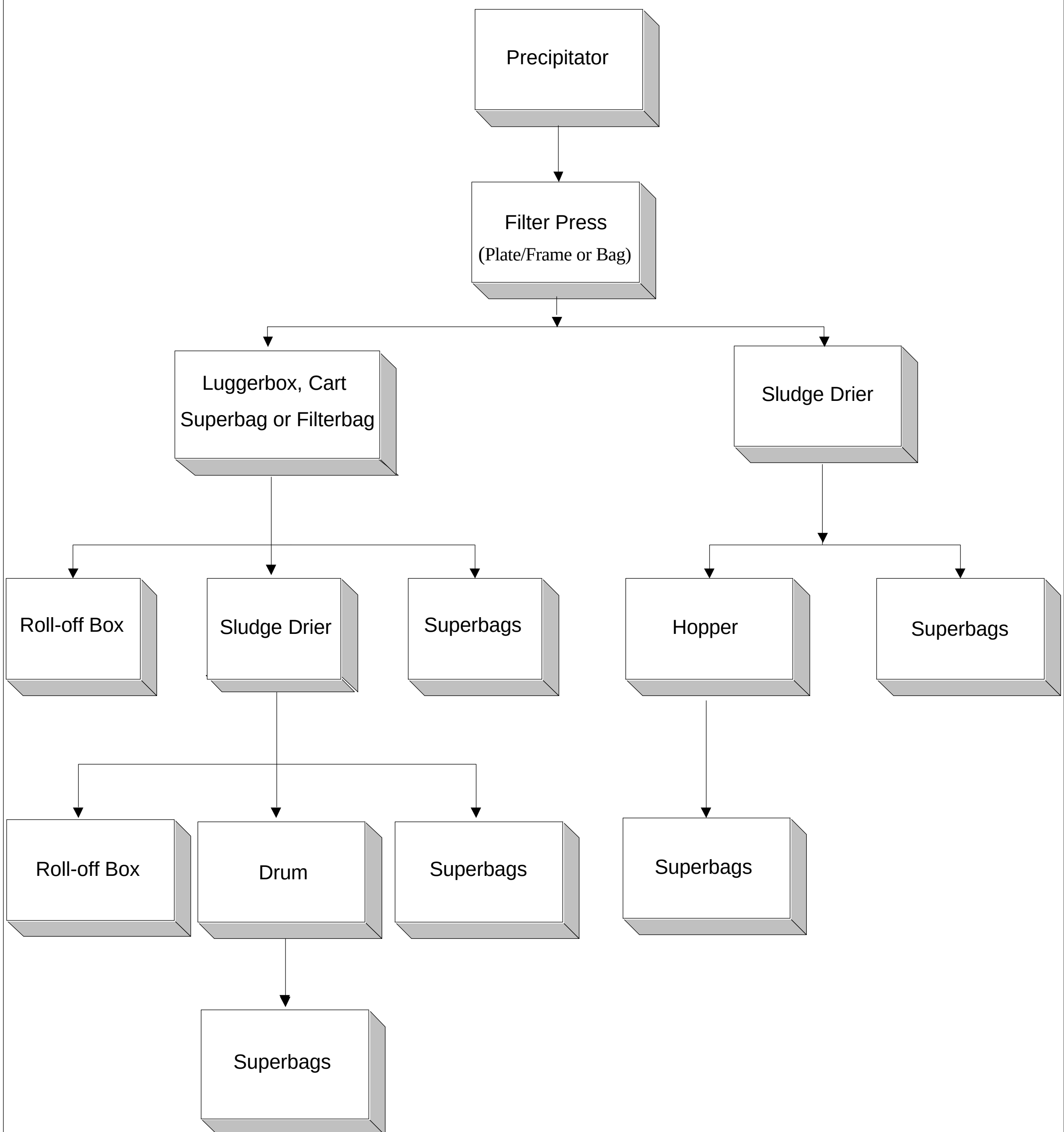
WR = Reported on WR form: identifies off-site facilities that receive and manage F006 in a landfill.

Appendix C:
Observed F006 Handling Practices at Metal Finishing Facilities and List of Worker Health and Safety Regulations

Description of F006 Generation and Handling at Metal Finishing Facilities

Diagram 1 presents a generic F006 waste generation and handling process. Electroplating process wastewaters are treated through multiple processes to form a slurry/precipitate. The slurry/precipitate is sent to a filter press where excess water is separated by the filter press. The moist F006 drops from the filter press to a cart, supersack, roll-off box or to a sludge drier. When used a sludge drier reduces the amount of water in the sludge and reduces its volume. After drying or in the moist state, the F006 is either taken away by a recycler or hazardous materials handler to its final destination.

Diagram 1- Generic Flow Diagram of F006 After Wastewater Treatment to Final Storage*



*Flow diagram generated from Chicago ESVs conducted during CSI Project 10/97

Health and Safety Regulations and Guidelines

This section provides a list of worker and safety regulations, policies, guides and operating procedures which may apply to on-site and off-site management of F006 waste. All of OSHA General Industry Standards are applicable. In addition, OSHA Construction Industry Standards would be applicable to construction activities at these facilities.

Table 1 - List of Regulations, Policies, and Guidelines

Agency/Organization	Title of Regulation	Location of Regulation
EPA	Personnel Training	40 CFR §262.34(a)(4) and 40 CFR §265.16
	Preparedness and Prevention	40 CFR §265, Subpart C
	Contingency Plan and Emergency Procedures	40 CFR §265, Subpart D
	Use and Management of Containers	40 CFR §265, Subpart I
	Best Management Practices for Pollutant Dischargers	40 CFR §125.104
OSHA	Walking-Working Surfaces	29 CFR §1910.22
	Guarding floor & wall openings & holes	29 CFR §1910.23
	Fixed Industrial Stairs	29 CFR §1910.24
	Fixed Ladders	29 CFR §1910.27
	Scaffolds	29 CFR §1910.28
	Means of Egress	29 CFR §1910.37
	Emergency Action Plan Implementation	29 CFR §1910.38(a)
	Fire Prevention Plan Implementation	29 CFR §1910.38(b)
	Powered Platform Operation	29 CFR §1910.66
	Ventilation	29 CFR §1910.94
	Hearing Conservation	29 CFR §1910.95
	Flammable and Combustible Liquids	29 CFR §1910.106
	Dip Tanks Containing Flammable or Combustible Liquids	29 CFR §1910.108
	Process Safety Management of Highly Hazardous Chemicals	29 CFR §1910.119
OSHA (cont.)	Hazardous Waste Operations (HAZWOPER) Training	29 CFR §1910.120
	Personal Protective Equipment	29 CFR §1910.132
	Eye & Face Protection	29 CFR §1910.133
	Respirator Requirements	29 CFR §1910.134

Table 1 - List of Regulations, Policies, and Guidelines		
Agency/Organization	**Title of Regulation**	**Location of Regulation**
	Head Protection	29 CFR §1910.135
	Electrical Protective Devices	29 CFR §1910.137
	Sanitation	29 CFR §1910.141
	Confined Space	29 CFR §1910.146
	Lockout/Tagout	29 CFR §1910.147
	Medical Services & First Aid	29 CFR §1910.151
	Fire Extinguisher Use	29 CFR §1910.157
	Fixed Extinguishing Systems	29 CFR §1910.160
	Air Receivers	29 CFR §1910.169
	Materials Handling	29 CFR §1910.176
	Powered Industrial Trucks (Forklift Operations)	29 CFR §1910.178
	Overhead and Gantry Cranes Machines, General Requirements	29 CFR §1910.179 29 CFR §1910.212
	Mechanical Power Presses	29 CFR §1910.217
	Hand and Portable Powered Tools and Equipment, General	29 CFR §1910.242
	Welding, Cutting, Brazing - Definitions	29 CFR §1910.251
	Welding, Cutting, Brazing - General Requirements	29 CFR §1910.252
	Electrical Systems	29 CFR §1910.301
	Air Contaminants (PELs)	29 CFR §1910.1000
	Inorganic Arsenic	29 CFR §1910.1018
	Lead	29 CFR §1910.1025
	Cadmium	29 CFR §1910.1027
	Hazard Communication	29 CFR §1910.1200
OSHA (cont.)	Occupational Exposure to Hazardous Chemicals in Laboratories	29 CFR §1910.1450
DOT	HAZMAT Transport Training	49 CFR §173
ACGIH*	Threshold Limit Values (TLVs)	Guidelines only in "1996 TLVs and BEIs"

*****ACGIH (TLVs) are not legally enforceable

F006 Handling Practices That May be Used to Minimize Potential Hazards

Table 2 summarizes F006 handling practices observed at Milwaukee, Chicago, and Phoenix metal finishing facilities. This table represents observed practices not recommended best management practices.

Table 2 - F006 Handling Activities Observed in Regional Benchmarking Study

Work Activity	Potential Hazard	Hazard Control Method
Paddling wet F006 sludge cake from the filter press into a lugger box, cart, or drum	Skin exposure to sludge, ingestion hazard, Physical body damage, slip hazard, possible dust hazard	Personal Protective Equipment (eye protection, gloves, respirator, non slip boots), ergonomics Training
Replacing worn or damaged filter cloths in the filter press.	Skin exposure to sludge, ingestion hazard, Physical damage to body appendages if press is activated	Personal Protective Equipment (eye protection, gloves, respirator), Training, Means of locking out filter press
Shoveling dried F006 sludge into supersacks, luggerboxes, or drums.	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard, Physical lifting hazards, confined space entry	Personal Protective Equipment (eye protection, gloves, respirator), Training on lifting
Shoveling dried F006 sludge into a roll-off box	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard, Physical lifting hazards	Personal Protective Equipment (eye protection, gloves, respirator), ergonomic training on lifting activities
Manually moving cart or lugger box to supersack or roll-off box	Inhalation of metal dust, skin exposure, ingestion hazard, Physical hazard	Personal Protective Equipment (eye protection, gloves, respirator), ergonomic training
Operation of overhead crane to transport cart or lugger box to roll-off box	Physical hazard of falling objects, Crane failure, Inhalation of metal dust	Personal Protective Equipment Training on crane operation, crane inspection program
Opening/closing a roll-off box manually or with a forklift	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard, Forklift operation safety hazards, Physical lifting damage	Forklift Training, Personal Protective Equipment, Standard Operating Procedures (SOPs)
Changing the filter to the sludge drier.	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard, drier lock-out	Personal Protective Equipment (eye protection, gloves, respirator), Training, means of locking out drier to prevent accidental operation
Any work activity in the sludge drier room.	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard, noise exposure, eye hazard	Personal Protective Equipment (respirator, eye protection, hearing protection)
Sampling the F006 sludge (wet or dry)	Inhalation of metal dust particles, Skin exposure to dust, ingestion hazard	Personal Protective Equipment (eye protection, gloves, respirator)

Table 2 - F006 Handling Activities Observed in Regional Benchmarking Study		
Work Activity	**Potential Hazard**	**Hazard Control Method**
Housekeeping (i.e., cleaning roll-off box)	Inhalation of metal dust particles, Skin exposure to sludge or dust, ingestion hazard, Physical lifting hazards, Slip/trip/fall hazards, Discharge of F006 while cleaning the inside of the roll-off box, confined space entry	Personal Protective Equipment (eye protection, gloves, respirator) Means of locking-out Filter press
Any work activity in noisy areas (wastewater treatment pumps)	Noise exposure	Personal Protective Equipment (hearing protection)
Forklift operation a lugger box, drum, or bag.	Forklift operation safety hazards	Forklift Training, Personal Protective Equipment (respirator), Standard Operating Procedures (SOPs)
"Wet" sludge as the term is used here is that sludge produced after the filter press which constitutes about 25-60 % solids. "Dry" sludge is produced by the sludge drier and constitutes about 90% solids.		

Personal Protective Equipment Guidance

The National Institute for Occupational Safety and Health (NIOSH) is the government agency responsible for performing health and safety studies and making health and safety recommendations. NIOSH has recommended personal protective equipment and sanitary measures for handling specific chemicals and substances. Table 3 is extracted from the NIOSH "Pocket Guide to Chemical Hazards" recommending protective equipment and sanitary measures for specific chemicals and substances commonly found in F006 waste. This is not an all inclusive list, for example, respirators were not addressed. These recommendations supplement general work practices (e.g., no eating, drinking, or smoking where chemicals are used.)

Table 3 - NIOSH Recommended Personal Protection and Sanitation

Contaminant	Skin:	Eyes:	Wash Skin:	Remove Clothing:	Change Clothing:	Provide:
Aluminum	N.R.	N.R.	N.R.	N.R.	N.R.	
Antimony	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Arsenic	Prevent skin contact	Prevent eye contact	When contaminated and daily	When wet or contaminated	Daily	Eyewash, Quickdrench
Barium chloride/nitrate (ASRA)	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Beryllium	Prevent skin contact	Prevent eye contact	Daily	When wet or contaminated	Daily	Eyewash

Contaminant	Skin:	Eyes:	Wash Skin:	Remove Clothing:	Change Clothing:	Provide:
Bismuth as telluride doped with selenium sulfide	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	N.R.	Eyewash, Quickdrench
Cadmium	N.R.	N.R.	Daily	N.R.	Daily	
Chlorine	Frostbite	Frostbite	N.R.	N.R.	N.R.	Frostbite protection
Chromium	N.R.	N.R.	N.R.	N.R.	N.R.	
Chromium III	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	N.R.	
Cobalt	Prevent skin contact	N.R.	When contaminated	When wet or contaminated	Daily	
Copper	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Cyanide	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Iron	N.R.	N.R.	N.R.	N.R.	N.R.	
Lead	Prevent skin contact	Prevent eye contact	Daily	When wet or contaminated	Daily	
Manganese	N.R.	N.R.	N.R.	N.R.	N.R.	
Mercury	Prevent skin contact	N.R.	When contaminated	When wet or contaminated	Daily	
Nickel	Preven skin contact	N.R.	When contaminated/ daily	When wet or contaminated	Daily	
Platinum	N.R.	N.R.	N.R.	N.R.	Daily	
Platinum (soluble salts)	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Selenium	Prevent skin contact	N.R.	When contaminated	When wet or contaminated	N.R.	
Silver	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Sodium hydroxide	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	Eyewash, Quickdrench
Sulfur dioxide	Frostbite	Frostbite	N.R.	When wet or contaminated	N.R.	Frostbite protection
Tin	N.R.	N.R.	N.R.	N.R.	N.R.	

Contaminant	Skin:	Eyes:	Wash Skin:	Remove Clothing:	Change Clothing:	Provide:
Vanadium	Prevent skin contact	Prevent eye contact	When contaminated	When wet or contaminated	Daily	
Zinc	N.R.	N.R.	N.R.	N.R.	N.R.	

Notes: Skin - Recommends the need for personal protective equipment
Eyes - Recommends the need for eye protection.
Wash skin - Recommends when workers should wash the spilled chemical from the body in addition to normal washing.
Remove - Advises workers when to remove clothing that has accidentally become wet or significantly contaminated.
Change - Recommends whether the routine changing of clothing is needed.
Provide - Recommends the need for eyewash fountains and/or quick drench facilities.
These recommendations supplement general work practices (e.g., no eating, drinking, or smoking where chemicals are used.)
N.R. - No recommendation specified

References

ACGIH. *1996 Threshold Limit Values and Biological Exposure Indices for Chemical Substances and Physical Agents.* Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1996.

Cushnie, Jr., George. *Pollution Prevention and Control Technology for Plating Operations.* Ann Arbor, MI: National Center for Manufacturing Sciences, 1994.

EPA. *Development Document for Existing Source Pretreatment Standards for the Electroplating Point Source Category.* EPA 440/1-79/003, Washington, D.C.: Environmental Protection Agency, August 1979.

NIOSH. *NIOSH Pocket Guide to Chemical Hazards.* DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, 1997.

OSHA Regulations (Standards - 29 CFR) - Part 1910 Occupational Safety and Health Standards, http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc_1910.html

Appendix D:
Checklist Used to Identify Pollution Prevention Technologiesat Metal Finishing Facilities

P2 Technology	✓	Comment
1. SPENT PLATING SOLUTIONS		
General Bath Life Extension		
• Filtration		
• Carbon Treatment		
• Replenishment		
• Purified Water		
• Electrolytic Dummying		
• Cyanide Bath Carbonate Freezing		
• Precipitation		
• Monitoring		
• Housekeeping		
• Drag-in Reduction		
• Purer Anodes and Bags		
• Ventilation/Exhaust Systems		
Hexavalent Chrome Alternatives Trivalent chrome Non-chrome conversion coatings		
Nonchelated Process Chemistries Continuous filtration		
Non-cyanide Process Chemicals		
Solvent Degreasing Alternatives Hot alkaline cleaning Electrocurrent Ultrasonic		
Alkaline Cleaners Filtration (Micro/Ultra) Skimming Coalescer		
Caustic Etch Solution Regeneration		
Acid Purification Ion Exchange		
2. DRAG-OUT REDUCTION		
• Process Bath Operating Concentration and Temperature		
• Wetting Agents		

P2 Technology	✓	Comment
• Workpiece Positioning		
• Withdrawal and Drainage Time		
• Air Knives		
• Spray or Fog Rinses		
• Plating Baths		
• Drainage Boards		
• Drag-Out Tanks		
3. DRAG-OUT RECOVERY		
• Evaporation		
• Ion Exchange		
• Electrowinning		
• Electrodialysis		
• Reverse Osmosis		
• Meshpad Mist Eliminators		
4. RINSE WATER		
Improved Rinsing Efficiency		
• Spray Rinse/Rinse Water Agitation		
• Increased Contact Time/Multiple Rinses		
• Countercurrent Rinsing		
Flow Controls		
• Flow Restrictors		
• Conductivity-Actuated Flow Control		
Recycling/Recovery		
• Rinse Water		
• Spent Process Baths		
• Solvents		

Appendix E:
Laboratory Analysis Information: Constituents, Methods, and Detection Limits Used in the Benchmarking Studies

Table 1. Volatile Organic Target Analytes

Method 8260A

CONSTITUENT	TARGET DETECTION LIMIT (g/Kg)
Chloromethane	5
Vinyl Chloride	5
Bromomethane	5
Chloroethane	10
Trichlorofluoromethane	5
Acetone	10
2-Chloroethyl vinyl ether	20
1,1-Dichloroethene	5
Methylene Chloride	5
Carbon Disulfide	5
Vinyl Acetate	10
1,1-Dichloroethane	5
2-Butanone	10
trans-1,2-Dichloroethene	5
cis-1,2-Dichloroethene	5
Chloroform	5
1,1,1-Trichloroethane	5
Carbon Tetrachloride	5
1,2-Dichloroethane	5
Benzene	5
Trichloroethene (TCE)	5
1,2-Dichloropropane	5
Bromodichloromethane	5
4-Methyl-2-pentanone	10
2-Hexanone	10
cis-1,3-Dichloropropene	5
trans-1,3-Dichloropropene	5
1,1,2-Trichloroethane	5
Toluene	5

Table 1. Volatile Organic Target Analytes	
Method 8260A	
CONSTITUENT	**TARGET DETECTION LIMIT (g/Kg)**
Dibromochloromethane	5
Tetrachloroethene (PCE)	5
Chlorobenzene	5
Ethylbenzene	5
m,p-Xylenes	5
o-Xylene	5
Styrene	5
Bromoform	5
1,1,2,2-Tetrachloroethane	5
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
1,2-Dichlorobenzene	5

Table 2. Semivolatile Organic Target Analytes	
Method 8270B - Solid Samples	
CONSTITUENT	**TARGET DETECTION LIMIT (g/Kg)**
Phenol	660
bis(2-Chloroethyl)ether	660
2-Chlorophenol	660
2,3-Dichlorobenzene	660
1,4-Dichlorobenzene	660
Benzyl alcohol	1300
1,2-Dichlorobenzene	660
2-Methylphanol	660
bis((2-Chloroisopropyl)ether	660
4-Methyphenol	660
N-Nitroso-di-n-propylamine	660
Hexachloroethane	660
Nitrobenzene	660
Isophorone	660
2-Nitrophenol	660
2,4-Dimethylphenol	660
bis(2-Chloroethoxy)methane	660
Benzoic acid	3300
2,4-Dichlorophenol	660
1,2,4-Trichlorobenzene	660
Naphthalene	660
4-Chloroaniline	1300
Hexachlorobutadiene	660
4-Chloro-3-methylphenol	1300
2-Methylnaphthalene	660
Hexachlorocyclopentadiene	660
2,4,6-Trichlorophenol	660
2,4,5-Trichlorophenol	660
2-Chloronaphthalene	660

Table 2. Semivolatile Organic Target Analytes

Method 8270B - Solid Samples

CONSTITUENT	TARGET DETECTION LIMIT (g/Kg)
2-Nitroaniline	3300
Dimethylphthalate	660
Acenaphthylene	660
2,6-Dinitrotoluene	3300
3-Nitroaniline	3300
Acenaphthene	660
2,4-Dinitrophenol	3300
4-Nitrophanol	3300
4-Nitrophenol	660
Dibenzofuran	660
2,4-Dinitrotoluene	660
Diethyphthalate	660
4-Chlorophenyl-phenylether	660
Fluorene	660
4-Nitroaniline	3300
4,6-Dinitro-2-methylphenol	3300
N-Nitrosodiphenylamine	660
4-Bromophenyl-phenylether	660
Hexachlorobenzene	660
Pentachlorophenol	3300
Phenanthrene	660
Anthraoene	660
Carbazole	660
Di-n-butylphthalate	660
Fluoranthene	660
Pyrene	660
Butylbenzylphthalate	660
3,3'-Dichlorobenzidine	1300
Benzo(a)anthracene	660

Table 2. Semivolatile Organic Target Analytes	
Method 8270B - Solid Samples	
CONSTITUENT	**TARGET DETECTION LIMIT (g/Kg)**
bis(2-Ethylhexyl)phthalate	660
Chrysene	660
Din-octylphthalate	660
Benzo(b)fluoranthene	660
Benzo(k)fluoranthene	660
Benzo(a)pyrene	660
Indeno(1,2,3-cd)pyrene	660
Dibenz(a,h)anthracene	660
Benzo(g,h,f)perylene	660

Table 3. Target Analytes: Metals and other Inorganics

Analyte	SW-846 Method(s)	Target Detection Limits[1] Solid mg/kg
Aluminum	6020	10
Antimony	6020	1
Arsenic	6020	2
Barium	6020	10
Beryllium	6020	1
Bismuth	6020	1
Cadmium	6020	1
Calcium	6020	100
Chromium	6020	2
Copper	6020	1
Iron	6020	10
Lead	6020	0.6
Magnesium	6020	100
Manganese	6020	3
Mercury	7471	0.1
Nickel	6020	1
Selenium	6020	1
Silver	6020	1
Sodium	6020	100
Tin	6020	1
Zinc	6020	4
Chloride	SM 300.0	NR
Fluoride	SM 340.2	NR
Cyanide (total and amenable)	9010	NR
Hexavalent chromium	3060A/7196A	NR

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Notes:

1 The target detection limits provided are for reference purposes. The actual method detection limits are sample dependent and may vary as the sample matrix varies.

NR - Not required, best achievable limit by laboratory to be used.

Table 4. TCLP Compliance Criteria

Analyte	Methods [1]	Target Quantitation Limits mg/L
Metals		
Arsenic	6020	5.0
Barium	6020	100.
Cadmium	6020	1.0
Chromium	6020	5.0
Lead	6020	5.0
Mercury	7470	0.2
Selenium	6020	1.0
Silver	6020	5.0

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Notes:

1. All methods are SW-846 3rd Ed.

Appendix F:
Regional Benchmarking Survey

EPA's CSI Survey of 10 Milwaukee Platers
Instructions

The National Association of Metal Finishers (NAMF) is member of Environmental Protection Agency's Common Sense Initiative (CSI) metal finishing sector workgroup and is participating in the data gather effort focusing on hazardous waste regulatory issues has identified the need to compare the characteristics of F006 wastes generated today with F006 wastes generated at the time of the listing under RCRA (1980). The following survey will be used to evaluate the chemical content of F006 generated by 10 metal finishing facilities from Milwaukee. This information will be used to characterize F006, evaluate the processes generating F006 and the level of pollution prevention practiced, and determine the recyclability of F006. **Please note that this survey should be completed using available information or best engineering judgement and that you are not required to generate any new data.**

Confidentiality: If you believe that some parts of the information supplied by your are commercially sensitive, you may claim protection for your data. However it will be extremely difficult for the workgroup to use any data that is considered confidential in determining the F006 recyclability. If you believe your information to be sensitive, it may be blinded in order for the workgroup to develop a final report.

Return the completed survey within 10 days from date of receipt to:

William (Bill) Sonntag
NAMF
2600 Virginia Ave. NW, Suite 408
Washington, DC 20037
Phone: (202) 965-5190
Fax: (202) 965-4037

The survey may also be submitted to the EPA contractor during the engineering site visit and sampling effort.

For technical assistance, call Kristy Allman, SAIC at (703) 318-4766.

Response may be typed or handwritten neatly. Use additional paper as needed.

A. Corporate and Facility Information

Parent Corporation ____________________

Name of Company/Affiliate ____________________

Address of Corporation Headquarters

Street ____________________

City ____________ State ______ Zip _______

Name of Facility ____________________

Address of Facility (if different from above)

Street ____________________

City ____________ State ______ Zip _______

RCRA Hazardous Waste Generator ID Number: ____________________

POTW/NPDES Permit Number: ____________________

PSD Permit Number: ____________________

Name(s) of personnel to be contacted for additional information pertaining to this questionnaire

Name	**Title**	**Telephone**
____________	____________	____________

Type of Facility: _______ Job shop _______ Captive shop

Number of Employees: ________

B. Process Flow Diagram

The purpose of this question is to provide the workgroup with an overview of the plating operations and understanding of how the various plating operations are linked together, and the flow of wastewaters to the waste water treatment plant (WWTP) generating the F006 sludge.

The workgroup is most interested in the following commonly used processes:

- zinc plating on steel
- nickel/chromium plating on steel
- copper/nickel/chromium plating on non-ferrous substrates (zinc, brass, ABS)
- copper plating/stripping in the printed circuit industry
- hard chromium plating on steel
- cadmium plating

Please provide a general process block flow diagram for each these plating processes that identifies basic plating operation. This should contain general information on feedstocks, plating solutions, waste generation, etc.

Please provide a brief written description of the plating process. This should include:

- Feed stock, intermediate, or product storage
- Waste management units
- Waste storage and shipping equipment
- Production output
- Waste generation
- Plating sequence, solutions, and substrates

C. Wastewater Treatment Plant Flow Diagram

Please provide a brief description of the treatment process wastewaters go through to remove metals and other toxic substances prior to discharge. Please discuss the following steps and equipment used (as applicable):

- waste stream segregation
- hexavalent chrome reduction
- cyanide oxidation
- neutralization, flocculation, clarification, effluent polishing
- sludge dewatering and drying
- sludge blending to achieve desired concentration
- sludge storage and duration

D. F006 Quantity Generated and Management Methods

D.1. What was the total product weight produced by your facility in 1995?
_____________________ Long Tons or Surface area (Circle one)

D.2. Is the F006 generated at your facility process-specific or is it combined in the wastewater treatment plant? ________

D.3. What was the total quantity of F006 generated in 1995? _____________ Dry tons

D.4. Estimate the quantity of F006 generated from each process in 1995?

Process **Quantity (dry tons)**

D.5. Please provide a description of any onsite recycling of your F006. Please estimate the quantities (dry tons) recycled or recovered.

D.6. Please provide the name, location, brief process description (e.g., pyrometallurgical) and quantity (dry tons) for all F006 sludge that is sent offsite for recycling/metals recovery.

D.7. Please provide the name, location, management method (e.g., Subtitle C landfill) and quantity (dry tons) for all F006 sludge that is sent offsite for disposal.

D.8. What is the quantity of F006 sludge disposed of onsite? ______________ Dry tons

D.9. What was the quantity exported outside the U.S. in 1995? ____________ Dry tons

E. F006 Waste Characterization

Please provide waste characterization analytical data sheets for your F006 sludge. Submit both Toxicity Characteristic Leaching Procedure (TCLP) and total compositional data when possible. Please provide characterization information (if available) for pH, reactive cyanide, specific gravity, and phase distribution. Please be sure your facility name and F006 sludge sample identification is clearly marked on each page or provide it in the top right hand corner of the analytical data sheet with any additional information you may wish to provide. Please provide any specifications required by recyclers.

F. Pollution Prevention/Waste Minimization Activities

Briefly please respond to each of the following questions concerning your present or past pollution prevention/waste minimization (P2) activities. Please remember it is just as important to document your failures as well as your successes in conducting P2.

F.1. What types of equipment changes or equipment layouts have you implement in conducting P2?

F.2. Describe how you have improved operating practices including operator training.

F.3. Describe any material substitution or elimination you have implemented to make your F006 less toxic or more recyclable.

F.4. Describe your water-use (e.g., flow restriction, drag out) reduction program or policy and any addition P2 measures conducted at your facility not mentioned before.

F.5. Describe any closed-loop recycling conducted by your plating operation.

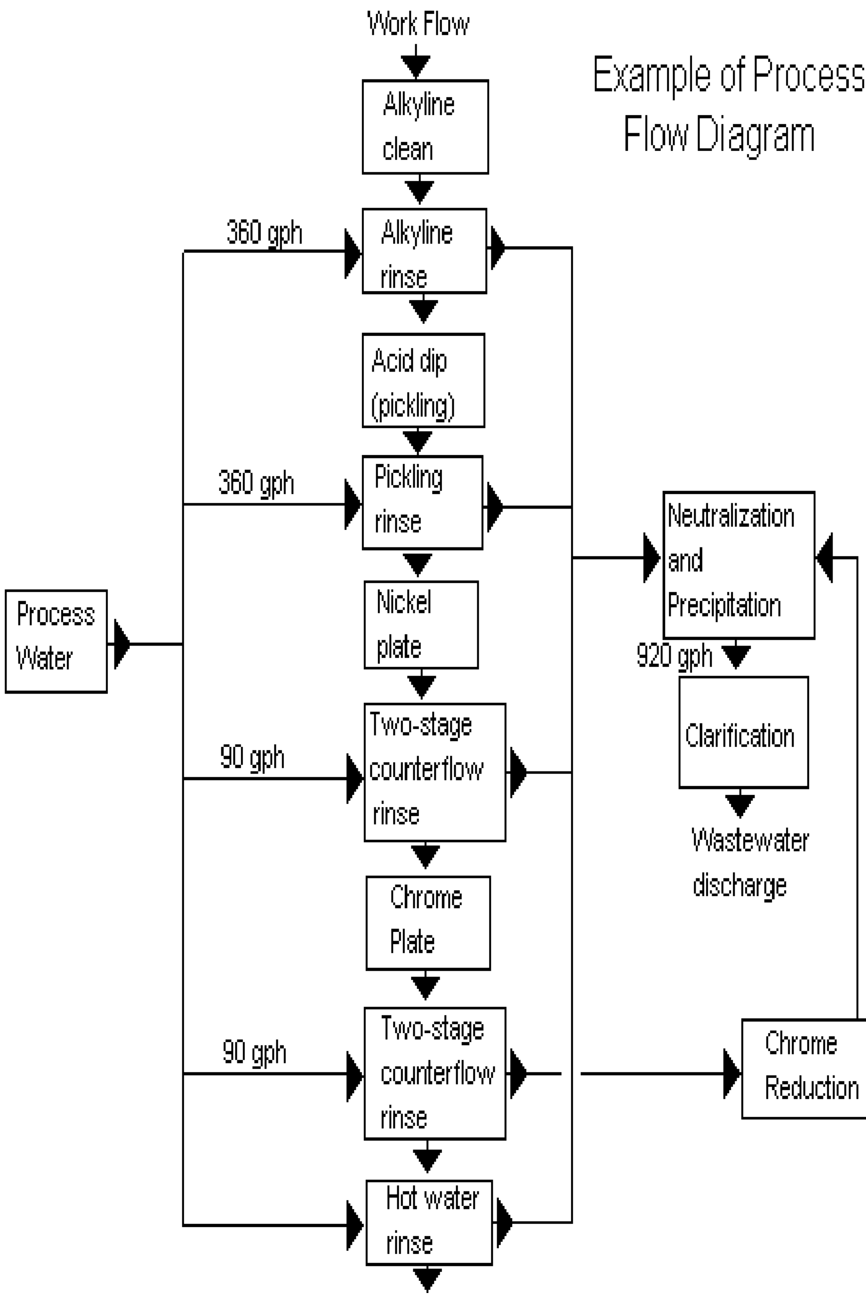
F.6. Please describe how your facility's use of pollution prevention has (or has not) affected the quantities and/or quality of F006 sludge generated at your facility.

F.7. Do you have any documentation where P2 was implemented and subsequently partially or completely abandoned in favor of reclamation. If so can you provide EPA with a copy of the documentation and briefly describe it below.

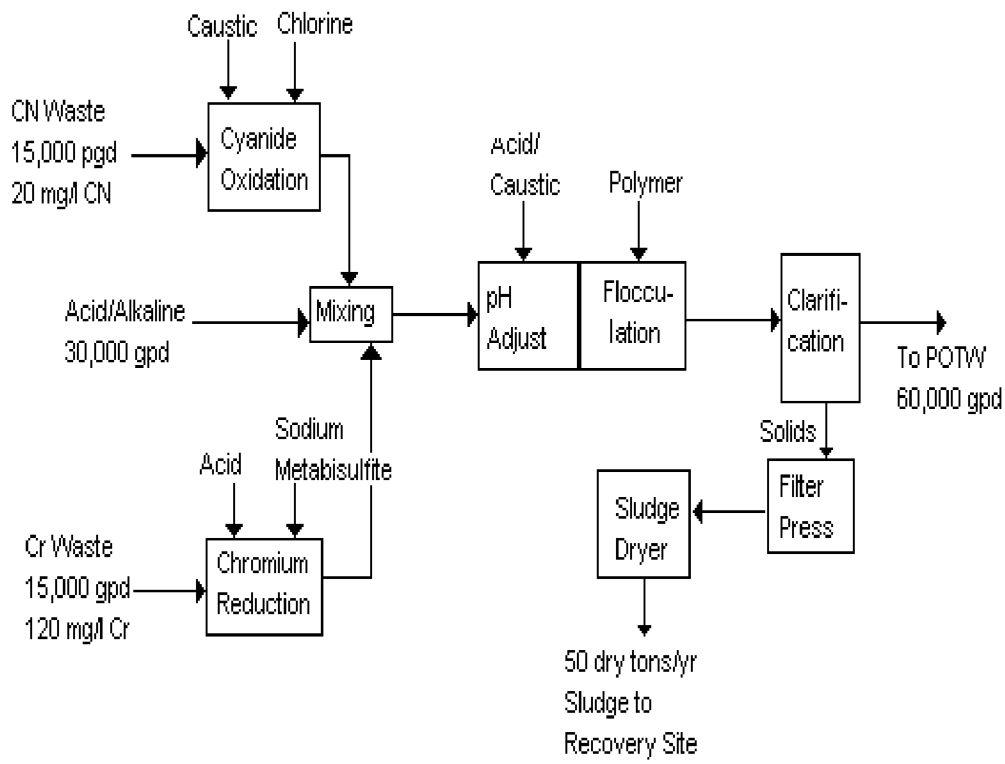
F.8. Please describe any industrial trends affecting your metal finishing facility or the metal finishing industry as a whole and/or the generation of F006 sludge.

F.9. Please describe any economic barriers and/or incentives to conducting P2. Please describe the principle economic factors that have lead to your facility's current practices.

F.10. Please describe any regulations that affect P2, recycling and sludge treatment/management decisions.


Work Flow
Example of Process
Flow Diagram
Alkyline
clean
360 gph
Alkyline
rinse
Acid dip
(pickling)
360 gph
Pickling
rinse
Neutralization
and
Precipitation
Process
Water
Nickel
plate
920 gph
Clarification
90 gph
Two-stage
counterflow
rinse
Wastewater
discharge
Chrome
Plate
90 gph
Two-stage
counterflow
rinse
Chrome
Reduction
Hot water
rinse

Example of Wastewater Treatment Process Flow Diagram



(Example from "Pollution Prevention and Control Technology for Plating Operation," G. Cushnie for NCMS.)

Appendix G:
National Benchmarking Survey and Instructions

Call for Data as Part of EPA's CSI
Instructions

The National Association of Metal Finishers (NAMF), American Electroplaters and Surface Finishers (AESF), and Metal Finishing Sciences Association (MFSA) are members of the Environmental Protection Agency's Common Sense Initiative (CSI) metal finishing sector workgroup and are participating in the data gathering effort focusing on hazardous waste regulatory issues and has identified the need to compare the characteristics of F006 wastes generated today with F006 wastes generated at the time of the listing under RCRA (1980). The following survey will be used to characterize F006, evaluate the processes generating F006 and the level of pollution prevention practiced, and determine the recyclability of F006. **Please note that this survey should be completed using available information or best engineering judgement and that you are not required to generate any new data.**

> F006 is defined as "Wastewater treatment sludges from electroplating operations except from the following processes: (1) Sulfuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum." (40 CFR §261.31)

Return the completed survey as soon as possible but not later than 30 days after receipt of this survey to:

Christian Richter
NAMF/AESF/MFSA
2600 Virginia Ave. NW, Suite 408
Washington, DC 20037
Phone: (202) 965-5190
Fax: (202) 965-4037

Response may be typed or handwritten neatly.

A. CORPORATE AND FACILITY INFORMATION

Parent Corporation ____

Name of Company/Affiliate ____

Address of Corporation Headquarters

Street ____

City ________________ State ______ Zip _______

Name of Facility ____

Address of Facility (if different from above)

Street ____

City ________________ State ______ Zip _______

RCRA Hazardous Waste Generator ID Number: ____

POTW/NPDES Permit Number: ____

PSD Permit Number: ____

State or Local environmental permits: ____

Name(s) of personnel to be contacted for additional information pertaining to this data

Name	**Title**	**Telephone**
____________________	____________________	______________

Type of Facility: _______ Job shop _______ Captive shop

Number of Employees: ______________

B. METAL FINISHING OPERATIONS

What type of plating operations are conducted by your facility? Specify cyanide- versus non-cyanide-based plating.

	zinc plating on steel CN Non-CN
	nickel/chromium plating on steel
	copper/nickel/chromium plating on non-ferrous substrates (zinc, brass, ABS)
	copper plating/stripping in the printed circuit industry
	hard chromium plating on steel
	Copper plating
	tin (acid) plating
	cadmium plating
	sulfuric acid anodizing
	silver plating
	gold plating
	bright dip of copper/alloy
	Other,(specify):

C. F006 QUANTITY GENERATED AND MANAGEMENT METHODS

C1. What was the total product weight produced by your facility in 1996? ___________________ (Long Tons/Cubic yards/Cubic feet) Please circle appropriate units.

C2. Is the F006 generated at your facility process-specific or is it combined in the wastewater treatment plant? _______

C3. Are cyanide-bearing F006 sludges segregated from non-cyanide F006? Yes / No

C4. What was the total quantity of F006 generated in 1996? _______________ (Dry Tons/Cubic yards/Cubic feet) Please circle appropriate units.

C5. Estimate the quantity of F006 generated from each process in 1996?

Process	**Quantity (Specify units)**

C6. Please provide a description of any onsite recycling of your metals prior to discharge to wastewater treatment. Please estimate the quantities (Dry Tons/Cubic yards/Cubic feet) recycled or recovered.

Description of any onsite recycling	Quantity recycled or recovered

C7. Please provide the name, location, and quantity (Dry Tons/Cubic yards/Cubic feet) for all F006 sludge that is sent offsite for recycling/metals recovery.

Name	Location	Quantity

C8. Please provide the name, location, management method (e.g., Subtitle C landfill) and quantity (dry tons) for all F006 sludge that is sent offsite for disposal.

Name	Location	Management Method	Quantity

C9. What was the quantity exported outside the U.S. in 1996? ____________ Dry tons

C10. Please check any of the wastewater treatment process used to remove metals and other toxic substances prior to discharge. Please discuss the following steps and equipment used (as applicable):

	waste stream segregation
	hexavalent chrome reduction
	cyanide oxidation
	neutralization, flocculation, clarification, effluent polishing
	sludge blending to achieve desired concentration

D. F006 WASTE CHARACTERIZATION

Please provide waste characterization analytical data sheets for your F006 sludge. Submit both Toxicity Characteristic Leaching Procedure (TCLP) and total compositional data when possible. Please provide characterization information (if available) for pH, reactive cyanide, specific gravity, and phase distribution. Please be sure your facility name and F006 sludge sample identification is clearly marked on each page or provide it in the top right hand corner of the analytical data sheet with any additional information you may wish to provide. Please provide any specifications required by recyclers.

E. POLLUTION PREVENTION/WASTE MINIMIZATION ACTIVITIES

E1. Check the techniques used at your site. If requested, indicate whether the technique is automated or manual. The pollution prevention benefits from the techniques you use (1= low success, 5= high success). If the rating is 1 or 2, indicate below what problems were encountered. Also, use the space below or other sheets to describe any innovative methods or to provide additional information.

	Reduce Drag-Out Losses By:	P2 Benefit
	Using drag-out rinse tanks and returning chemicals to the process bath Manual or Automatic	
	Using drip tanks and returning chemicals to the process bath Manual or Automatic	
	Reducing speed of rack/part withdrawal Manual or Automatic	
	Allowing rack/part to drip over plating tank Manual or Automatic	
	Using a drag-in/drag-out arrangement (i.e., use of same rinse tank before and after plating also referred to as a double-dip or double-use rinse) Manual or Automatic	
	Fog or spray rinses installed over process bath Manual or Automatic	
	Air knives that blow off drag-out Manual or Automatic	
	Drip shields between tanks Manual or Automatic	
	Lower bath concentration	
	Increasing solution temperature (reduces viscosity)	
	Using a wetting agent (reduces viscosity)	
	Positioning work piece to minimize solution holdup	
	Other, specify	

	Reduce Rinse Water Use By:	P2 Benefit
	Manually turning off rinse water when not in use	
	Conductivity or pH rinse controls	
	Timer rinse controls	
	Flow restrictors	
	Countercurrent rinses	
	Spray rinses	
	Air agitation in rinse tanks	
	Use flow meters/accumulators to track water use at each rinse tank or plating line	
	Reactive rinsing or cascade rinsing	
	Other, specify	

	Various Operating Practices:	P2 Benefit
Training and Programs:		
	Established a formal policy statement with regard to pollution prevention and control	
	Established a formal pollution prevention program	
	Conduct employee education for pollution prevention	
	Establish a preventative maintenance program for tanks	
	Use specifically assigned personnel for chemical additions	
Procedures:		
	Stricter conformance w/ Line Preventive Maintenance Schedule	
	Stricter conformance w/ SPC Procedures	
	Waste stream segregation of contact and noncontact wastewater	
	Strict chemical inventory control	
	Perform routine bath analyses	
	Maintain bath analyses/addition logs	
	Have written procedures for bath make-up and additions	
	Use process baths to maximum extent possible (no dump schedule)	
	Remove anodes from bath when they are idle (e.g., cadmium, zinc)	
	Regularly retrieve fallen parts/racks from tanks	
F006 Volume Reduction methods:		
	Closed-loop recycling	
	Use control method for adding water to process tanks	
	Sludge Dewatering- (Vacuum filter, Solid bowl centrifuge, Imperforate basket centrifuge, belt filter press, Recessed plate filter press, sludge drying beds, sludge lagoons, sludge dryers, etc.)	
	Install overflow alarms on process tanks	
	Install other spill/leak detection system, specify ___________________________________	
Inspections/ Maintenance:		
	Perform regular maintenance of racks/barrels	
	Pre-inspect parts to prevent processing of obvious rejects	
	Waste Reduction Study conducted	
Research/Evaluations:		
	Evaluation of recycling alternatives	
	Increasing drain time over process tanks	

	Various Operating Practices:	P2 Benefit
	Research of alternative plating technologies	
	Development of tracking system for monitoring flow from different areas	
	Monitoring of incoming water with strict control program	
	Two separate labs for process chemistry and wastewater treatment	
Elimination/ Replacement/Substitutions:		
	Eliminate obsolete processes and/or unused or infrequently used processes	
	Replace cyanide based plating solution with alkaline-based solutions	
	Elimination of rinse waters to waste treatment (nickel, chrome)	
	Substitution of chromate and dichromate seal with non chrome sealer	
	Elimination of plating services (cadmium, tin, nickel, copper, brass and hard chrome)	
	Elimination of vapor degreasing	
	Implementation of a multi- stage cyanide destruct system	
	Elimination of chelated cleaners	
	Other, specify	
	Other, specify	

Additional Information (attach other sheets, if necessary): ______________________________________

E.2. Has the implementation of pollution prevention reduced your wastewater discharge rate?
Yes No

If yes, approximately how many gallons per day average have you reduced your flow by using pollution prevention?
______________________ gpd eliminated (base year = 19__)

E.3. Recycle and Recovery Technologies - Check each technology that you have used in the past or currently use, indicate the type of process bath to which the technology is applied.

	Technology	Process Bath Technology is Applied to
	Electrodialysis	
	Electrowinning	
	Evaporator	
	Ion flotation	
	Ion exchange	
	Mesh pad mist eliminator/recycle	
	Reverse osmosis	
	Ultrafiltration	

Technology		Process Bath Technology is Applied to
	Other*	

E.4. Solution Maintenance Techniques

Check the techniques that you presently use and indicate the type of process bath to which the techniques applied. Use the space below to describe any innovative methods or to provide additional information.

Technology		Process Bath Technology is Applied to
	Acid retardation	
	Carbon treatment (batch)	
	Carbon treatment (continuous)	
	Dummying of metal contaminants	
	Electrodialysis for inorganic contaminants	
	Carbonate freezing	
	Filtration, in-tank	
	Filtration, external	
	High pH treatment	
	Precipitation	
	Liquid/ Liquid extraction	
	Microfiltration	
	Ultrafiltration	
	Other, specify	
	Other, specify	
	Other, specify	

Additional Information:____

____

____

Appendix H:
National Benchmarking Commercial Recyclers Survey

EPA's CSI Survey of Recyclers of F006 Instructions

The National Association of Metal Finishers (NAMF), American Electroplaters and Surface Finishers (AESF), and Metal Finishing Sciences Association (MFSA) are members of Environmental Protection Agency's Common Sense Initiative (CSI) metal finishing sector workgroup and are participating in the data gathering effort focusing on hazardous waste regulatory issues. The workgroup has identified the need to compare the characteristics of F006 wastes generated today with F006 wastes generated at the time of the listing under RCRA (1980). The following survey will be used to characterize F006, evaluate the F006 recycling processes, and determine the recyclability of F006. **Please note that this survey should be completed using available information or best engineering judgement and that you are not required to generate any new data.**

Return the completed survey within 30 days from date of receipt to:

William (Bill) Sonntag
NAMF/AESF/MFSA
2600 Virginia Ave. NW, Suite 408
Washington, DC 20037
Phone: (202) 965-5190
Fax: (202) 965-4037

For technical assistance, please call Kristy Allman at (703) 318-4766.

Response may be typed or handwritten neatly. Use additional paper, as needed.

A. CORPORATE AND FACILITY INFORMATION

Parent Corporation ______________________________

Name of Recycling Company/Affiliate ______________________________

Address of Recycling Company Headquarters

Street ______________________________

City ____________ State ______ Zip _______

Address of Facility (if different from above)

Street ______________________________

City ____________ State ______ Zip _______

RCRA Hazardous Waste Generator ID Number: ______________________________

POTW/NPDES Permit Number: ______________________________

PSD Permit Number: ______________________________

State and local environmental permits: ______________________________

____

Name of person to be contacted for additional information pertaining to this questionnaire

Name	**Title**	**Telephone**
____________	____________	____________

Manner of Handling F006: Hydrometallugical ________ %

Pyrometallurgical ________ %

Blender/Broker ________ %

Other, specify (%) ______________________________

Number of Employees: ________

B. PROCESS FLOW DIAGRAM

B.1 On a separate sheet of paper, please provide brief description of your process and, if possible, a process flow diagram that identifies basic metal recovery methods. This should include general information including process steps, feeds, products, and the emissions and wastes from the recycling process. This should include:

- Feed stocks, intermediates, and/or products
- Process steps
- Waste management units
- production output
- emissions and waste generation points

C. F006 QUANTITIES

C.1. What was the volume of all the materials processed by your facility in 1995?[15] ___________ Long tons

C.2. What was the volume of F006 sludge processed by your facility in 1995?[1] _________ Dry tons

D. F006 CHARACTERIZATION

D.1. Please provide analytical data for F006 evaluated in 1995[1]. If this represents a large quantity of data, you may present a subset focusing on either more complete analytical scans or on a more recent time period (i.e., the last month). If the data is confidential, you may present a range, with the average and number of data points. If available, please provide the broader pre-approval scans, typically examining a broader spectrum of constituents, rather than the more cursory screening analyses typically performed on each load of newly received F006. When available, submit both Toxicity Characteristic Leaching Procedure (TCLP) and total concentration data. Please be sure your facility name, and F006 sludge sample is clearly identified on each page or provide it in the top right hand corner of the analytical data sheet with any additional characteristic information you may wish to provide. If you have any questions, you may call the technical assistance line.

D.2. Please provide a copy or descriptions of the specification for the F006 sludge must meet for your facility to accept it for recycle. Use additional paper if necessary.

____

D.3. Explain any undesirable physical or chemical characteristics F006 might possess making it unacceptable to you facility. Use additional paper if necessary.

____

____

EVALUATION OF F006

E.1. How does your facility establish the value of F006 (i.e., how do you determine what your company will charge or pay for F006)? Please list the specific metals or combination of metals, or contaminants which affect your valuations. (Please respond in less specific terms if specific termination is considered proprietary.) Use additional paper if necessary.

____

____

[15] The CSI workgroup is attempting to characterize the F006 sludge based on 1995 data. If data for 1995 is not available, other recent time frames will be useful. Please clearly mark the date or time frame on the data sheets.

Appendix I:
Responses to Citizen Group Phone Survey

Individual responses are summarized below.

Question #1: Is the Group Aware of Environmental Impacts from the Recycling Facility?
NO
NO. "Not in the past 6 years. No known violations. Involved in moving waste from one state to another--some question concerning whether it is "sham recycling" or not."
NO
NO COMMENT. The environmental group technically no longer exists.
NO
NO. "They generally try to make env. laws easier, through political influence. They also operate a superfund site."
NO
NO
UNKNOWN. "Never heard of the company."

Question #2: Is the Group Aware of Economic Impacts from the Recycling Facility?
NO
NO. "They are the largest waste recycler in this state, but mostly imported from other states."
NO
NO COMMENT. The environmental group technically no longer exists.
YES. "Positive impact, always in the business pages of the newspaper."
NO
NO. "Provides a good service for local companies."
NO
UNKNOWN. "Never Heard of the company."

Question #3: Is the facility considered a "Good Neighbor?"
UNKNOWN
NO. "They spread the waste on the ground to dry it."
UNKNOWN. "Have heard little about this facility, it is 50 miles away."
NO COMMENT. The environmental group technically no longer exists.
YES. "Have no information to say they are a bad neighbor."
NO. "Don't trust them."
YES. "They make an effort to get involved in informing the community on what they do."

Question #3: Is the facility considered a "Good Neighbor?"
YES. "They received an environmental award and, we have participated with them on voluntary P2 committees and projects."
UNKNOWN. "Never heard of the company."

Appendix J:
Statistical “Representativeness” of the National Benchmarking Study

Statistical "Representativeness" of the National Benchmarking Study

A chi-square analysis was performed to determine whether there is a difference in the distribution of sample proportions for D&B, BRS and "national" databases over the different regions.

- Summary of results of comparison of the National sample with the Dun & Bradstreet extract

A chi-square analysis was performed to compare the National sample and the D & B extract (Primary SIC code of 3471) on the number of data points for each of the ten EPA regions.

Results of the test showed that they are statistically different (p-value - 0.003. Please refer to Table 1 of Attachment 1). The difference can be attributed to the difference in percentages of the number of facilities in the National sample and the D & B extract for EPA regions 4, 5, and 6. The D & B extract had nearly 30% of the data points as against 42% in the National sample for region 5. The National sample had 5.78 % (region 4), 1.16% (region 6) of the data points as against 9.84% (region 4) and 7.43% (region 6) in the D & B. The difference in size of the National sample (173) and the D & B (4147) was an important issue for the significant p-value of 0.03%. If the National sample is used to produce any national estimate, there should be caveats for the differences mentioned above for EPA region 4, 5, and 6.

The National and the D&B extract were also compared on the basis of mean number of employees per facility. It was found that the means for the National sample were consistently higher than the corresponding means in the D & B (Please refer to table 2 of Attachment 1). This shows that relatively larger facilities in terms of manpower volunteered for the National sample. Hence, any national estimate from this sample must come with a caveat indicating a potential bias problem.

For 9 degrees of freedom, the χ^2 value of 25.22 is significant beyond both 5% and 1% levels. Therefore, we reject the null hypothesis that there is no difference in the sample proportions for D&B and "national' databases. Note, however, that due to small sample sizes in the "national" database, the results could be more informative after collapsing several regions in larger strata.

2. In this section, a statistical method for testing the difference between average number of employees from the D&B and "national" databases is described. Histograms and normal probability plots applied to the total number of employees suggest that the characteristic of interest (# of employees) is distributed more lognormally than normally. Therefore, the log-transformed version was used in all calculations. Assuming that the D&B database covers almost all facilities of interest, the true mean and true standard deviation for each region can be approximated by

$$\bar{Y}_j = \frac{1}{N_j}\sum_k Y_{jk} , \qquad S_j = \sqrt{\frac{1}{N_j}\sum_k (Y_{jk}-\bar{Y}_j)^2}$$

Since N_j is large enough and S_j is known, we can use normal approximation to test the differences between the true (*D&B*) mean, Y_j, and the sample (*"national"*) mean, y_j. In this case the test statistic is given by

$$z_j = \frac{|\bar{y}_j - \bar{Y}_j|}{S_j}, \qquad j = 1,2, \ ,10$$

- Summary of results of comparison of the National sample with the BRS sample

Results of the chi-square test performed to compare the National sample and the BRS sample are similar to the results of comparison of the National sample and the D & B extract. In fact, with a precision of 0.1%, we conclude that the distribution of sample points by region in the National sample is significantly different from the distribution of sample points by region in the BRS sample.
The difference can be attributed to the difference in percentages of the number of facilities in the national sample and the BRS sample for EPA regions 3, 4, 5, 6, and 9.

Comparing the average F006 discharge for each region in the national sample and in the BRS sample, we found that, in general, there are no significant differences for most regions in these two samples. Only two regions (region 1 and region 5) out of ten in the National sample discharged significantly more F006 than the corresponding regions in the BRS sample. Note also that there were no samples taken from region 8 in the National survey.

- Comparison of the Regional Benchmarking Sampling data to the National Survey data

The results of the test for all 10 groups along with the corresponding p-values are attached.
In order to compare the responses from the ALLDATA sample and the NATIONAL sample, we examine how much the mean and distribution of each analyte from the ALLDATA sample differ from those from the NATIONAL sample. The table below summarizes the results of statistical tests performed to compare the two samples. It contains p-values for the analytes that are in both ALLDATA and NATIONAL samples. P-values less than 0.05 indicate a statistically significant difference between the responses from the ALLDATA sample and the NATIONAL sample for a particular analyte.

From this table we conclude that the reported values are significantly different for Amenable Cyanide, Magnesium, Selenium, Total Cyanide, and Zinc from the TOTAL group. The results for other analytes do not show significant differences between the two samples under study.

TCLP METALS		TOTAL METALS	
ANALYTE	P-VALUE	ANALYTE	P-VALUE
BARIUM	0.0691	ALUMINUM	0.1407
CADMIUM	0.5960	AMENABLE CYANIDE	0.0084
CHROMIUM	0.0517	ANTIMONY	0.3772
LEAD	0.3126	ARSENIC	0.2715
MERCURY	0.1071	BARIUM	0.6320
SILVER	0.4097	BERYLLIUM	0.3729
		BISMUTH	0.2239
		CADMIUM	0.3766
		CALCIUM	0.1183
		CHLORIDE	0.4763
		CHROMIUM	0.1502
		CHROMIUM, HEXA	0.2812
		COPPER	0.1159
		FLUORIDE	0.1477
		IRON	04179
		LEAD	0.6072
		MAGNESIUM	0.0044
		MANGANESE	0.3262
		MERCURY	0.2802
		NICKEL	0.2023
		SELENIUM	0.0365
		SILVER	0.2741
		SODIUM	0.6743
		TIN	0.2546
		TOTAL CYANIDE	0.0319
		ZINC	0.0146