Pollution Prevention for the Electroplating and Metal Finishing Industry

Kansas Small Business Environmental Assistance Program
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Pollution Prevention for the Industry

What is Pollution?

*Webster’s Dictionary* defines pollution as the process of contaminating or making an environment unfit with man-made waste. Laws have been put into effect in the last 30 years to help protect our environment. Many of these laws were in response to catastrophic events in order to protect human health and the environment. Air pollution is regulated by the Clean Air Act and its amendments, water pollution by the Clean Water Act and Safe Drinking Water Act, and solid pollution by numerous laws including the Resource Conservation and Recovery Act (RCRA). Other laws place emphasis on the rights of the public to know what chemicals are in their communities.

The Development of Pollution Prevention Concepts

Congress began addressing pollution in the late 1800’s. The Rivers and Harbors Act of 1899 made dumping waste into the Mississippi River illegal. Since then numerous laws and agencies have been created to deal with environmental issues. The vast majority of environmental regulations have focused on identification and cleanup of pollution such as the Resource Conservation and Recovery Act of 1976.

However, in 1990, beginning with the Pollution Prevention Act, EPA shifted focus from “end-of-pipe” pollution treatment and cleanup to policies, technologies, and processes which prevent and minimize the generation of pollution. The underlying theory behind pollution prevention (P2) is that it is economically more sensible to prevent wastes rather than implement expensive treatment and control technologies to insure that waste does not threaten human health and the environment.

The Metal Finishing Industry

Almost all products that are manufactured from or contain metal are subject to some type of finishing operation. The metal finishing industry uses a wide variety of processes and chemicals to clean, etch, and plate both metallic and non-metallic surfaces to enhance their appearance and surface properties.

The industry is principally dominated by small specialty job shops that cater primarily to larger industries in aerospace, agriculture, electronics, defense, and transportation. Because most metal finishing operations are small, numerous, and highly capital intensive, there is extreme competition to continually provide quality products and services to their customers at the lowest possible cost. In addition, processes used in metal finishing operations are extremely chemical-dependent, making them one of the
most heavily environmentally regulated industries in the United States. These factors generally result in lower profit margins for the job shop.

The challenge facing metal finishers in years to come will be primarily concerned with maintaining their current market niche and finding new markets, while at the same time investing in equipment that will both reduce costs and keep them in compliance with local, state, and federal environmental regulations. Implementation of P2 practices and technologies provides a method by which metal finishers can cost-effectively meet each of these challenges.

![Image of industrial site with smoke stacks and a polluted stream.]

**P2 for Your Industry**

If you are an electroplating or metal finishing “job shop” owner, this manual is designed for you. It covers pollution prevention strategies that can be implemented in your shop to minimize the generation and release of wastes. Our manual introduces pollution prevention concepts applied to common processes, gives an overview of some of the alternative technologies available to minimize pollution, and briefly discusses regulatory requirements in the state of Kansas. Case studies and success stories from shops using these technologies are included to show how others have reduced their waste streams and their regulatory requirements by using P2 technologies.
Section 1: P2 and You

A Different Perspective

Look at environmental management from a different perspective. Instead of looking at pollution prevention as something that is going to require a lot of extra time and effort (which in itself may be a misconception), look at P2 as something that can give your company a competitive edge over your rivals. Consider some of the “old” and “new” ways of looking at pollution prevention efforts.

It’s Costly

“old” – Environmental improvements are costly, and therefore, must be mandated.

“new” – P2 can be a win-win situation for the company’s bottom line and the environment, if done right. Remember that decreasing your waste volume and more efficient use of materials not only lowers costs associated with waste disposal, but also saves purchasing additional raw materials.

It’s an Overhead Burden

“old” – Meeting minimum compliance requirements is a sound business strategy.

“new” – Integrating environmental management into the entire business operation creates a competitive edge.

Regulatory Compliance Issues

“old” – Sound environmental strategies involve helping companies address compliance requirements.

“new” – Regulations are a guide; compliance may be a driver, but business excellence is the objective.

Technology Fixes Everything

“old” – People create pollution problems; new technology and equipment will solve them.

“new” – Technology and equipment are only as good as the people who operate and maintain them.

“It’s time . . . to prevent pollution . . . to stop it before it starts.” – George Bush
When examining your pollution prevention efforts, look not only on a facility-wide basis, but also on a process-by-process basis. P2 success depends on:

- Quantifying the true costs of waste generation
- Efficient process measurement
- Efficient monitoring and control
- Focus on the individual processes
- Time and facility conditions

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**Artistic Plating and Metal Finishing, Inc. – Aqueous Cleaning**

**Change:** Replacement of a PERC (perchloroethylene) solvent degreasing unit with aqueous cleaning for the removal of oils, particulates and buffing compounds.

**Result:** A 50% reduction in labor hours and operating and maintenance costs, no air permit costs, and minor savings in chemical and hazardous waste costs versus the old unit. Also, a more pleasant working environment due to the elimination of unpleasant and harmful fumes.

**Total Capital Costs:** $14,000

**Savings:** $8,440 per year (1.7 year simple payback)
Hierarchy of P2 and Waste Management Strategies

Any P2 initiative which lessens or eliminates the generation of wastes is classified in the category of source reduction. Source reductions decrease the amount of waste generated and usually are some of the least expensive methods of minimizing waste. Many options require only minor process changes or simple housekeeping changes. Pollution control regulations have provided the incentives for process chemical alternatives that are less toxic. Eliminating such materials, through material substitution or reduced drag-out, eliminates the need to detoxify the wastes they generate. This is particularly true of processes involving hexavalent chromium or cyanide. Consider the P2 hierarchy and ask yourself the following questions when looking at alternatives.

### Heirarchy of Pollution Prevention Strategies

**priority one: source reduction**
- Material Substitution
- Extend Bath Life
- Reduce Drag-out
- Recover Drag-out
- Reduce Rinse Water

**priority two: recycling and reuse**
- Reuse Spent Baths
- Reuse Rinse Water
- Recycle Bath / Rinse Water
- Segregate Waste Streams

**priority three: improved waste water treatment**
- Improve WWTS Efficiency

- Are the substitutes practical and available?
- Will one problem be solved only to have created another?
- Will product quality and production rate be affected?
- What will be the economic impacts of changing to the alternative?
Although more difficult to quantify, simple improvements to housekeeping techniques can provide inexpensive means of reducing waste generation. Examples include inventory rotation and avoiding cross-contamination of materials by keeping the work area clean and organized. Waste can be reduced by having inspection and maintenance schedules to insure equipment is in peak working order and thus not wasting raw materials, and by controlling the purchasing, handling, and storing of raw materials, so as to not have chemicals with a shorter shelf life “go bad”.

Besides source reduction, recycling and recovery methods minimize waste disposal by retrieving usable materials. Recovery technologies can either remove the desired materials from a waste stream before disposal or can directly use waste from one process as raw material in another. Evaluate waste streams for the properties that make them useful rather than for the properties that render them waste. Waste stream segregation is usually a part of any recovery program, and thus process piping modifications or extra holding tanks are often necessary to facilitate this.

In addition to the reuse of waste material, examine the possibilities of recycling rinse water, process bath water, or solvents. Solvents can be recycled off-site as part of a package solvent service. Some companies will rent degreasing equipment, supply all solvents, and accept the waste solvents for off-site recycling. Such services may be cost effective for low volume users of solvents, and usually reduce management issues involved with the cleaners. High volume solvent users can recycle solvent wastes on site using distillate technologies. The benefits of off-site vs. on-site recycling depend on solvent purchase cost, service and equipment fees, waste generation, and associated disposal costs.

“The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, not impaired, in value.”

– Theodore Roosevelt
Pollution Prevention through Process Control

All manufacturers of goods and services have production and quality concerns. For metal finishers, a successful business is based on getting a good product out in an efficient and economic manner. The following factors affect the bottom line.

- product throughput rate
- process bath purity
- quantity of chemical use
- rinse bath effectiveness
- product rejection rate

It’s counterproductive to initiate new mechanisms, process controls, or pollution prevention technologies, if the product quality suffers. Every rejected part means more waste generated – the very thing P2 is trying to prevent!

Pioneer Metal Finishing – Closed Loop Pretreatment System

Change: Replacement of a single-pass wastewater treatment system with a closed-loop system to correct minor electroplating process upsets that allowed metals and inorganics to be released into the effluent.

Result: A reduction in sludge volume, treatment chemical use, and water usage.

Total Capital Costs: $210,000

Savings: $58,460 per year (3.6 year simple payback)

One area of concern for finishers is bath quality. For proper bath maintenance, most shops have some kind of bath monitoring techniques, personnel responsible for bath additions, or periodic bath dumps based on production scheduling. Obviously, no one
wishes to waste the production chemicals they have to purchase, but deterioration of the process bath and maintaining product quality dictates periodic dumps. What can be controlled is the rate at which both drag-out and drag-in cause the bath chemistry to go bad. If the life of the bath can be extended, savings can be realized in raw materials for the process baths and those chemicals used for treatment. Waste and sludge disposal costs can be reduced as well.

One of the chief factors determining bath life is drag-out, which pulls needed chemicals out of the process bath, and drag-in, which affects the purity and effectiveness of the bath. The increased drag-out means increased rinse water use, which means increased wastewater generation. This in turn means an increased need for treatment chemicals, which leads to increased sludge cake generation, and on and on and on...

The severity of drag-out in your shop can be monitored in several ways. Measuring the volume of drag-out drained from treated parts is a direct means of determining drag-out. Other methods include measuring metal concentrations or conductivity in rinse tanks or wastewater. Whichever method is chosen, a period of time may be required to get an average or typical drag-out representation.

Once drag-out amounts are accurately calculated, the associated costs and methods of reducing drag-out and their effectiveness are easily determined. It may be that longer hang times or slower bath withdrawal rates, while slowing down production, may be economically advantageous if they are offset by reduced drag-out costs. Other means of reducing drag-out include improved rack and barrel designs, spray systems to return chemicals to the bath, and one of the most overlooked components – the well-trained worker.

污染预防（P2）可以帮助您的车间减少：
- 危险废物
- 垃圾处理成本
- 原材料采购
- 短期与员工健康相关负债
- 长期与不适当危险废物处理相关的负债

<table>
<thead>
<tr>
<th>Pollution prevention (P2) can help your shop reduce:</th>
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<tbody>
<tr>
<td>• hazardous waste</td>
</tr>
<tr>
<td>• waste disposal costs</td>
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<tr>
<td>• raw material purchases</td>
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<tr>
<td>• short-term liabilities associated with employee health issues</td>
</tr>
<tr>
<td>• long term liabilities from improper hazardous waste disposal</td>
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Establishing a Waste Management Program

Any waste management program is an organized, comprehensive, and continuous effort to systematically reduce waste generation. It should reflect the goals and policies of management. Steps of an effective program include the following.

Pre-Audit Phase

- Top management support – management must be convinced of the program and provide the necessary resources to ensure it will succeed.
- Clear definitions of project scope and objectives – define project goals in a formal policy statement. Use specific terms, such as compliance issues, toxicity reductions, increased production capacity, or improved public relations.
- Pervasive philosophy – no project succeeds without the involvement and enthusiasm of employees.

Audit Phase

- Accurate baseline definition and data collection – information required may include process flow diagrams, material and energy balances, operation and maintenance records, production control logs, discharge permits, and compliance records.
- Accurate cost accounting – look at material costs, disposal costs, and utility costs per square foot, per process, or per part produced.
- Program leadership – audit teams should have an understanding of all critical variables at the completion of process and cost assessments.

Feasibility Analysis

- Technology transfer – look at the potential of transferring technologies between processes, departments, and facilities. Often times the counter argument, “this is the way we have always done it”, is an excuse to avoid change.
- Continuous reappraisal – after project completion, begin again. Assess emerging technologies and changing business objectives.
“Before everything else, getting ready is the secret of success”

- Henry Ford
Section 2: Checklist for Success

Using checklists can help spot areas in your shop that create unnecessary waste, labor, paper work, and regulatory problems. This information is strictly for your use. If your shop modifies its processes or grows, go over the checklist again to see if any waste reduction strategies will apply to your new operations.

Before You Plate…

<p>| | |</p>
<table>
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<tbody>
<tr>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td><strong>1. Do you inspect all parts before plating?</strong></td>
<td></td>
</tr>
<tr>
<td>• Ensure that surfaces are clean, dry, and free of rust and mill scale. Unclean surfaces may be responsible for producing a poor quality product and shortening process and rinse bath life.</td>
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<tr>
<td>• Check the machining operation if parts are consistently oil-covered. Can they modify their processes to produce a cleaner part?</td>
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<tr>
<td>• Mask areas of parts that don’t need to be plated to prevent unnecessary plating, reduce drag-out, and reduce buildup of dissolved metals.</td>
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<tr>
<td><strong>2. Do you mechanically clean parts?</strong></td>
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<tr>
<td>• Clean parts using a wire brush or other mechanical means whenever possible. This reduces the amount of solvent needed for cleaning parts.</td>
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</table>
### Process Bath Maintenance

<table>
<thead>
<tr>
<th>1. Is bath life extended by filtration, electrolytic dummying, or precipitation?</th>
<th>Yes/No</th>
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<tbody>
<tr>
<td>• Remove bath contaminants and extend bath life using continuous filtration. Filtration systems remove accumulated solids that reduce process bath effectiveness. Filter media replacement generates a solid waste that needs to be disposed of properly. Some filters may be cleaned and reused.</td>
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<tr>
<td>• Remove copper in zinc and nickel baths by electrolytic dummying. An electrolytic panel is placed in the bath and a “trickle current” is run through the system. The copper is plated out, but the bath additives are unaffected.</td>
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<tr>
<td>• Precipitate out lead and cadmium to extend bath life.</td>
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<tr>
<th>2. Do you continuously monitor baths?</th>
<th>Yes/No</th>
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<tr>
<td>• Monitor bath characteristics such as pH, chemical concentrations, and metal content to maintain the baths. Many plating processes have ideal operating ranges. Making the necessary adjustments will extend bath life.</td>
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<tr>
<td>• Establish written procedures for bath or chemical make-up and additives.</td>
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<tr>
<th>3. To extend bath life, do you prevent entrance of foreign material?</th>
<th>Yes/No</th>
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<tbody>
<tr>
<td>• Keep racks free from contaminants, protect anode bars from corrosion, and filter incoming air.</td>
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<tr>
<th>4. Do you use the lowest possible chemical concentrations at which process baths can operate effectively?</th>
<th>Yes/No</th>
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<tbody>
<tr>
<td>• Slow degradation of rinse baths by minimizing chemical concentrations in the process baths. In general, higher chemical concentrations cause higher viscosities. The liquid bath film adhering to work pieces is thicker and won’t drain back as quickly. Lower concentrations reduce bath drag-out.</td>
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<tr>
<td>• Determine the lowest bath concentration that will provide adequate bath quality. Chemical product manufacturers may recommend operating concentrations greater than necessary.</td>
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<tr>
<th>5. Are fresh process bath solutions operated at a lower concentration than replenished process bath solutions?</th>
<th>Yes/No</th>
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<tbody>
<tr>
<td>• Operate fresh process baths at lower concentrations than used baths. Make-up chemicals can be added to the bath to gradually increase concentrations.</td>
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<tr>
<th>6. Do you use deionized water for process baths and rinse water?</th>
<th>Yes/No</th>
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<tbody>
<tr>
<td>• Deionized water eliminates buildup of natural contaminants present in tapwater. Use deionized water in both process baths and rinse baths which replenish process baths.</td>
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# Drag-out Reduction

1. **Can chemical process baths be operated at higher temperatures without adversely affecting production quality?**
   - Maximize bath temperature to lower viscosity of bath solution. A lower viscosity allows a bath solution to drain from work pieces faster and decrease drag-out.
   - Counter the increased evaporation caused by a higher temperature by using solution from a rinse tank to replenish bath solution. Excessively high temperatures can break down brighteners and other bath components.
   - Consider increased energy costs before implementing.

2. **Do you use work piece withdrawal rates and drain times that are optimum and consistent for reducing drag-out losses?**
   - Increase drain times to reduce drag-out. Drain times of 10 seconds or more have been used successfully to decrease drag-out by 67%. Faster removal rates increase drag-out because a thicker film is left on the work piece surface.
   - Install a bar or rail draining process above plating baths to ensure consistent, effective drain times before rinsing.
   - Control drain times by automating the process if possible. If the process cannot be automated, train operators to drain pieces for a specific length of time, and have an easy-to-read clock or timer at the tank.

3. **Are spray or fog rinses used above heated baths?**
   - Use spray or fog rinses directly over plating baths to remove most of the drag-out from work pieces with a minimum of water. Rinses wash the drag-out directly back into the plating baths. Spray rinses use a small amount of water and may be adjusted to flow at rates equal to evaporation rates from the plating bath.

4. **Have you looked into using air knives above process tanks to decrease drag-out?**
   - Use air knives to drain fluids back into the process tank. Air is blown onto the surface of the work pieces as the rack is raised from the tank.
5. **Do you use drag-out tanks for capturing drag-out from work pieces?**
   - Use drag-out tanks to reduce water and chemical losses by 50% or more. Drag-out tanks, also known as dead or static tanks, capture the most concentrated drag-out.
   - Replenish process baths with drag-out tank solution when concentrations reach appropriate levels. As work pieces are passed through the tanks, chemical concentrations rise.

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<th>Yes/No</th>
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6. **Do you have drain boards located between process and rinse tanks?**
   - Use drain boards to capture process chemicals that drip from the work piece rack as it moves from process baths to rinse tanks.
   - Mount drain boards at an angle to route chemical solutions back into process baths.

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<th>Yes/No</th>
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7. **Do you position work pieces to keep drag-out to a minimum?**
   - Orient work pieces so that liquids drain freely as you remove them from baths.
   - Remove cup-shaped parts from the bath so the cup faces down to increase drainage of the plating solution.
   - Tilt parts so that fluid will flow off of them.
   - Position work pieces so that only a small surface area comes in contact with the solution surface as they are removed from the process bath.
   - Avoid positioning parts directly over one another while draining.
   - If using a basket, rotate the basket as you remove it from the bath.

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<th>Yes/No</th>
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# Rinse Water Minimization

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<th>Yes/No</th>
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<tbody>
<tr>
<td>1. <strong>Do you minimize the flow of fresh water feed into rinse tanks?</strong></td>
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<tr>
<td>• Restrict rinse water flow to a minimum rate.</td>
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<tr>
<td>• Turn off flow when tanks are not in use.</td>
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<tr>
<td>• Place flow restrictors at the rinse water inlet of a rinse tank to restrict the flow of water. Restrictors effectively maintain flow rates at pre-determined quantities.</td>
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<tr>
<td>2. <strong>Do you practice counter-current rinsing?</strong></td>
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<tr>
<td>• Use counter-current rinsing to reduce rinse water use by a significant amount. In a multistage, counter-current rinse system, work piece flow moves in a direction opposite to the rinse water flow. Water exiting the last tank in which the work piece is immersed becomes the feed water to the second tank. This water then feeds the third tank, and so on for the number of tanks in the line. Thus, the tank in which the part is initially cleaned contains rinse water that has been used in other rinsing stages and the chemical concentration may be enough to use as a process make-up bath. The final cleaning of the part occurs in a tank containing clean rinse water.</td>
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<tr>
<td>3. <strong>Do you reuse rinse water?</strong></td>
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<tr>
<td>• Determine if rinse water from one process may be suitable for reuse with another process. For example, acid rinse water may be used in a counter-current rinse process to provide the rinse for a preceding alkaline cleaner. This is known as reactive rinsing. This process reduces the amount of rinse water needed and additionally neutralizes the rinse water.</td>
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<tr>
<td>4. <strong>Are rinse tanks used in your processes designed for optimum rinsing efficiency?</strong></td>
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<tr>
<td>• Improve rinsing efficiency by agitating rinse baths, which reduces the required contact time needed between part and bath. Propeller-type agitation mechanisms result in the highest efficiency. Good mixing assures efficient equilibrium of rinse water and part.</td>
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<tr>
<td>• Add fresh water to the bottom of the final rinse tank.</td>
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# Waste Stream Management

1. **Do any of your processes contain chelating compounds?**
   - Non-chelated process chemicals decrease sludge volume because additional chemical treatment is not necessary. Non-chelating chemicals can be used for processes in which it is not necessary to keep metals from adhering to work piece surfaces.
   - Yes/No

2. **Have you replaced cyanide process baths with non-cyanide process baths to simplify treatment required?**
   - Replace cyanide process chemicals with non-cyanide process chemicals. Waste stream treatment of free cyanide involves chemicals that increase waste sludge volume. Some non-cyanide chemicals decrease hazardous waste sludge by eliminating a process step. There are alternatives to both cyanide cleaners and cyanide plating bath chemistries.
   - Yes/No

3. **Do you recover metal from your processes using one of these methods?**
   - **Evaporation** - Waste rinse water is evaporated by heating the solution. This method is used until the solution concentration equals the plating bath concentration and can be reused.
   - **Reverse Osmosis** - Diluted wastewater is applied to a membrane at high pressure. The membrane retains metals and other solutes and allows water to pass through. The metal solution can be returned to the plating bath and the water can be reused as rinse water.
   - **Ion Exchange** - This method involves passing the solution over an ion exchange resin that exchanges one of its own ions for a metal ion in solution. Once a resin has reached its capacity, it must be regenerated and metals must be separated for reuse.
   - **Electrolytic Metal Recovery** – Ions in the wastewater solution are plated electrochemically onto a cathode surface within the solution. When the cathode becomes fully coated with metal, it’s removed from the solution and placed in a plating bath as an anode.
   - **Electrodialysis** - An electric current and selective membranes are employed to separate the positive and negative ions from the solution into two streams. This is primarily used to concentrate dilute solutions of metals and salts.
   - Yes/No

4. **Are waste streams kept segregated?**
   - Segregate waste streams to increase wastewater treatment efficiency and recovery efficiency. Segregate acidic from alkaline wastes, chrome from non-chrome containing wastes, chelated from non-chelated wastes, and cyanide from non-cyanide-containing wastes.
   - Yes/No
Section 3: Consider the Alternatives.

The biggest challenge facing the metal finishing industry is concern over increased environmental regulations which has a direct effect on a businesses’ operating and maintenance costs, as well as its ability to provide improved supplies and other services. There is no question that environmental policy and subsequent regulations will continue to become more stringent and no doubt have a tremendous effect on shaping metal finishing business practices as well as competition for markets. Compliance with local, state, and federal regulations can result in a significant expense for the business.

The primary environmental problems associated with metal finishing and electroplating operations are concerned with disposal of contaminated cleaner, recovery of metals from the rinse water, and the treatment of wastewater before it is discharged to the local POTW. In addition, the business must also address the problem of disposing of solid wastes generated by metal finishing/electroplating processes.

New technologies have been shown to help meet or exceed requirements for environmental regulation compliance and waste reduction. In fact, it is widely accepted that the adoption of these new technologies in the metal finishing industry will be driven primarily by the advent of having to comply with increasingly stringent environmental regulations.

Following are brief, basic descriptions of some of these technologies applicable to common processes found in most metal finishing operations; why the technology would be needed; and applications, benefits, and common capital and operating costs associated with the implementation of the particular technology. The tables are courtesy of EPRI.
Layout Modifications: Methods of Improving Efficiency

Not all pollution prevention implementations require money, new machinery, or other similar commitments. Sometimes simple, yet effective measures can be taken using existing equipment in your shop. The layout of process and rinse tanks in your shop cannot only affect your efficiency, but play a significant role in the amount of waste generated. While no one designs an inefficient layout initially, process lines do evolve as tanks are removed, added, or changed due to customer demands and changing technologies. Over time, your once methodical system can evolve into a confusing and counterproductive mess. Modifying your tank layout not only eliminates unnecessary walking and backpedaling for your workers, but can more efficiently use chemical feedstocks and water at your site, reduce generation of wastes, and encourage recovery and reuse of certain chemicals.

Some shops may already have an effective layout. If you are unsure, here are some things to look for:

- **Work flow.** If your work flow overlaps, chances are your workers are backtracking quite a bit. Not only can this affect your daily production rate through worker fatigue, but can also increase the chances of drag-out or chemical losses to the floor.

- **Drag-out Losses.** An insufficient number of drag-out tanks, and the absence of either spray rinses or spill guards between tanks, all contribute to chemical loss.

- **Rinsewater use.** If only single-stage rinse tanks are utilized, a higher water flow rate is required to maintain product quality following the rinse. If a multi-tank rinsing system is in place, is any of the solution in the most chemically concentrated rinse tank being used as feedstock for the process bath, or is it all heading to your wastewater treatment system? Additionally, rinse tanks shared between operating lines may mean that rinse quality is adversely impacted and prohibits recovery and reuse of process chemicals.

Worker satisfaction and drag-out reductions are your keys to quick and inexpensive pollution prevention implementation. Steps taken to ease worker load will be repaid in increased productivity and product quality. By minimizing drag-out, you reduce the quantity of both process and water treatment chemicals needed, decrease rinse water requirements, and decrease wastewater and sludge generation.
Why Use Spray Rinses?

Often times, complying with wastewater limits and maintaining a good relationship with your local publicly owned treatment works (POTW) can be an endeavor. Drag-out is the primary source of contaminated rinse water in metal finishing processes. Utilizing spray rinse systems can help decrease the occurrence of contamination in rinse waters and is more efficient in terms of water use compared to stagnant rinses. Used above the process tanks, spray rinses easily return excess drag-out. Spray rinses also reduce the overall amount of water use. Because of reduced drag-out, immersion-type rinse tanks used in conjunction with spray rinses operate at lower water flow rates. Whether the electroplating line is manual or automatic, spray rinse applications include use over process tanks, drag-out tanks, and additional rinse tanks.

One key to a successful spray rinse system is designing it to fit your specific needs. Systems can vary depending on several factors. Minimizing flow rates may or may not be crucial, and nozzle selection can reflect this. Often times, the net flow rate of the spray rinse matches the evaporation rate from the tank it is stationed above.

- Chief nozzle types include hydraulic and air-atomizing nozzles, with the latter spraying both water and air, as its name implies.

- Hydraulic nozzles come in a variety of spray patterns, including fans, fine sprays, and both full and hollow cones.

- Angle and length of spray are also important, since complete coverage is desirable.

Other components to a spray rinse system are just as important as nozzle selection. Check valves, filters, and switches are all equally important.

- Not only do check valves keep water in the supply line from draining into the tank when spraying is not occurring, but they also help maintain water pressure, allowing for rapid spray pattern development. There should be one check valve per nozzle, with placement close to the nozzle.

- One of the chief downfalls of a spraying system is the disruption that rust and other debris can have if they enter the nozzle and prevent it from operating properly. A filter added to the spray system’s water supply prevents clogging and deterioration of the nozzles.

- Switches regulating the flow of rinse water help keep water usage at a minimum. Keeping the volume of the resulting rinse low helps to keep washed chemical concentrations higher, enabling the solution to be returned to the process tank. Switches can be either manual, such as foot pedal or trigger designs, or automatic.
Spray rinses offer many advantages, including reduced drag-out, reduced subsequent contamination of process baths or rinse tanks further down the line, and reduced rinse water use. Additionally, the higher efficiency, better quality rinses allow for recovery of greater concentrated process chemicals, making their reuse in the process bath easier and thereby saving you money. Finally, do not forget, preventative maintenance is the best. Even with filters, periodic removal and cleaning of nozzles is recommended, thus limiting permanent damage to the nozzles and spray pattern deterioration.

**Leonardt Plating Company – Spray Rinse Recovery**

<table>
<thead>
<tr>
<th>Change:</th>
<th>Installation of a spray rinse system above a drag-out recovery tank for a decorative chrome plating line.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result:</td>
<td>Reduction in metal salt use due to recycling of concentrated rinse water back to process tank, and overall reduction in water treatment costs.</td>
</tr>
<tr>
<td>Total Capital Costs:</td>
<td>$2,500</td>
</tr>
<tr>
<td>Savings:</td>
<td>$5,400 per year (0.46 simple payback)</td>
</tr>
</tbody>
</table>
Aqueous Cleaning: If No Solvent Degreasing, Then What?

For some time now, use of chlorinated solvents in degreasing activities has been falling out of favor with state and federal officials. Although solvents have advantages of quickly and efficiently dissolving dirt, grease, and oil residues and then drying rapidly, they have also been found to contribute to ozone depletion and pose hazards to worker health. Increasingly stringent state and federal regulations and costs associated with regulatory compliance are only one reason for replacing solvent degreasing. Purchase and disposal costs, storage handling procedures, and overall safer working conditions are also driving forces behind the continued development and implementation of effective water-based treatments.

One of the disadvantages of an aqueous-based cleaning system is the fact that most residues are less soluble in water than in solvents. Several techniques, including surfactant and emulsifier use, sprays or agitation, and ultrasonics are employed to increase cleaning efficiency of aqueous systems.

The following are types of aqueous cleaning units:

- immersions – utilize mechanical agitation, submerged spray nozzles, or ultrasonics
- sink-tops – involving manual scrubbing
- sprays – high pressure applications in an enclosed environment
- wet blasts – parts are subjected to a blast of abrasive medium slurry at extremely high pressures

Many systems use cleaning chemicals in combination with ultrasonic units for soils removal. Surfactants, which penetrate and loosen soils, are effective, as are emulsifiers which keep the oils in suspension, and inhibitors which reduce corrosion on metal parts. The cleaning chemical selected should be compatible with both the type of soil being removed and the metal being cleaned. An additional parts rinse, following the cleaning procedure, may be necessary to prevent potential contamination later in the process by any cleaning chemicals.

Aqueous cleaning systems have several advantages over their chlorinated counterparts. While soils, oil, and grease dissolve in chlorinated solutions, most organics are immiscible with the aqueous system, and can therefore allow for skimming of oil floats and filtration or removal of settling soils. Aqueous systems also have the potential to be used in conjunction with biodegrading filters, which remove organic contaminants. With these modifications, aqueous solutions can be used for longer periods of time before becoming ineffective. Additionally, while aqueous solutions may accumulate enough contaminants, whether it be metals, soils, or greases, to become designated as
hazardous wastes, they are usually classified as non-hazardous. On the other hand, chlorinated solvents typically are disposed of as hazardous wastes and are associated with increased health risks.

One immersion technology, ultrasonic cleaning, involves high frequency sound waves to generate a “scrubbing” action on the parts surface, at the microscopic level. The sound waves produce an oscillating pressure front which generates bubbles on the part’s surface. Destruction of these miniature bubbles causes contaminants to be stripped away from the part. Because it works at the microscopic level, ultrasonic cleaning is excellent for crevices and fine pores, as well as the general surface. Care should be taken, however, because excess transducer power can also eat away at soft metal parts. Some operating parameters to consider in selection of an ultrasonic system are cleaning time restraints, temperature, cleaning solution concentration, and the number of objects cleaned per operation.

Replacing solvent degreasers with ultrasonic cleaners and other aqueous cleaning technologies can mean fewer environmental headaches and reduced costs for you. By eliminating regulation compliance costs, solvent purchase, storage and disposal costs, and improving worker safety, many systems have an acceptable payback period.

The following table, courtesy of EPRI, provides a brief description of both aqueous and ultrasonic cleaning, and discusses the costs and benefits of each system.
“Closing the Loop”

Although not a new technology to the electroplating industry, different applications of reverse osmosis (RO) technology have sparked new interest in the concept. Reverse osmosis involves using semi-permeable membranes to separate water from a solution of dissolved solids. By applying pressure to a solution, water and other smaller, lighter molecules are forced through pores of the membrane, while larger molecules such as dyes and metal compounds get caught. Water is thus purified as it passes through the membrane, and the remaining solution now has a higher concentration of metals and solids. Many RO systems are cross-flow, meaning solution flows the length of the membrane, allowing captured metals and solids to be swept along by the remaining concentrate, rather than getting caught and fouling the membrane.

Previously, reverse osmosis was implemented as a final treatment for a shop’s combined wastewater stream. The cleaned water, or permeate, was sent to the local publicly owned treatment works (POTW). However, larger RO units were necessary to handle the wastewater streams being treated. As expected, these larger units had proportionally larger costs associated with their operation. Recently, the idea of using RO systems to treat wastes from specific processes, rather than combined wastestreams, has been explored. By using process-specific RO systems, concentrate can be returned to the process bath as feedstock and permeate can be repeatedly used for rinsing. Recapturing process chemicals and rinse water help “close the loop” and reduce costs.
associated with chemical purchase and wastewater treatment. Although a closed loop system has several economic and environmental advantages, it does have one significant disadvantage – contaminant buildup. Unwanted metals, from previous processes, may enter and accumulate, slowly plugging or fouling the membrane, making bath monitoring essential.

A basic RO system consists of four components: cartridge filters, membrane modules, a pressure booster pump, and a strainer. The strainer, positioned before the pump, removes larger solids which may otherwise damage the pump. The booster pump supplies the necessary pressure, typically 150 to 800 pounds per square inch (as a comparison, the earth’s atmosphere pushes down on us at roughly 15 pounds per square inch) to force solution through the membrane. Cartridge filters following the pump screen out some particulates before they hit the membrane, helping to reduce fouling. Membranes are the final component to the RO system, and are typically one of two common types for metal finishers, aromatic polyamides and cellulose acetate. Aromatic polyamides can be used over a broad pH range of 2 to 11 and tolerate temperatures up to 115°F, while cellulose acetate membranes operate in a pH range of 2.5 to 7 and to a maximum temperature of 85°F. The type of membrane necessary for your operation depends on your solution characteristics, and can be determined by a vendor.

To extend RO membrane life, you may wish to consider one or all of the following pretreatment steps:

- **Disinfection.** Using ultraviolet light or chlorine to kill bacteria prevents fouling of membranes.
- **Oil and grease separation.** Use oil-water separators to remove oils and lengthen membrane life.
- **pH and temperature adjustment.** Adjustments may be necessary to bring solution pH or temperatures back within operating ranges.

Before implementing a RO system, examine which other pollution prevention techniques can be easily and inexpensively implemented on your process line. For example, counter-current rinsing may reduce required rinse flow rates necessary for your process, thus reducing RO feed flow rates which can result in a less costly unit.

See Section 4: Case Studies to check out the case study on the application of a RO unit at a small electroplating operation. The following table, courtesy of EPRI, discusses three wastewater treatment systems: ion exchange, membrane filtration and vacuum evaporation. The advantages and costs of each are outlined.
One of the most common environmental headaches for metal finishing facilities is spent process baths. While several factors can contribute to deterioration of the bath, the end result is the same, creation of a costly waste stream that must be dealt with. A spent bath can be batch-treated on site, sent to a wastewater treatment system, or prepared for off-site treatment. Obviously, the more frequently you change out your process bath, the more chemicals you will use and the more waste you will be required to dispose of.

Process bath life can be extended by several techniques, some more easily and economically implemented than others. The end result for you can be significant waste reduction and hence overall cost savings. The following are techniques implemented at metal finishing facilities.

Bath controls. One factor that will reduce the life of your bath is not maintaining adequate bath conditions. Allowing such parameters as bath concentration, pH, or temperature to fall outside specified ranges not only reduces bath life, but can also interfere with product quality. Monitoring of bath conditions also has the added benefit of potentially reducing chemical use. If chemicals are added only when needed, and not on a scheduled or routine basis, excess use can be eliminated, saving you money. Finally, you may wish to consider slight modifications in bath chemistry, based on results in your shop. These adjustments may save you chemicals, energy, time, and money while maintaining or even improving product quality. Elevated bath temperatures lower solution viscosity, resulting in less product drag-out.

Extending Bath Life: Getting the Most Out of Your Bath
Reducing contamination  Two principle factors contributing to contamination of a process bath are water impurities and drag-in from other processes. The following steps can be taken to limit these, thereby increasing the life of your bath:

• With water impurities, switch to deionized water. Removal of impurities, such as silicates and other minerals found in water, reduces sludge generation.

• Removing suspended solids from the bath by filtration eliminates the potential for contaminates to damage the product coating. Filtration systems also have the benefit of maintaining uniform concentration and temperature throughout the bath because of fluid circulation. Some filters may even be reused after cleaning, but must be disposed of properly when spent.

• Utilizing spray rinses reduces drag-in from preceding baths or processes by reducing cross-contamination. Additionally, spray rinses allow for collection and return of potential drag-in to respective process baths, which reduces chemical use and saves you money.

• Electrolytic dummying can remove contaminant metals, such as copper, from zinc baths. Precipitation of unwanted metals also rids the solution of contaminants.

Additives. Use of additives may boost bath performance by minimizing the potential for product defects, or by reducing drag-out. Wetting agents are one example.

As a side note, you may wish to consider lowering chemical concentrations in your process bath. Chemical manufacturers may suggest concentrations greater than are necessary to obtain desired product quality. While lower bath concentrations do not extend bath life, they do help in reduction of drag-out and hence improve the life of your rinse tanks.

Remember, implementing these simple, preventative techniques can save you both time and money. Longer bath life corresponds to less disruption to the process, less chemical purchases, and less labor costs and sludge disposal, all of which correspond to increased profitability.
Conductivity Controls for Rinse Water

Minimizing wastewater treatment costs and maintaining a good relationship with your local publicly owned treatment works (POTW) doesn’t sound like they go hand-in-hand, but they can. Proper rinsing removes excess process solution from parts and can have a profound affect on the quality of the finished product. Obtaining a good rinse is important, and some facilities use a continuous water flow into their rinse tanks as insurance. But there are many benefits to reducing rinsewater use, including lower water bills, decreases in wastewater generation, and diminished sludge production. One could lessen the water flow through rinse tanks as long as the integrity of the rinse was not compromised. One such measure of rinse bath quality is conductivity.

As excess process chemicals are removed from product surfaces during rinsing, concentrations in rinse tanks increase. This increase can easily be monitored by measuring the conductivity of rinse tank solutions. If conductivity monitors are integrated with control systems, not only could rinsewater quality be measured, but maintained as well. Conductivity control systems introduce only the water necessary to rinse baths to maintain a set conductivity. By maintaining the rinse solution at this conductivity, chemical concentrations in the bath would never increase to a level which would interfere with product quality. By only adding water to rinse tanks when necessary, overall water use rates decrease, thereby resulting in cost savings.

Three main components make up a conductivity control system: an analyzer, a conductivity sensor, and a solenoid valve. The conductivity sensor is a probe placed in the rinse water which measures solution conductivity. The sensor sends data to the analyzer, which receives input and calculates bath conductivity. Two types of sensors are available, contacting and electrodeless, and cleaning and calibration checks are required for both. The analyzer has a preprogrammed conductivity set point, above which the solution is not to rise. Upon reaching the set point, the analyzer signals the solenoid valve to open, supplying fresh water to the rinse bath, and lowering solution conductivity to the correct level. Once measured conductivity is below the set point, the analyzer closes the valve, stopping rinse water flow to the bath.

Good rinse water circulation and proper sensor placement are necessary for accurate sensor readings and efficient rinsing. Rinse tank circulation can be ensured by air agitation, diverters at clean water inlet, or mechanical mixing. The following locations are good installation points for conductivity sensors:

- Away from clean water inlets, stagnant areas, and tank walls
- Halfway below the rinse water surface
- In the final rinse tank of a multistage counterflow system
When researching the applicability of conductivity control systems for your facility, consider the following:

- **Acceptable conductivity range of the rinse water.** Sensors and analyzers are developed to measure within certain conductivity ranges. Additionally, because conductivity is a measure of chemical concentration, this is also an indication of what type of sensor is required. Higher chemical concentrations may require electrodeless sensors, which do not foul, unlike their contacting counterparts.

- **Analyzer configuration, location, and channel number.** Included with most analyzers is hardware for mounting on an instrument panel or pipe. Some analyzers have water and corrosion-resistant enclosures to allow for installation near process tanks. Some analyzers are even capable of accepting inputs from two sensors, allowing for water flow control on two separate tanks.

With a conductivity control system in place, a shop not only reduces water use, but also costs associated with treatment chemical purchases, and sludge production and disposal.

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**Artistic Plating and Metal Finishing, Inc. - Reducing Water Use**

<table>
<thead>
<tr>
<th>Change:</th>
<th>Implementation of conductivity controls on copper, nickel, and chrome plating on a manually-operated hoist line to reduce rinse water use.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result:</td>
<td>Decreased rinse water use, wastewater generation, on-site wastewater treatment system chemical use, and sludge generation with no adverse impacts on product quality.</td>
</tr>
<tr>
<td>Total Capital Cost:</td>
<td>$14,500</td>
</tr>
<tr>
<td>Savings:</td>
<td>$14,300 per year (~ 1 year simple payback)</td>
</tr>
</tbody>
</table>
Chemical Reduction and Recovery through Electrowinning

Traditionally used for metal recovery, electrolytic technology known as electrowinning is finding applications in rinse water systems as well. Electrowinning is a recovery technology for metals, and its integration into an effective rinse system can reduce both water use and chemical discharge.

Electrowinning units have three components: a pump, a rectifier, and an electrolytic cell. The electrolytic cell, which consists of cathodes and anodes in alternating order, may also include air sparges, flow dispersers, or other mechanisms to enhance rinse water circulation within. When in operation, dissolved metals flow through, are electrically attracted to, and deposit upon cathodes within the cell. As metals plate out onto cathodes, the rate at which they deposit decreases. After some time, the deposition rate is no longer sufficient and cathodes are removed for metals recycling. Metal deposition rates are key design parameters in developing an effective electrowinning unit. Units are most effective when installed in rinse tanks immediately following drag-out tanks.

Cathodes are not the only part of the system which capture rinse water contaminants; anodes do as well. While cathodes plate metals in solution, anodes break down cyanide, through a process called oxidation, into nitrogen gas and carbon dioxide. Operating the electrowinning unit 24 hours a day allows cyanide, which typically accumulates during production hours, to be destroyed. “Around the clock” operation also maximizes metals recovery. Dissolved salts not oxidized will accumulate in rinse water, and thus periodic draining of rinse tanks is still required.

Electrowinning is not a viable recovery technology for all metals. While the process works well for metals with high electropotential, such as gold, silver, copper, cadmium, and zinc, it does not work as well on others, such as chromium. Nickel can be recaptured; the process is very pH sensitive and must be rigorously maintained for any deposition to occur.

For metals which electrowinning works, the following criteria are important in the operating performance of electrowinning units:

- **Cathode surface area.** Because metal deposition rates are related to available surface area, maintaining properly working cathodes is important. Two cathode types exist, flat-plate and reticulated cathodes, each with their own advantages. Flat-plate cathodes can be cleaned and reused, and plated metals recovered. Reticulated cathodes have a much higher deposition rate as compared to flat-plate cathodes. However, they are not reusable and must be sent off for recycling.

- **Current density.** The deposition rate of metals onto cathodes increases with higher current densities. However, “excess” current is wasted on converting water to hydrogen and oxygen gas, instead of plating out desired metal contaminants.
- **Metals concentration**  Higher deposition rates occur in concentrated rinse water. Stagnant rinse baths are better for applying electrowinning technology. Mixing inhibits operation of the unit at a higher current density and thus prevents obtaining a higher deposition rate than would otherwise occur.

While electrowinning can aid in rinse water reduction and contaminant control, as with any process technology, it must be maintained. Cathode installation and maintenance is critical to unit performance. Know the limitations and effective operating ranges of the working unit.

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**All Metals Processing Company – Recovery and Reduction**

<table>
<thead>
<tr>
<th>Change:</th>
<th>Installation of an electrowinning unit on their cadmium electroplating line due to drag-out contributing to high metals contamination in the wastewater.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result:</td>
<td>Lower water use, zero discharge to the sewer, lower operating and maintenance costs for the on-site wastewater treatment system, and filter cake disposal with no adverse impacts on product quality.</td>
</tr>
<tr>
<td>Total Capital Costs:</td>
<td>$9,000</td>
</tr>
<tr>
<td>Savings:</td>
<td>$1,560 per year (~8.7 year simple payback)</td>
</tr>
</tbody>
</table>
Exterior Systems – A Cool Solution for Hard Chrome Plating

Hard chrome (hexavalent) plating is a precise operating process. Successful plating is dependent upon adequate mixing of the plating solution and regulation of bath temperature, and long plating times and intense heat generation are standard for this electroplating process. If generated heat cannot be dissipated and a uniform temperature maintained, product quality suffers. An earlier solution to these problems was to direct air bubbles through the plating solution. Not only did the bubbles help dissipate heat into the air, but also kept the solution well mixed. However, this solution had a problem of its own, air emissions containing chromium. Introduction of the National Emission Standards for Hazardous Air Pollutants (NESHAP) in 1995 meant hard chrome electroplating facilities were required to take measures to minimize chrome emissions in plating operations. They were able to do this by discontinuing the use of air bubbles and adding fume-suppressant systems. However, the original problem of maintaining adequate plating conditions still remained.

Cooling coils, installed in the interior walls of chrome plating tanks was the alternative to air bubbling, but not without its own problems. Increased downtime, slower plating rates, and higher production rejection rates were experienced when platers switched to these systems. Some finished products suffered from discoloration, poor adhesion, roughness and lack of hardness. The increased number of rejections meant higher operating and maintenance costs as well as additional waste generation. A rejected product part creates triple the waste of a quality part by the time raw materials, stripping agents, and discarded platings are considered. An average of three to five pounds of sludge is generated for every pound of chrome plating that must be stripped. Additionally, cooling system components, mounted on interior tank walls, took up precious tank volume and were easily damaged with product movement.
To improve chrome production and minimize waste, several plating facilities have experimented with using exterior cooling systems. Recent improvements in heat exchanger technology, including better corrosion resistance and increased system durability in addition to design refinements, have made external systems a more viable option. In an exterior cooling system, the plating solution is continuously circulated by a pump, submerged on one end of the tank, and attached to the “hot” side of a heat exchanger. The plating solution passed through the exchanger and cooled solution is returned to the plating tank in a header, situated at the opposite end of the tank. Continuous circulation of plating solution not only allows for a uniform temperature throughout the bath, but also keeps the solution well mixed. Additionally, relatively small pump and header volume means that nearly all the tank volume remains for plating. The “cool” side of the heat exchanger acts as the controller, and by changing the cooling water flow rate, a constant, ideal process temperature can be maintained. A comparison between rejection rates of interior and exterior cooling systems for one facility found that by switching to an exterior system, rejection rates were reduced by over 90%. And a reduction in rejected parts means a reduction in waste generation and an increase in cost savings.

Other potential applications of the external cooling system include the following:

- Acid copper electroplating - an exterior exchanger made of titanium or stainless steel works.
- Cadmium cyanide plating - platers can use a heat exchanger made of steel.
- Decorative chrome (trivalent) electroplating - exchangers composed of niobium or columbium are preferred.
Section 4: Case Studies

When a business is considering incorporating new pollution prevention ideas, activities, and/or technologies into their everyday operations, it requires commitment and support from both management and employees. One key area associated with potentially initiating pollution prevention into a business involves a technical and economic evaluation to insure that the P2 options chosen will actually be beneficial and cost-effective to the business.

Following are two case studies that present a technical and economic evaluation associated with the evaluation and implementation of pollution prevention in metal finishing businesses.

Zero Water Discharge Using an Ion Exchange Process

Background

Gold Seal Plating, located in Oakland, California, provides nickel, copper, and gold plating of jewelry and flexible circuits with both manual and automatic rack-and-barrel plating lines. Before implementation of this improved ion exchange process, Gold Seal previously treated approximately 2,100,000 gallons of metal-containing rinse waters through its on-site treatment plant each year which generated 73,000 pounds of metal hydroxide sludge. All rinse waters were discharged to the sewer and the sludge was manifested off-site for metals recovery.

In order to reduce their rinse water use, Gold Seal first implemented several pollution prevention measures including improved bath maintenance and reuse of spray rinses in their rinse tanks. Through the incorporation of these measures, the metals loading into their rinse water was reduced by 90% and the rinse water flow rate was decreased 60%. However, this caused some concern about final product quality in that the lower flow rates might result in more contaminated rinses. Gold Seal wanted to improve rinse water quality without requiring additional city water, or wastewater treatment, or increasing its discharge to the sewer. They then considered an ion exchange system for water purification.
Ion Exchange Technology Description

Technologies exist that can potentially “close the loop” on rinse/wastewater associated with plating operations, thereby eliminating the need for additional rinse water use. One such technology involves an improved ion exchange process. Traditional ion exchange technologies do not achieve a “zero water discharge” since regeneration of the spent resin beds produces significant quantities of hazardous aqueous wastes. The improved ion exchange process works as follows:

Hazardous rinse water generated from rinsing operations is first routed through a carbon filtration unit to remove organic by-products of the plating process. The rinse waters then proceed through cation exchange beds where dissolved positive charged ions (nickel, copper, gold, silver, sodium, etc.) are exchanged with hydrogen. Following the cation exchange beds, the rinse waters are routed through the anion exchange beds where negatively charged ions (sulfates, chlorides, cyanides, etc.) are removed and exchanged with hydroxide. A final polishing bed is used to improve water quality. The final deionized water is recycled back to a holding tank which is used to replenish the spray tanks and rinsing baths, as needed. An organic destruct ultraviolet light is used in a recirculatory loop on the deionized water holding tank. Ultraviolet light destroys any surfactants or organics left over in the treated water, and helps eliminate the build up of bacteria in the storage tank.

Once the ion exchange beds are exhausted, they are regenerated to replenish the hydrogen and hydroxide ions lost during the service cycle. The regeneration process requires four steps: chemical draw, slow rinse, fast rinse, and final rinse. A backwash of the system is usually the first step required in conventional ion exchange systems to remove dirt and debris from the resins. This step is not required since the system provides good filtration upstream prior to the ion exchange units. Therefore, the first step is the regeneration of the cation resin with hydrochloric acid and the anion resin with sodium hydroxide, termed "chemical draw." The ions removed during service are exchanged with hydrogen and hydroxide ions. After complete chemical draw, clean water is fed at a very slow rate to rinse the excess acid and caustic from the resins. The slow rinse is then followed by a fast purge to remove hidden pockets of chemicals. The entire system is then rinsed to eliminate all remaining chemicals until a desired conductivity is achieved. During the regeneration process, portions of the acid, caustic, and water rinses are recycled to holding tanks to be used in the next regeneration cycle. The remaining spent acid and caustic are combined and routed through Gold Seal Plating's primary and secondary evaporation units.
Economic Analysis

The following table presents a comparison of Gold Seals rinse and wastewater treatment costs before and after the improved ion exchange process was implemented. A system capital cost was not provided for this analysis, but Gold Seal reported a short to moderate payback on their investment.

| Major Operation Cost Comparisons  
for the Improved Ion Exchange System at Gold Seal |

| Without Recovery System  
(6 gpm flow) | Annual Amount | Unit Cost, $ | Annual Cost, $ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming City Water</td>
<td>2,170,000 gal</td>
<td>$.0045/gal</td>
<td>$9,800</td>
</tr>
<tr>
<td>Wastewater treatment *</td>
<td>2,170,000 gal</td>
<td>$.007/gal</td>
<td>$15,500</td>
</tr>
<tr>
<td>Sludge Recycling</td>
<td>73,150 lbs</td>
<td>$.33/lb</td>
<td>$24,100</td>
</tr>
<tr>
<td>Permit (EBMUD)</td>
<td>Na</td>
<td>Na</td>
<td>$11,400</td>
</tr>
<tr>
<td>Outside Lab Testing</td>
<td>Na</td>
<td>Na</td>
<td>$2,200</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td></td>
<td>$63,000</td>
</tr>
<tr>
<td>Cost per 1,000 gal. of rinse water</td>
<td></td>
<td></td>
<td>$29</td>
</tr>
</tbody>
</table>

| With Recovery System  
(12-15 gpm Flow) ** | Annual Amount | Unit Cost, $ | Annual Cost, $ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming City Water (rinse, makeup)</td>
<td>260,000 gal</td>
<td>$.0045/gal</td>
<td>$1,200</td>
</tr>
<tr>
<td>Chemicals (regeneration)</td>
<td>1,440 gal</td>
<td>$1.42/gal</td>
<td>$16,200</td>
</tr>
<tr>
<td>Energy (evaporators)***</td>
<td>70,200 gal</td>
<td>$.034/gal</td>
<td>$2,400</td>
</tr>
<tr>
<td>Sludge Recycling</td>
<td>36,000 lbs</td>
<td>$.36/lb</td>
<td>$13,000</td>
</tr>
<tr>
<td>Permit (EBMUD)</td>
<td>Na</td>
<td>Na</td>
<td>$0</td>
</tr>
<tr>
<td>Outside Lab Testing</td>
<td>Na</td>
<td>Na</td>
<td>$0</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td></td>
<td>$32,800</td>
</tr>
<tr>
<td>Cost per 1,000 gal. of rinse water</td>
<td></td>
<td></td>
<td>$ 6-8</td>
</tr>
</tbody>
</table>

* includes treatment chemicals and wastewater discharge costs  
** rinse water flow was increased to improve the quality of rinsing  
*** estimated values
Conclusions

Implementation of the improved ion exchange system has provided the following advantages to Gold Seal with no adverse impacts on their product quality or production capability:

• no water discharge to the local sewer system
• use of 100% of its recycled deionized water back into plating and rinsing operations
• elimination of all sewer fees
• reduction of metal sludge by nearly 50% versus previous system

“If you would hit the mark, you must aim a little above it.”

– Henry Wadsworth Longfellow
Application of Reverse Osmosis

Background

Danco Metal Surfacing (Danco) is a small electroplating operation located in Ontario, California, that anodizes small- to medium-sized parts such as screws, flashlight parts, and bicycle frames. Their anodizing operations include cleaning, etching, anodizing with sulfuric acid-base, chromate conversion, and several types of dying. Danco was primarily concerned with the amount of city water they were using as well as their wastewater discharge to the sewer. In addition, several months before they had been awarded a contract that would increase production in their black dye operations by 50%, which would further increase water use and wastewater discharge. For these reasons, Danco decided to investigate the possibly of implementing a reverse osmosis system. This case study focuses only on the implementation of a reverse osmosis unit in their black dye operation.

Reverse Osmosis Description and Application

The reverse osmosis (RO) unit installed in the black dye operation at Danco is a closed-loop that returns the reclaimed rinse water (permeate) to the rinse baths and returns concentrated process chemicals to the process baths. Danco had previously used several single-stage rinses and with the implementation of the RO unit, replaced them with two-stage, counter-flow rinsing tanks to reduce rinse water flow rates needed for effective rinsing.

In each operation, the rinse water that overflows the first-stage rinse tank is pressurized by a high-pressure feed pump. Particulates are removed from the feed solution by two 1-micron cartridge filters. The feed solution then flows in series through spiral wound modules containing thin-film composite RO membranes (two modules for nickel acetate and four modules for black dye operations). After separation, the portion of the concentrate stream needed to maintain the correct level in the process bath is returned to the process bath in order to recover valuable chemicals. The remaining portion of the concentrate stream is conveyed to the recirculation tank, where it is temporarily stored before being recirculated through the RO unit. Permeate is conveyed to the second rinse tank and is reused as clean rinse water. A small amount of fresh deionized water from an outside source is added to the process baths in order to make up for evaporative water losses.

The black dye solution contains about 300 parts per million trivalent chromium. Before installation of the RO unit, rinse water containing this trivalent chromium was discharged to the local POTW. The RO unit eliminated this need.
Economic Analysis

The capital cost, including installation of the RO unit for the black dye operation, was $10,000. Operation and maintenance charges included power requirements for the system estimated at $105 per month, membrane cleaning, and cartridge filter replacement. Membranes require periodic cleaning and because the system is relatively new, replacement frequency is unknown. Cartridge filters are replaced at a cost of $12 per month.

The following table presents a comparison of the costs concerning black dye use, city water use, and wastewater discharge allocated to their black dye operation. Annual savings to Danco were determined to be $6,111 with less than a 2-year payback on their investment.

<table>
<thead>
<tr>
<th></th>
<th>Before RO</th>
<th>After RO</th>
<th>Monthly Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Dye Use</td>
<td>20.7 lbs/month</td>
<td>9.2 lbs/month</td>
<td>$293</td>
</tr>
<tr>
<td>City Water Use</td>
<td>3 gallons per minute</td>
<td>0 gallons</td>
<td>$83</td>
</tr>
<tr>
<td>Wastewater Discharge</td>
<td>3 gallons per minute</td>
<td>0 gallons</td>
<td>$133</td>
</tr>
</tbody>
</table>

Danco reported no adverse affects on product quality or on production capability since the RO unit has been installed.
Section 5: …And Regulatory Issues

Due to its nature, the metal finishing industry has traditionally been subject to extensive health, safety and environmental regulations. Both organic solvents and metals, which unlike other pollutants do not degrade or decompose, are of potential concern. Because these are indispensable components of most finishing processes, their replacement is unlikely, and yet it is these primary materials that trigger compliance issues.

What follows is intended to be a regulatory overview for the metal finishing industry. As you already know, state and local limits are often more stringent and encompassing than the federal limits. Pretreatment cities and counties in Kansas include the following:

- Chanute
- Coffeyville
- Emporia
- Hutchison
- Independence
- Iola
- Johnson County
- Kansas City
- Lawrence
- McPherson
- Olathe
- Pittsburg
- Salina
- Topeka
- Wichita

Shops must comply with all sorts of regulations, from air and water discharges to waste disposal, worker safety and community right-to-know laws. What follows is provided for overall guidance. For specific concerns, consult a state or local regulator, or technical assistance provider.

“About the only thing you can get in a hurry is trouble” - Unknown
Water Regulations

The first nationwide attempt to regulate the use of water by industries involved in metal finishing operations was the Federal Water Pollution Control Act (FWPCA) Amendments of 1972. Previous to the FWPCA, some states and municipalities regulated the use of their water resources through a variety of local laws and ordinances. With the passage of an amendment to the FWPCA referred to as the Clean Water Act (CWA) in 1977, the federal government finalized the legislative underpinnings for the regulatory context in which metal finishers operate today.

Companies involved in metal finishing operations are usually regulated by state and local authorities who have been delegated the responsibility of enforcing the regulations. In cases where there are no state or local authorities, the USEPA Regional Office is in charge of enforcement.

Generally speaking, electroplaters and metal finishers are subject to one or more of the following federal wastewater pretreatment regulations:

- General Pretreatment, 40 CFR 403
- Electroplating Standards, 40 CFR 413
- Metal Finishing Standards, 40 CFR 433
- National Pollution Discharge Elimination System (NPDES)

Kansas has accepted the federal standards as state standards. Additionally, local publicly owned treatment works (POTWs) may have similar or more stringent standards. They may also place additional limits on nitrogen, oil/grease loadings, organics, phosphate, and solids. Additionally, POTWs may require shops to treat their effluent in some manner before sending it into the sewer system. These extra stipulations allow POTWs to comply with their own NPDES permits and make certain the sludges generated from their operations meet federal requirements (40 CFR 503).
The classification system devised by the EPA divides the metal finishing sector into electroplaters and metal finishers. To be covered under the electroplating standards, a facility must be a job shop which electroplates or an independent printed circuit board shop in operation before 1980, who operates any of the following processes:

- Precious metal electroplating
- Common metal electroplating
- Anodizing
- Chemical conversion coatings (chromating, phosphating, etc.)
- Chemical etching and milling
- Electroless plating
- Printed circuit board manufacture

To qualify as a metal finishing operator (40 CFR 433), a shop must perform the operations listed above and be

- A captive electroplating operation, or
- A job shop or independent circuit board manufacturer that began construction after August 31, 1982.

KDHE reports that as facilities modify their processes or change locations, more shops are falling under 40 CFR 433 and that 40 CFR 413 standards are slowly being phased out.

The system further divides the industry into companies that discharge wastewater directly to the watershed and those that discharge their wastewater indirectly through a POTW. Companies are further divided into those that are captive shops (owning more than 50% of the basis material being finished) and job shops (owning less than 50% of that material). Regulations are slightly different depending upon the combination of factors that best define a company's situation.

Companies that discharge their wastewater directly to the surface water are regulated under the NPDES system. All facilities that discharge directly to a waterway are required to apply for a NPDES permit which specifies what pollutants may be discharged and a schedule for compliance, monitoring, and reporting. In Kansas, the NPDES permit system is administered by KDHE.
An important initiative that affects direct dischargers took place in 1989 when the USEPA amended the Water Quality Planning and Management Regulations (40 CFR 130). The amendment was intended to develop water quality-based effluent limitations for discharges to surface water. As a result of this amendment, more stringent effluent limitations, including biological toxicity testing in some states, are being imposed on direct dischargers. This also affects indirect dischargers to the extent that these more stringent limitations will lead treatment plant operators to tighten their standards in order to ensure that their effluent will meet the new limitations.

Most facilities engaged in metal finishing discharge their wastewater to POTWs. Industrial facilities that dispose of their wastewater in this way are referred to as "indirect dischargers." Because wastewater treatment plants are designed primarily to deal with domestic sewage, the operators of these plants require indirect dischargers to treat their effluent in some way before sending it to the sewer system. These requirements are designed to allow POTW operators to comply with their own NPDES permits and help them ensure that the sludge from their treatment operations can meet federal requirements.

All facilities discharging to local POTWs are governed by the General Pretreatment Standards, which state that discharges

- Cannot create fire or explosion
- Must have a pH greater than 5.0
- Cannot obstruct the flow of wastewater through the system
- Cannot interfere with the sewage plant operations
- Cannot contain excessive heat
- Cannot contain excessive petroleum, mineral, or non-biodegradable oils

In addition to these General Pretreatment Standards, facilities in metal finishing must also comply with specific pretreatment standards for either electroplating or metal finishing operations, depending upon the USEPA definitions described earlier. These pretreatment standards differ primarily in the way limits are set. The electroplating standards provide a daily maximum and a four-day average for metals and total toxic organics for flow rates less than 10,000 gal/day and more than 10,000 gal/day. The metal finishing pretreatment standards provide a daily maximum and a thirty-day average for these pollutants. In general, the metal finishing pretreatment standards are more stringent than the electroplating pretreatment standards.
**Electroplating Limitations (40 CFR 413)**

*all values are milligrams per liter (mg/l)*

<table>
<thead>
<tr>
<th>Pollutant (or Pollutant Parameter)</th>
<th>less than 10,000 gallons per day of regulated process flow</th>
<th>more than 10,000 gallons per day of regulated process flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily max.</td>
<td>4-day avg.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Copper</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Cyanide (total)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Cyanide-amenable</td>
<td>5.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Lead</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Nickel</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Silver</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Zinc</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Total Metals (sum CR, CU, NI, Zn)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Total Toxic Organics</td>
<td><strong>4.57</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Metal Finishing Pretreatment Standards (40 CFR 433)**

*Existing Source Limitations*

*all values are milligrams per liter (mg/l)*

<table>
<thead>
<tr>
<th>Pollutant (or Pollutant Parameter)</th>
<th>Daily max.</th>
<th>30-day avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>0.69</td>
<td>0.26</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>2.77</td>
<td>1.71</td>
</tr>
<tr>
<td>Copper</td>
<td>3.38</td>
<td>2.07</td>
</tr>
<tr>
<td>Cyanide (total)</td>
<td>1.20</td>
<td>0.68</td>
</tr>
<tr>
<td>Cyanide-amenable</td>
<td>0.86</td>
<td>0.32</td>
</tr>
<tr>
<td>Lead</td>
<td>0.69</td>
<td>0.43</td>
</tr>
<tr>
<td>Nickel</td>
<td>3.98</td>
<td>2.38</td>
</tr>
<tr>
<td>Silver</td>
<td>0.43</td>
<td>0.24</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.61</td>
<td>1.48</td>
</tr>
<tr>
<td>Total Toxic Organics</td>
<td><strong>2.13</strong></td>
<td></td>
</tr>
</tbody>
</table>
Metal Finishing Pretreatment Standards (40 CFR 433)
New Source Limitations
all values are milligrams per liter (mg/l)

<table>
<thead>
<tr>
<th>Pollutant (or Pollutant Parameter)</th>
<th>Daily max.</th>
<th>30-day avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>2.77</td>
<td>1.71</td>
</tr>
<tr>
<td>Copper</td>
<td>3.38</td>
<td>2.07</td>
</tr>
<tr>
<td>Cyanide (total)</td>
<td>1.20</td>
<td>0.65</td>
</tr>
<tr>
<td>Cyanide-amenable</td>
<td>0.86</td>
<td>0.32</td>
</tr>
<tr>
<td>Lead</td>
<td>0.69</td>
<td>0.43</td>
</tr>
<tr>
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<td>3.98</td>
<td>2.38</td>
</tr>
<tr>
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<td>0.43</td>
<td>0.24</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.61</td>
<td>1.48</td>
</tr>
<tr>
<td>Total Toxic Organics</td>
<td>2.13</td>
<td></td>
</tr>
</tbody>
</table>

Other considerations metal finishers must keep in mind when considering wastewater discharge include the fact that permit applications must be filed in sufficient time so they can be approved before discharge begins. In many states and localities, the permit approval process can take two to four months. The Baseline Monitoring Report is due 90 days before discharge begins. Many agencies are requiring that sampling for certain parameters, such as heavy metals, be done on a flow-proportion basis. KDHE allows grab samples where industries “batch” discharge.
Air Regulations

With the enactment of the Clean Air Act Amendments (CAAA) in 1990, air emissions have become a greater issue of concern for metal finishing operations. Any metal finishing operation with processes that emit volatile organic compounds (VOCs), or hazardous air pollutants (HAPs) as defined in the CAAA, may be required to obtain an operating permit and/or comply with other regulatory requirements for those processes.

The CAAA can potentially affect any metal finishing process. Some commonly covered processes include:

- electroplating processes which have the potential to release chromium or other HAP metal compounds
- solvents used in painting processes
- solvents used in paint stripping
- solvents used in parts cleaning

Chromium electroplaters and solvent degreasers meeting certain criteria must meet the requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAP). Each NESHAP regulates the emissions of specified pollutants from facilities.

For chromium electroplaters, facilities that perform hard chromium electroplating, decorative chromium electroplating, and chromium anodizing are subject to the rule. It applies to tanks where an electrolytic process occurs. The rule does not apply to rinse, etching or cleaning tanks, or to chrome conversion tanks using no electrical current. Requirements include specific equipment or processes to control emissions, specific work practice standards, and recordkeeping.

Facilities that use halogenated solvents for degreasing, which contain greater than five percent by weight of any of the following, are subject to the halogenated solvent NESHAP:

- methylene chloride
- perchloroethylene
- trichloroethylene
- 1,1,1-trichloroethane
- carbon tetrachloride
- chloroform
Requirements include specific emission control equipment, work practices and record keeping. If your facility is subject to either the halogenated solvent NESHAP or chromium electroplaters NESHAP, contact SBEAP to get more information on the rule.

Metal finishers are also subject to limits on their VOC and HAP emissions from solvents used in paints, paint stripping, or cleaning. Your facility is defined as a major source of air pollution if it has the potential to emit 10 tons of any single HAP, 25 tons of any combination of HAPs, or 100 tons of VOCs in a single year. There are other regulated pollutants that typically don’t apply to metal finishing but may affect your facility if metal finishing is only one part of your total operation.

In January 1995, the Kansas Department of Health and Environment, KDHE, adopted regulations to implement provisions of the CAAA of 1990. The new clean air rules specify three different types of air operating permits, depending on whether a facility has the potential to emit more than the above stated amount of HAPs or VOCs, or if it falls under a NESHAP.

The Class I operating permit is a single document that contains all air quality requirements your facility has to meet. If your facility is defined as a major source, then it will need a Class I permit. As stated above, Class I status is based on the potential to emit. Your potential to emit, or PTE, is the maximum amount of air pollution your facility can emit if:

- each process unit is operated at 100 percent of its physical and operational design capacity
- materials that emit the most air pollution are used 100 percent of the time
- all of the equipment is operating 24 hours per day, 365 days per year, and
- no pollution control equipment is used.

If your facility’s actual emissions are less than the major source thresholds, but the potential emissions still exceed them, then your facility may qualify for a Class II permit, which is less expensive and time consuming to complete than the Class I permit. The Class III permit, is primarily a registration form that needs to be completed if you are subject to a NESHAP, if you are located in Johnson or Wyandotte counties and are subject to VOC regulations, have an incinerator, or are subject to a new source performance standard.

The Kansas Small Business Environmental Assistance Program, SBEAP, has several publications to help you understand the air regulations, including a detailed pamphlet titled Kansas Degreasers, as well as fact sheets on determining how to figure your potential to emit and the amount of HAPs or VOCs of your materials, the Kansas Air Quality Act, permit requirements under the degreaser MACT standards, and the MACT standard for chrome platers. SBEAP’s toll free number is 800-578-8898, or visit the web site at sbeap.nair.twsu.edu.
Waste Disposal Regulations

Tracking the movement of hazardous wastes has become a “cradle-to-grave” effort. The days of landfill disposal disappeared with the coming of the Resource Conservation and Recovery Act (RCRA) in the late 1970’s. The first step in proper waste handling is to determine if the waste is considered hazardous. Waste is classified as hazardous in one of two ways. First, a waste is considered hazardous if it exhibits one of the characteristics of a hazardous waste; that is:

- **Corrosive:** the pH of the substance is less than or equal to 2 or greater than or equal to 12.5
- **Ignitable:** the substance has a flashpoint less than 140°F
- **Reactive:** the material vigorously reacts with air or water, has a tendency to explode, or produce toxic gases
- **Toxic:** is deemed toxic according to approved toxicity tests

The material can also be considered hazardous if it is on EPA’s list of hazardous waste (F-list, K-list, P-list and U-list). The lists can be seen in *The Hazardous Waste Generator Handbook*, a KDHE guide for complying with Kansas’s hazardous waste generator regulations. Additionally, RCRA defines certain substances hazardous unless proven otherwise. For metal finishers, such materials include:

- Spent stripping and cleaning solutions
- Spent plating bath solutions
- Wastewater treatment
- Plating bottom sludges

What generator class you are in is dependent upon how much waste is generated at your facility. In Kansas, three classes exist: Small Quantity, Kansas and EPA.
Small Quantity Generator

If the following criteria is met, the state of Kansas considers you a Small Quantity Generator (SQG).

- The facility generates no more than 25 kg (55 lbs) of hazardous waste, or no more than 1 kg (2.2 lbs) of acutely hazardous (P-listed) waste in a calendar month.

- The facility accumulates no more than 1,000 kg (2,200 lbs) of hazardous waste or no more than 1 kg (2.2 lbs) of acutely hazardous waste, or no more than 25 kg (55 lbs) of debris and contaminated materials from the cleanup of spillage of acutely hazardous waste.

SQG’s are required to handle the hazardous waste they generate in an environmentally sound manner and are not subject to any notification or reporting requirements. Small Quantity Generators may use any of the following alternatives to handle their hazardous wastes when disposed of in quantities less than 25 kg: recycling, reuse, reclamation, disposal at a permitted sanitary landfill, neutralization and discharge to the sanitary sewer only with permission of the city, and disposal at a permitted hazardous waste disposal facility.

Hazardous wastes such as solvents, sludges, and pesticides are not suitable for discharge to the sanitary sewer. Small quantities of hazardous waste may NOT be disposed of by dumping on the surface of the ground or into surface waters, burying in the ground at an unpermitted site, or by using wastes such as solvents for killing weeds. The small quantity generator regulations are located at K.A.R. 28-31-4(m).
Kansas Generator

Each of the following criteria must be met to be considered a Kansas Generator:

- The facility generates 25 kgs (55 lbs) or more of hazardous waste but less than 1,000 kg (2,200 lbs) in a calendar month.
- The facility does not generate 1 kg (2.2 lbs) or more of acutely hazardous waste or 25 kg (55 lbs) or more of debris and contaminated materials from the cleanup of spillage of acutely hazardous waste.
- The facility accumulates no more than 1,000 kg (2,200 lbs) of hazardous waste or 1 kg (2.2 lbs) of acutely hazardous waste, and no more than 25 kg (55 lbs) of debris and contaminated materials from the cleanup of spillage of acutely hazardous waste.

Kansas Generators must comply with the following regulatory requirements:

(a) Determine which wastes generated by the facility are hazardous.

(b) Obtain an EPA identification number by submitting a hazardous waste notification form to the Kansas Department of Health and Environment.

(c) Prepare a manifest for all shipments of hazardous waste. Package, label, mark, and placard all shipments of hazardous waste in accordance with pre-transportation requirements.

(d) Prepare and maintain the following records for three years:

1) A signed copy of all manifests initiated
2) Manifest exception report(s)
3) Hazardous waste analyses
4) Weekly inspection reports

(e) Meet all storage requirements for containers and/or tanks.

(f) Meet emergency preparedness requirements.

(g) Report all international shipments of hazardous waste to the Kansas Department of Health and Environment and the Environmental Protection Agency.
**EPA Generator**

An EPA Generator is one who fulfills any one of the following:

- The facility generates in any single month or accumulates at any time 1,000 kg (2,200 lbs) or more of hazardous waste.
- The facility generates in any single month or accumulates at any time 1 kg (2.2 lbs) of acutely hazardous waste.
- The facility generates or accumulates at any time more than 25 kg (55 lbs) of debris and contaminated materials from the cleanup of spillage of acutely hazardous waste.

EPA Generators are subject to all regulations for Kansas Generators, except for the emergency preparedness requirements, as well as the following additional requirements:

(a) Provide a personnel training program to ensure that facility personnel are able to respond effectively to a hazardous waste emergency. The program must include the following:
   1) A director trained in hazardous waste procedures.
   2) Instruction which teaches facility personnel about the location of emergency response and monitoring equipment; maintenance and operation of such equipment; communications procedures and response procedures for fires, explosions, and contamination incidents. Training must be completed within six months after the date an employee enters a position.
   3) An annual review of the initial training.
   4) Development of job titles, job descriptions, a description of training to be given each job title, and a record of all training which occurs.

(b) Adequately provide for preparedness and prevention with the following precautions:
   1) Proper maintenance of facilities to minimize releases of hazardous waste.
   2) Where appropriate for the type of waste generated, provide an internal communications or alarm system, a telephone or two-way radio, and fire extinguishing and control equipment. All required equipment must be tested and maintained to ensure proper operation.
   3) Provide personnel working directly with hazardous waste with immediate access to communications and alarm equipment.
   4) Maintain aisle space sufficient to allow passage of personnel and fire, spill control, and decontamination equipment.
5) Make arrangements with the local hospital, police department, fire department and emergency response team to familiarize them with the plant layout and hazards involved with the wastes generated. Such arrangements should be documented.

(c) Prepare a contingency plan and implement emergency procedures to ensure that releases of hazardous waste are properly handled. The contingency plan must provide for:

1) A description of the actions facility personnel must take to respond to a release.
2) A description of the arrangements made with local authorities for emergency services.
3) Designation of primary and secondary emergency coordinators and listing of their addresses and phone numbers. Assure that an emergency coordinator is on site or on call at all times.
4) A list of all emergency equipment on site, including capabilities and locations.
5) An evacuation plan where the potential need for evacuation exists.
6) Copies of the contingency plan to be maintained at the facility and submitted to the local police department, fire department, hospital, and emergency response team.
7) The contingency plan is to be periodically reviewed and current.

The above list is an abbreviated version of compliance requirements. For a complete listing of requirements associated with hazardous waste, please consult the *Hazardous Waste Generator Handbook*, the *Kansas Statutes Annotated*, Chapter 65 - Article 34, and the *Administrative Regulations*, Article 31.

To determine the quantity of hazardous waste, consider the following:

- Is the material still within the production process? Listed or characteristic waste material is not counted until it is removed from the process.
- If the material is recycled, it is counted each time it is generated as a waste.
- Are wastes discharged directly and legally to a POTW? If done in compliance with the Clean Water Act Pretreatment Standards, such wastes are not considered part of the RCRA system.

*In Appendix A is a copy of KDHE’s Hazardous Waste Generator/Transporter Compliance Inspection Checklist. Check it out!*
“...implementation of P2 practices and technologies can reduce waste streams and regulatory requirements...and help you save money...”
What Else Is There?

Superfund and Community Right-to-Know Regulations

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, known generically as the "Superfund" law, and its subsequent amendments are an attempt to provide for the cleanup of contaminated sites and to assign financial responsibilities for that cleanup.

CERCLA’s major impact on metal finishers in their everyday operations result from the additional reporting requirements they will be subject to as they generate and dispose of hazardous materials. Aside from the day to day concerns of complying with those reporting requirements, CERCLA impacts metal finishers by making them permanently responsible for all the hazardous materials they send off-site. Also of concern is the fact that the owner of a property is responsible to clean up any hazardous waste contamination on his or her site before that site can be sold. This requirement will have the most impact of older operations that may have used disposal practices that were accepted at the time, but have led to the contamination of the site with hazardous materials.

All CERCLA requirements apply to hazardous substances as defined under the Clean Water Act, the Clean Air Act, the Resource Conservation and Recovery Act, and the Toxic Substances Control Act. Generally, CERCLA combines the "cradle to grave" responsibility for the hazardous wastes generated by a facility with "joint and several liability" for wastes to make a facility forever responsible for the ultimate disposition of any and all hazardous wastes they produce and the cleanup costs associated with remediating any sites that contain their wastes. In essence, the facility is not only responsible for its own actions in disposing of its waste, but also for the actions of the waste hauler as well as the treatment and disposal contractor they hire to handle, treat, and dispose of their hazardous wastes.

CERCLA impacts facilities by requiring them to report spills of hazardous materials; requiring reports and the notification of local authorities on the use, storage, and release of hazardous materials; and requiring them to report the release of certain toxic substances if the facility meets a set of thresholds. These requirements combine those in the original CERCLA law and those added through the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA - a section of the Superfund Amendments and Reauthorization Act of 1986). Following is a short summary of the primary requirements likely to affect metal finishers:

Reporting Spills

Spills of hazardous substances must be reported to the appropriate authority if "reportable quantities" are spilled. These quantities range from 1 to 5,000 pounds of substances spilled within a twenty-four hour period. In many cases, state and local authorities require facilities to report smaller spills.
Reporting the Use, Storage, and Disposal of Hazardous Materials

The 1986 Amendments to the Superfund law require facilities that use, store, or dispose of hazardous waste to provide information concerning their on-site management of those materials to state and local authorities.

The EPCRA requirements are included in Title III of SARA. Section 302 of Title III requires a facility to notify the state emergency response commission (SERC) if the company exceeds the Threshold Planning Quantity for any extremely hazardous substance. Section of 304 of Title III requires a facility to report any potentially dangerous release of any hazardous substance to the SERC and local emergency response committee in addition to reporting such a release to the federal authorities.

In Section 311 of EPCRA, facilities are required to submit Material Safety Data Sheets (MSDSs) or a list of MSDSs for each extremely hazardous substance or OSHA hazardous material that exceeds a certain threshold. This information is to be submitted to the USEPA (they prefer a list), the SERC, the local emergency response committee, and the local fire department.

Section 312 of EPCRA requires facilities to submit an inventory of the hazardous chemicals stored on-site, if threshold quantities are met. Facilities required to submit MSDSs under Section 311 are required to comply with this section for the chemicals they report under 311. The inventory must be submitted on Tier II reporting forms. This information is to be submitted to the SERC, the local emergency response committee, and the local fire department. Most states require the submission of Tier II forms. These forms contain more detailed information on the chemicals stored on-site and the locations of those chemicals at the facility.

The aspect of EPCRA that has gotten the most publicity is the requirement under Section 313 that facilities that "routinely" and/or accidentally release a defined set of chemicals must report annually on those releases. The compilation of this information is called the Toxics Release Inventory, or TRI. Facilities required to report have the following characteristics:

- Be classified in SIC codes 10 (except 1011, 1081, 1094), 12 (except 1241), 20-39, 4911, 4931, 4939, 4953, 5169, 5171, or 7389,
- Have ten or more full time employees, and
- Use any of the designated chemicals at a rate of 10,000 lbs or more a year, or
- Manufacture and process any of the designated chemicals at a rate of 25,000 lbs or more a year.

Because the list of chemicals to which the TRI requirements apply is revised periodically, it is important for metal finishers to get an approved list from a relevant governmental agency, KDHE, to confirm their need to comply.
Occupational Safety and Health Regulations and Metal Finishers

All manufacturing companies in the U.S. are subject to regulation under Section 6(a) of the Williams-Steiger Occupational Safety and Health Act of 1970. This law and its attendant regulations require conditions or the adoption or use of one or more practices, methods, operations, or processes reasonably necessary or appropriate to provide safe or healthful conditions in places of employment.

Hazard-Communication Standard

Of particular interest to operators of metal finishing operations are the OSHA rules governing the dissemination of information to workers concerning the hazards posed by chemicals in the workplace. The extensive use of hazardous materials in metal finishing operations makes this an important standard for companies with those operations. Facilities that use materials included on the OSHA list of hazardous chemicals are required to make available all the MSDSs for those chemicals used in the work area hazardous chemicals are also labeled in a manner that clearly identifies the material to the worker. Facilities must also provide training for workers on the handling of these materials. The labeling, training, and MSDS requirements are all part of the required "Hazard Communication" program each company using such material is required to put in place. Also included in this program is the requirement for a complete inventory of all chemicals and an assessment of the hazard potential for all chemicals used in the workplace.

Hazardous Waste Operations and Emergency Response Standard

This standard requires metal finishers to develop a written plan for emergency response, to have procedures for handling an emergency response, to train employees for activities in areas related to the emergency response position held, to provide the appropriate protective clothing, and to have procedures for post-emergency situations.

Control of Hazardous Energy

This set of standards is intended to provide for the safety of workers while major pieces of equipment are undergoing service and maintenance. The regulations protect workers from the unanticipated startup or release of stored energy that could cause injury. The standards lay out requirements for a program to be initiated by the facility that provides for the lockout of equipment undergoing maintenance and a tagging system to identify those in charge of the lockout. Included in these regulations are requirements for the establishment of lockout/tagout procedures, the proper selection of protective material and hardware, annual inspection and certification of energy control procedures, informing outside contractors of lockout/tagout requirements, procedures for shift changes, and an employee training program on lockout/tagout procedures.
Respiratory-Protection Standard

OSHA has promulgated standards governing the protection of workers from air contaminated with harmful dust, fumes, vapors, mists, gases and smoke. In cases where the use of engineering controls does not sufficiently reduce the presence of contaminated air, or control measures are in the process of being implemented, workers must be protected by using appropriate respiratory devices. A facility-wide respiratory-protective equipment program is the focus of this protective effort.

A respiratory-protective equipment program must include written standard operating procedure, the selection of proper equipment, procedures for the cleaning and storage of such equipment, emergency rescue procedures, and provisions for the physical examination of workers to determine if they are capable of performing their work while wearing a respirator.

Flammable-Storage Requirements

These standards state that all flammable and combustible liquids must be stored in either an approved storage cabinet or a room designed specifically for the storage of flammable and combustible materials. The features of an approved storage area for flammable liquids can be found in Section 30 of the National Fire Protection Association Standards.

Noise-Exposure Hearing-Conservation Program

OSHA requires that a facility must establish and administer a hearing conservation program whenever worker exposure levels equal or exceed an eight-hour time-weighted average level of 85 decibels measured on the "A" scale. Facilities must determine whether any worker's exposure meets or exceeds the standard. If any worker's exposure meets or exceeds the standard, the facility must maintain a hearing-conservation program.

Requirements for a hearing-conservation program include an audiometric testing program, the availability of hearing protectors, and training on their use. Exposure measurement records must be kept by the facility for two years and the audiometric testing records must be kept for the duration of the worker's employment.

The Kansas Department of Human Resources (KDHR) has an assistance program to answer your questions. Their number: 785-296-4386
Section 6: Where To Find Help

General Information
KDHE: 785-296-1500
SBEAP (Small Business Assistance Program): 800-578-8898

Air
Community Right-to-Know
KDHE: 785-296-1550

Air Permits and Emission Calculations
KDHE: 785-296-1593

Technical Assistance with Air Emissions
SBEAP: 800-578-8898

Water
NPDES Requirements
KDHE: For Cities: 785-296-5525
KDHE: For Industry: 785-296-5547
KDHE: Pretreatment Requirements: 785-296-5551

Well Pumping
KDHE: Water Quality: 785-296-3565
Water Resources: Water Quantity: 785-296-3717

Groundwater Remediation
KDHE: 785-296-1660

Waste
Waste Management Requirements
KDHE: 785-296-1600

Pollution Prevention
Technical Assistance – Free and Non-regulatory
SBEAP: 800-578-8898
Section 7: For You Surfers…

The amount of information on the Internet just keeps growing. Several good sites exist for metal finishers, and a few are listed below. This is by no means a complete list.

www.epa.gov
www.osha.gov
www.kdhe.state.ks.us
sbeap.niar.twsu.edu
www.engg.ksu.edu/enggext/ppi
These are the home pages for the EPA, OSHA, KDHE, Kansas SBEAP, and the Pollution Prevention Institute at Kansas State University, respectively.

The Small Business Home Page not only contains a lot of good information on its own, but provides lots of links to other sites.

www.aesf.org
This is the homepage for the American Electroplaters and Surface Finishers Society. The website tells of upcoming meetings, and conferences and training events, as well as providing links to similar technical associations.

www.strategicgoals.org
This site contains information on the National Strategic Goals initiative program for metal finishers. Goals of the program and progress made on related issues can be checked here.

www.nmfrc.org
The National Metal Finishing Resource Center maintains this site. Membership to the site is free, but gives you limited access. The site contains many fact sheets with updates on chrome-emission testing methods, rulings on F006 waste, CSI metal finishing workgroup progress, etc. It also has vendor information and an events calendar.

www.ctcnet.net
www.epa.gov/etv
Concurrent Technologies Corporation is an independent, nonprofit organization. In working with the EPA, they are establishing an Environmental Technology Verification (ETV) Center for Metal Finishing. The ETV Center will verify commercially available P2 technologies for finishers and makes results available.

www.p2iris.com
This is a “pay-to-view” site, and a password is needed to enter. However, the amount of information contained within is astonishing. Topics covered include plating processes, plating methods – theories and principles, surface finishing processes, substrate participation, and other topics.