

Metal Finishing Pollution Prevention

What Is Pollution Prevention?

Pollution prevention (P2) is the reduction or elimination of pollutants or wastes *at the source* to avoid producing waste in the first place. When waste is not produced, storage and disposal are not issues.

Many pollution prevention practices are low-cost and low-risk alternatives to minimize waste and the resulting disposal costs. Most approaches are based on common sense and do not require sophisticated technology. These fact sheets contain ideas for good pollution prevention practices.

Pollution Prevention Benefits

- Reducing hazardous material usage results in decreased waste disposal costs and less regulatory reporting requirements.
- Extend the life of expensive process bath solutions.
- Process bath solutions are kept from contaminating subsequent process baths.
- Less rinse water is needed and as a result, less has to be treated.

Commitment to Pollution Prevention

- ◆ The commitment to preventing waste should be part of your company's policy with strong support from management and training for plant operators.
- ◆ Employee participation and suggestions in your waste reduction program helps make it a success.
- ◆ The first step in pollution prevention is evaluating and mapping your shop's chemical consumption and production. This makes it easier to spot areas where pollution prevention tips can be applied.

Good Housekeeping

Simple housekeeping techniques provide low- to no-cost opportunities for reducing waste. Maintaining your shop's cleanliness decreases the amount of water used and chemical waste produced.

Maintenance

- ◆ Perform preventative maintenance. Routinely check for leaky valves and fittings; repair immediately. Develop inspection and maintenance schedules.
- ◆ Maintain plating anodes, racks and barrels to prevent bath contamination.
- ◆ Monitor tanks, tank liners, steam coils and heat exchangers to prevent accidents.

Spills

- ◆ Prevent spills by training personnel in improved material handling.
- ◆ Install liquid level alarms on process baths.
- ◆ Install spill containment areas.
- ◆ Manage spills without excess water usage by using absorbent materials (dry cleaning methods).

Inventory

- ◆ Do not allow materials to exceed shelf life. Use materials on first-in, first-out basis.
- ◆ Buy materials in appropriate amounts.

Substitute Materials

Cadmium, cyanide and chromium are the most toxic materials used in metal finishing. Processes using these substances emit highly toxic fumes. These materials can enter the body through skin absorption. The hexavalent form of chromium is a known carcinogen.

Hazardous chemical replacement can reduce hazardous waste disposal costs and provide a safe working environment. The following focuses on some replacements that are currently successful for the most toxic chemicals used in metal finishing.

Cyanide Baths

Substitute cyanide baths with alkaline baths when possible.

- ◆ To remove copper or nickel from various substrates, several non-cyanide alkaline immersion stripping baths are available. These baths typically use either the ammonium ion or an amine.
- ◆ For plating copper, non-cyanide alkaline and acid baths have been developed.
- ◆ For plating zinc, a non-cyanide alkaline and acid bath can be used.

Plating Materials

Chromium

- ◆ Substitute trivalent chromium for hexavalent chromium when possible. The use of trivalent chrome eliminates both misting and additional wastewater treatment.
- ◆ Replace chromium plating with tungsten-silicon carbide plating or molybdenum plating.

Cadmium

- ◆ Use zinc-nickel alloy to replace cadmium.
- ◆ Replace toxic cadmium plating process with relatively non-toxic aluminum ion vapor deposition to achieve metal hardening.

Pre-Finishing Cleaners

- ◆ Replace old-style chlorinated solvent vapor degreasers, traditionally TCE and PERC, with more efficient models which eliminate VOC releases.
- ◆ Switch to aqueous cleaners to eliminate VOC releases.
- ◆ Replace vapor degreaser with additional aqueous cleaning on the production lines.

Bath Life

Proper control of bath operating parameters will result in more consistent work piece quality as well as longer bath life.

Ideas for increasing bath life efficiency:

Operations

- ◆ Establish written procedures for bath make-up and additions and keep logs.
- ◆ Measure pH, temperature and concentration at least daily to help determine when more chemicals should be added or when impurities should be removed.
- ◆ Use deionized water instead of tap water in plating baths and rinses to extend bath life. This practice minimizes the precipitation of minerals in the water as sludge. Distilled water is a cheaper but less effective alternative.

Contamination Prevention

- ◆ Reduce drag-in contamination through good rinsing practices.
- ◆ Add chemicals only when needed and use high quality raw materials to reduce contamination.
- ◆ Ensure parts are properly cleaned before entering process baths and properly rinsed of contaminating solutions from previous baths.
- ◆ Quickly remove dropped parts and tools from process baths to reduce contamination. Have rakes available to remove dropped items.
- ◆ Cover baths with lids when not in use to prevent contamination and evaporation.

Contaminant Removal Methods

- ◆ Filtration: Use a filter that can be cleaned and reused.
- ◆ Activated carbon absorption: Continuous or batch
- ◆ Chemical precipitation: Batch
- ◆ Electrolytic purification -- used for large tanks to remove metallics and nitrates: Batch

Drag-Out Reduction

Chemical “drag-out” is the primary source of contaminated rinse water. Drag-out is the plating solution that clings to parts as they are removed from a bath. This solution either ends up dripping onto the floor or mixing into the next bath or rinse. The resulting contaminated rinse water requires treatment to remove harmful or regulated pollutants before the water is reused or discharged.

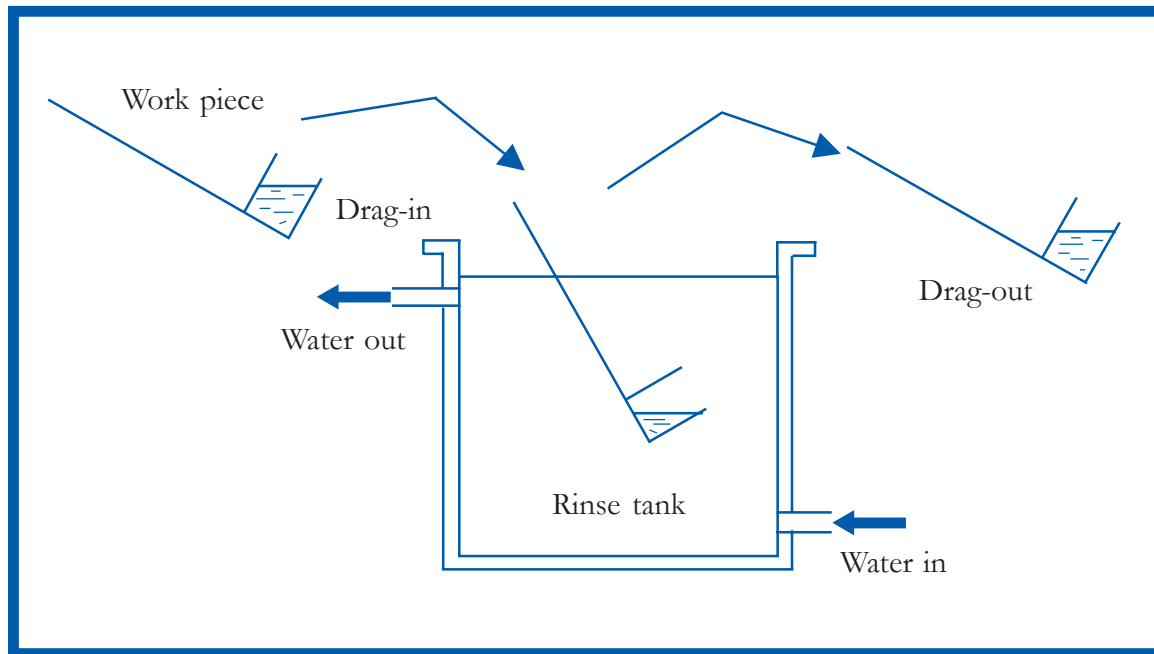


Figure 1: Illustration of Drag-Out

Ideas to reduce drag-out:

Design

- ◆ Redesign parts and racks/barrels to minimize formation of drag-out. Consult with work piece manufacturers to adjust design to provide better bath liquid release.
- ◆ Drain boards can be placed over the lips of two adjacent tanks to catch any drips of drag-out when transferring parts. Slope the boards back to the plating tank. This reduces drag-out and keeps floors clean.
- ◆ Spray the parts with a fine mist of fresh or recycled rinse water above the process bath to “wash” drag-out back into the bath. Low-pressure air knives can also be used, but watch for spotting due to localized drying effects.

Parts Positioning

- ◆ Position parts so fluids flow together and off parts by the quickest route. Tilt parts to avoid any pockets or flat surfaces and do not position parts directly over one another.

Work Piece Withdrawal

- ◆ Remove parts slowly (~11 feet/min). This allows for the most efficient flow of solution back into the process tank. For manual operations, overhead hoists can reduce worker fatigue due to slow lifting.
- ◆ A drain time of at least 10 seconds reduces drag-out by at least 40 percent compared to the three-second industry average. For manual operations, hang work pieces on hooks or racks over the baths. Establish and post draining time for employees.
- ◆ Maintain sufficient drag-out timing through automation.
- ◆ Barrel plating should incorporate rotation into drainage practices when possible.

Process Chemicals

- ◆ Plating baths can usually be operated at significantly lower concentrations than chemical manufacturer recommendations - the lower viscosity results in less drag-out.
- ◆ Add wetting agents (surfactants) to reduce surface tension. This allows the chemical to spread more easily on the surface of the work piece.
- ◆ Check for chemical compatibility with your vendor. Decreased compatibility causes increased and excessive water use.

Rinse Water Reduction

Increasing rinse efficiency reduces your water usage and wastewater treatment costs.

Here are some ideas for rinse water reduction:

Rinsing Techniques

- ◆ **Countercurrent rinsing** with multiple tanks in a series can dramatically reduce water usage, thereby reducing the amount of wastewater to be treated.

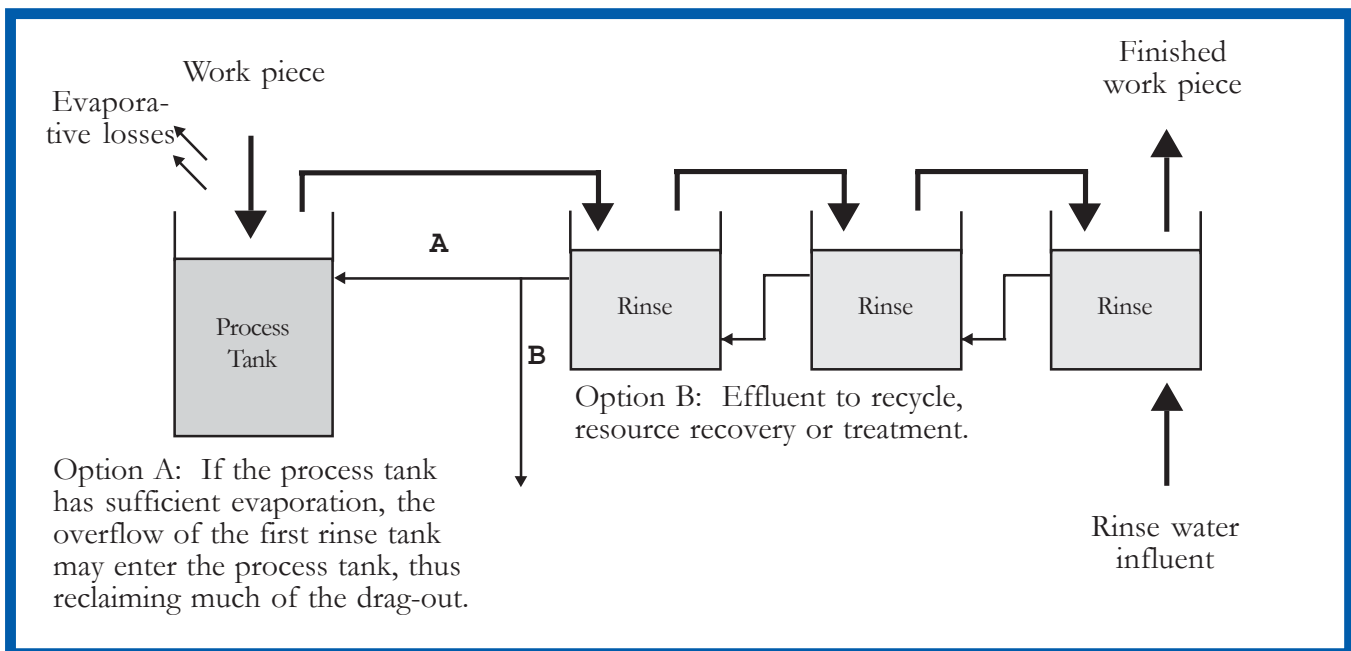


Figure 2: Three-Stage Countercurrent Rinsing

- ◆ **Spray or fog rinsing** is equivalent in effectiveness to approximately one-half of a dip rinse. In many cases spray nozzles can be sized and water flow rates adjusted so the spray rinse water balances the evaporative losses.
- ◆ **Agitating** the rinse improves rinse efficiency and shortens the required contact time. This can be done by:
 - Recirculation of a sidestream from the rinse tank.
 - Using a propeller-type agitator (highest efficiency).
 - Completely removing the parts and reimmersing them several times.
- ◆ A “static” or “still” rinse tank can be used prior to any flowing rinses or stagnant spray rinses to slowly build up a concentration of chemicals from the process bath. This rinse can be used as make-up for the process bath or for any spray rinsing above the process bath.

Rinse Water Control

Intermittent Workflow Options

- ◆ Operators adjust water valves to appropriate usage.
- ◆ Conductivity sensors check concentration levels and automatically add rinse water.
- ◆ Flow is programmed through variable-set rinse controls.

Steady Workflow

- ◆ Set the rinse water rate with flow restrictors. The flow rate should be set as low as possible, based on acceptable concentration levels in the rinse water.

Reuse and Recovery

Conventional treatment of process baths through precipitation generates large amounts of sludge as a hazardous waste. To reduce treatment and disposal costs, first optimize your process. Then segregate waste streams for efficient metal recovery.

Ideas for water reuse and metal recovery:

Water Reuse

- ◆ Use water from the first rinse tank to compensate for evaporative losses to the process bath.
- ◆ Following the alkaline cleaning bath, consider using the first rinse as cleaning bath make-up water.
- ◆ Reuse spent acid to neutralize an alkaline waste stream.
- ◆ Reuse spent alkali to neutralize an acid waste stream.

Material Recovery

The following recovery technologies remove metals and impurities from wastewater with varying degrees of efficiency depending on the metal to be recovered. The water can often be recycled into the process.

- ◆ **Ion exchange** uses beds of resin to filter wastewater, which results in a high quality effluent rinse water. Periodically, the resin beds are stripped of pollutants producing a concentrated solution. The metals may be reclaimed from the concentrated solution by electrowinning (see below).
- ◆ **Electrowinning:** Metals can be plated from concentrated solutions by using low plating currents and high surface area substrates. These metals can then be sent to recyclers or plating solution suppliers.
- ◆ **Porous Pots:** For hexavalent chromium plating baths a membrane separating the cathode from the anode can be used to accumulate bath impurities. The chromate ion is separated and may be purified and returned to the plating tank.
- ◆ **Reverse osmosis (RO) and ultrafiltration (UF)** separate suspended or dissolved solids in solutions by the use of a membrane surface. The process can be used to separate and reuse metals.
- ◆ **Electro/Diffusion dialysis** is another plating solution reclamation process. Electrodialysis achieves a higher concentration of metals than reverse osmosis or ion exchange. Diffusion dialysis is used for the recovery of acids contaminated with metals.