METAL FINISHING

RESOURCE EFFICIENT AND CLEANER PRODUCTION BRIEFING AND RESOURCE GUIDE FOR MICRO & SMALL ENTERPRISES

PURPOSE

Issue. Certain process, technique, and management deficits are commonly found in micro- and small-scale brick and tile operations. These deficits can have serious adverse effects on short- or long-term business performance---AND, on the local environment and on community health and safety. Among the most significant areas where economic savings can be realized through cleaner production are management actions that address fuel inefficiencies and energy resource depletion, poor clay mining practices, poor process control, and excess dust/chemical pollution.

Response. Addressing these deficits by adopting resource-efficient and cleaner production (RECP) processes, techniques, and management practices can reduce costs and improve business performance and, at the same time, avoid or minimize adverse impacts on the local environment and on community health and safety. RECP approaches generally focus on improving resource and production efficiency which saves physical and energy resources, time, and money needed in production—and results in less waste and pollution. This briefing supports the application of RECP solutions in these four key areas.

Contents. This briefing addresses each deficit area in turn. General business, environmental and health and safety issues are identified first. Then, a question and answer format is used to identify specific deficits and potential RECP solutions. The References and Resources section at the end of this briefing provides more detailed and quantitative information on these solutions.

Audience. This briefing is intended for business development services providers working directly with brick-and-tile MSEs, for those designing MSE strengthening projects, and for USAID staff (and the staff of other funding organizations) charged with overseeing projects in the brick and tile sector.

Scope. This briefing focuses on MSEs that are mining, processing, forming, and firing clay to produce bricks, tiles, and other ceramic products for the construction industry. However, some of the solutions outlined in this briefing could also be applied to MSEs that are mining and/or firing clay for other purposes, such as production of ceramic plates and bowls.

TABLE OF CONTENTS

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THE PROVEN BENEFITS OF RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP)

In 1990, UNEP defined Cleaner Production (CP) as "*The continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment*". The CP concept is widely accepted and promoted internationally, including by USAID. The strategies used to implement CP can be as simple as following the guidance in this briefing, or more complex and formal Environmental Management Systems (e.g., ISO 14001 standard) utilized by medium and large enterprises. UNEP is now advancing the concept of Resource Efficient and Cleaner Production, updating CP with additional emphasis on efficient utilization of resources in product and service enterprises.

This briefing is specifically concerned with RECP/CP technical and management interventions in production operations. Such interventions focus on (1) increasing the efficiency with which resources are utilized and/or (2) assuring that resources are utilized "cleanly"—without incurring costs and impacts that adversely affect the bottom line of the enterprise, the environment, and worker and community health and safety. Typical RECP interventions include:

- substituting different materials
- modifying processes
- improving process management
- upgrading equipment
- redesigning products

Inefficient use of resources like fuel, water and raw materials incurs both business and environmental costs. Experience shows that by reducing inefficiencies, RECP interventions in many cases substantially improve business performance AND deliver environmental, health and safety benefits—sometimes with little or no investment.

Is this always true? No. Some RECP interventions may not improve business performance. But RECP approaches offer the most cost-effective way to improve environmental or social performance when required by project implementation conditions, local regulations, or simply to preserve community goodwill.

For more information see http://www.usaidgems.org/sme.htm.

AREA 1: TRACK, MANAGE, AND REPLACE HAZARDOUS CHEMICALS

Business Issues: Metal finishing operations routinely use various hazardous chemicals, including solvents for cleaning metal parts, various acids and bases for etching them, and solutions of metal salts for plating the finish onto the desired form (substrate).

Most coating processes require the metal surface to be thoroughly cleaned beforehand, because surface contaminants greatly diminish the quality of the finished product. Both cleaning and plating processes generally occur in a "bath"—that is, a tank in which parts are dipped into a solution of chemicals. Preparing the surface of the metal for treatment involves the removal of greases, soils and oxides. Cleaning agents used for this purpose include detergents, solvents, acidic solutions and caustics.

Finished metal parts are often further coated with some combination of paint, lacquer or ceramic coating. These coatings can themselves contain toxic solvents and heavy metals.

Chemicals used may include the following:

- acids (sulfuric, hydrochloric, nitric, phosphoric)
- toxic metals (cadmium, nickel, zinc, chromium, lead, copper) and compounds which contain these metals
- solvents (1,1,1-trichloroethane, methylene chloride, tetrachloroethylene, methyl ethyl ketone [MEK], toluene, xylene)
- cyanide compounds

In general, cleaner production can improve the financial performance of the production process. For example, less toxic processing inputs may be cheaper to purchase and dispose of.

Environmental Issues: Toxicity is an issue for both human health and ecosystems. For example, hexavalent chromium in particular is highly toxic to aquatic animals at very small doses. It is also highly toxic to humans, causing kidney damage and increasing the risk of lung cancer in humans.

Community and Occupational Health and Safety Issues: Metal-finishing chemicals may be toxic to humans and animals, cause cancer in both humans and animals, easily catch fire. They may also persist in the environment for a long time, entering the food supply.

Both workers and local communities are at risk from exposure to these chemicals, particularly those that persist in ground and surface water supplies for long periods.

Cleaner production options in this area are simple techniques, including pre-cleaning, production/inventory planning, substituting less hazardous chemicals and/or processes, and reusing or reclaiming "dirty" chemicals.

Use the following questions and answers to identify specific causes of poor management of hazardous chemicals and the corresponding RECP methods that address them.

Is there a system to track chemical inventory?

Avoid keeping outdated chemicals. Chemicals may lose their effectiveness if used past their expiration date, resulting in poor-quality products and wasted bath solutions.

Recently purchased chemicals should be used after older chemicals (a “first in, first out” policy) in order to prevent accumulation of expired stock. Creating an inventory control system will prevent waste by ensuring that all chemicals are used in order of their arrival in the storeroom.

Label all chemical containers with the name of the chemical, the date it arrived at the storeroom, the name of the manufacturer/distributor, and any appropriate hazard warnings. The manufacturer, and in some cases the distributor, may be able to provide a Material Safety Data Sheet (MSDS), which includes necessary warnings as well as details about proper safety equipment and procedures for handling the chemical. Assistance providers may also be able to find MSDSs via the Internet.

Secure storage areas, and grant access to only a few designated employees. Provide health, safety and hazard signage with short clear instructions and strong visual content.

Require a one-for-one exchange policy, where workers must return an empty container in order to receive a new container. This will control the number of open containers, reducing the risk of spills, contamination and wasted materials.

Are employees trained to handle chemicals properly?

Conduct employee trainings in the proper handling of chemicals, the reasons for using safer techniques, and emergency response. Trained employees will be better able to operate baths at peak efficiency, minimize spills, and improve the consistency of solutions

Training can also minimize the number of “bad baths” in which the entire solution must be changed out, which wastes time, materials and water, and may require workers to reprocess metal parts. Ensure that only trained employees are responsible for mixing bath solutions and setting flow levels.

Establish awards programs for exemplary employee/worker performance.

Can any of the chemicals be replaced with less hazardous chemicals or non-chemical procedures?

Reduce the use of rust inhibitors (a toxic cleaning agent) by ordering metal parts to be delivered only at the time that they are needed, and also by storing them away from moisture if possible. This reduces the chances that they will rust.

Pre-clean parts (wipe them with rags, squeeze them, blow air or plastic pellets on them, vibrate them with abrasive media) before applying liquid or vapor degreasing solvents. This can reduce the amount (and cost) of solvents required and extend the life of degreasing solutions. Cold cleaning with mineral spirits can also help reduce the use of solvents by removing oil before vapor degreasing.

Is solvent used efficiently?

There are a number of ways to reduce the amount of solvents used throughout a facility; several require little or no investment.

Solvents left from “upstream” (earlier) processes can be reused in “downstream” (later) machine operations. For example, solvents used for final wash during equipment cleaning can be reused as paint thinner, eliminating the need to purchase paint thinners.

Rotating the treated metal parts before removing them from the degreaser will allow all condensed solvent to flow back into the degreasing unit, reducing the need to refill (top off) solvents.

Covering degreasing baths when they are not in use will reduce evaporation of solvents; firms can spend less on solvents and lower the risk of toxic exposures to workers.

Alkali washes can be used instead of solvents in degreasing operations. This way, wastes from alkaline cleaners can be chemically treated to reduce toxicity and then be discharged, which helps minimize cleaning costs. (See the description of wastewater treatment systems below.)

Extend the life of cleaning solutions and reduce costs by filtering the cleaning solutions to remove sludge buildup. Refresh the solution by topping it off with fresh solution and emulsifiers. For small operators, a single mobile filtration unit can service all caustic and acid solutions. Use cleanable polystyrene or metal filters in the filtration unit and clean the filters by blowing compressed air over them.

Use blast media to air-strip paint for line-of-sight stripping, instead of using solvents. Stripping paint using plastic blast media requires only low pressures and does minimal harm to the metal part substrate. Plastic blast media can be recycled, generate less waste than sand blasting, and can be cheaper and faster than chemical stripping methods.[1] Blast stripping should be performed only in well-ventilated spaces such as a walk-in booth or a large room. As with solvent-stripping methods, workers should always wear respirators to protect themselves from airborne particulates and hazardous emissions.

Recycle solvents onsite. Use gravity to separate a solvent/sludge mixture and reclaim the clear solvent for equipment cleaning. If reclaimed solvent is pure enough, it can also be used for formulating primers and base coats of paint. For larger volumes of solvents, recycle by using batch distillation. This works well for recovering isopropyl acetate, xylene, and paint thinner from cleanup operations. Residue from solvent recovery processes can be blended with fuel and burned in a combustion unit. Burning is safest for local communities as long as controls are used to capture toxic metals from the air emissions before they are released into the atmosphere. Do not burn residue without such controls. Residue from the burning must still be disposed of properly, as it will be toxic.

[1] Northeast Waste Management Officials' Association, 1998.

Have opportunities for process substitution been evaluated?

Use process substitution to reduce hazards to workers, communities, and the environment.

Zinc alloy plating, such as zinc-nickel or zinc-cobalt, can be used to provide corrosion protection instead of cadmium plating, which is highly toxic and carcinogenic. Alkaline zinc solutions can be used with existing equipment, although zinc solutions that do not contain cyanide require more thorough parts cleaning to be as effective as cadmium cyanide solutions. If cadmium plating is necessary, use bright chloride, high-alkaline baths, as they are less toxic than cadmium cyanide solutions.

Because cyanide is highly toxic to humans, use cyanide-free systems for zinc plating when possible. Cyanide-free systems include zinc chloride (acid) baths and zinc alkaline systems.

Zinc chloride baths have higher operating efficiencies, offer energy savings through improved bath conductivity, and result in better quality of product because hydrogen embrittlement is reduced. (This is a type of metal deterioration that reduces metal strength and ductility.) Zinc chloride baths, however, require that traditional steel tanks be lined with an acid-resistant material, such as hard rubber or polypropylene.

Zinc alkaline systems can be used in traditional steel tanks and produce good brightness, but require tighter operational controls to ensure an efficient process.

Replace cyanide cleaners with trisodium phosphate or ammonia. Use non-fuming cleaners such as sulfuric acid and hydrogen peroxide instead of chromic acid cleaner.

Use trivalent chromium instead of hexavalent chromium, as it is less toxic to humans and aquatic animals, creates less sludge, and is less viscous, therefore causing less drag-out (see below). Trivalent chromium also uses the same equipment as hexavalent chromium, so it requires no infrastructure changes. Unfortunately, trivalent chromium can only be used for a plating thickness no greater than 0.003mm. Trivalent chrome baths may also require additives to correct color differences.

For the copper bright-dipping process, use a sulfuric acid/hydrogen peroxide dip instead of cyanide and chromic acid dips. This reduces the toxicity of the bath and allows recovery of copper from the solution.

Has reduction of chemical waste by drag-out been investigated?

Drag-out is the residual solution that adheres to a part when it is removed from a process bath. Drag-out reduces the concentrations of chemicals in the plating bath, requiring more chemical inputs to maintain operating conditions. Methods to reduce drag-out include:

Drainage from baths: Install rails above process baths to rack pieces for drainage before rinsing. Add drain holes to plated parts to prevent bath solutions from pooling in racked items. Allow 10–20 seconds of drip time before rinsing.

Change bath conditions: Operate baths at lowest possible concentration to reduce drag-out loss. Using wetting agents to decrease the surface tension of the solution will also help prevent the solution from clinging to the parts. Increasing bath temperatures to make the solution less viscous can also reduce drag-out, but be sure that the higher temperatures do not reduce the effectiveness of any brightener being used. If MSEs choose to increase bath temperatures to reduce viscosity, they should insulate the tanks to reduce heating costs.

Redesign processes: Insert a drag-out recovery tank before the rinsing stage to minimize metal concentrations in the wastewater. Keep the drag-out that has been recovered from different process steps segregated so it can be used to top off plating tanks. This also streamlines the plating process and reduces drips on the floor.

If spray-painting is used to finish metal, have opportunities for greater efficiency been investigated?

Increase transfer efficiency of spray-painting by switching to a high-volume low-pressure (HVLP) system. This can increase transfer efficiency by 30 to 60 percent and thereby reduce supply costs for paint. Siphon-fed HVLP systems produce a fully atomized spray pattern with even surface coverage. Kits for converting conventional siphon sprayers to HVLP sprayers are inexpensive and practical to set up in small operations. All HVLP systems should be used in an enclosed space for maximum efficiency. Workers should always wear respirators when using spray guns to keep them from inhaling overspray and hazardous vapors.

Schedule paint jobs to start with light colors and end with dark ones so as to minimize cleaning between colors. Also, paint all products of the same color at the same time.

Scrape out paint cups and tanks before rinsing with solvent; this will make the solvent go further/last longer. Use various sizes of paint-mixing and sprayer cups to make it easier to prepare only the amount of paint needed.

Prevent nozzle tips for spray containers from clogging by inverting the can and spraying the nozzle to clear any residual paint. Repair clogged aerosols by cleaning or replacing the nozzle tip. Ensure that a spray gun's air supply is free of water, oil and dirt. Prevent spray gun leaks by submerging only the fluid control portion in cleaning solvents.

AREA 2: MANAGE AND REDUCE SOLID AND LIQUID WASTE

Business Issues: Metal finishing operations have many sources of non-hazardous and hazardous waste, including depleted or contaminated process baths, spent etchants and cleaners, waste from strip and pickle baths, exhaust scrubber solutions, degreasing solvents, and miscellaneous solid wastes (absorbants, filters, empty containers, etc.). Spills and accidental bath discharges, in particular, are sources of hazardous waste that are an easily correctible.

Surface preparation for metal coating generally involves removing soils and imperfections such as oxidation, rust, corrosion, heat scale, tarnish, smut and old paint. The process of removing these flaws generates waste oils and/or greases, as well as waste solvents and cleaners. Clean-up of spray guns, hoses and other paint equipment generates paint sludge and waste solvent. Also, expired chemicals and paints are waste materials that require special disposal plans.

Reducing generation of hazardous waste by conserving and reusing chemicals also reduces the amount of chemicals needed to be purchased.

Environmental Issues: Hazardous waste contaminates the soil, air, and water bodies.

Community and Occupational Health and Safety Issues: Hazardous waste can cause illness in the local community and among workers.

Cleaner production can help reduce the amount of hazardous and non-hazardous wastes generated by (1) preventing spills and leaks, (2) retraining employees, and (3) maximizing the efficiency of operations to use fewer inputs.

Use the following questions and answers to identify specific causes of excess solid and liquid waste and the corresponding RECP methods that address them.

Are spill-prevention techniques employed?

To prevent losses due to spills, purchase chemicals in the smallest possible quantities. When economic needs require purchasing chemicals in bulk, use spigots or pumps to transfer materials from large storage containers to smaller “working” containers to minimize drips and spills.

Keep containers tightly sealed at all times to prevent spills and evaporation of volatile chemicals.

Material storage areas should have a spill containment system such as a concrete pad with earthen berms enclosing the area.

Install drainboards between tanks. (A drainboard is a board that is placed over the lips of two adjacent tanks to catch drag-out.) Ensure that the drainboard is tilted to allow drag-out to flow back into the earlier tank in the process. Prevent and contain spills and leaks with drip trays and splash guards around processing equipment.

A worker at the Unis Tadiv machine tool production factory in Konjic, Bosnia-Herzegovina.

Hold training sessions to instruct employees on the proper handling of chemicals in order to reduce spillage and to minimize leaks and evaporative losses, which reduces supply and clean-up costs. Training can include low-cost, effective techniques such as:

- proper use of spouts, funnels, and drip pans during material transfer
- use of drainboards to reduce drag-out
- maintaining liquids in tanks at the correct levels to reduce spilling from overflows
- use of containment berms to contain spills

Create and implement regular inspection and maintenance schedules for process equipment and filters. Reinforce with signage and easy to follow manuals. Prevent leaks by frequently inspecting piping systems, racks, storage tanks, tank liners, air sparging systems, and automated flow controls.

If the MSE has process control equipment, is it regularly maintained and calibrated?

Make sure process controls are accurate. Set up schedules for calibrating all temperature controls, speed controls, and pH meters as a no-cost, preventative measure. Doing so helps ensure that operating conditions meet production requirements, reducing the number of substandard parts as well as energy, water, and raw materials usage.

Are substandard (unusable) products identified and removed from the process train?

Sort for substandard parts and set them aside before electroplating or painting to avoid waste in processing.

To prevent parts from failing to meet coating requirements, preparing surfaces well is key; 80 percent of coating adhesion failures can be attributed to improper surface preparation.[2]

Could chemical baths be changed less frequently?

Reduce contamination of bathwater, and thereby reduce the costs of replacing it with new bathwater, by ensuring that any dropped parts and tools are immediately retrieved. Locate rakes near baths to help pull dropped items out of the bathwater.

Clean racks between baths to minimize contamination.

Install a rain cover for outdoor tanks so that rain will not dilute chemicals.

In areas with “hard water” (water with high concentrations of calcium, magnesium, chloride, or other soluble minerals), use softened, distilled, or deionized water for rinsing in order to reduce contaminant build-up in baths. This will result in less drag-out and generate less sludge.

Use electrowinning[3] to remove unwanted metal contaminants from plating solutions, such as copper contaminating zinc-and nickel-plating baths. This allows the copper, for example, to attach to the metal plate, leaving the rest of the solution intact. Although small amounts of the plating metals will be removed along with the copper, generally the cost of replacing them is offset by savings from extending the overall life of the bath.

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[2] See Northeast Waste Management Officials Association, 1998.

[3] Electrowinning involves placing a sheet of metal in a bath and running a low current through it.

AREA 3: REDUCE AIR POLLUTION

Business Issues: Vapor degreasing operations and hot plating baths generate used solvents that emit volatile organic compounds (VOCs). VOCs are also emitted during paint application, curing and drying.

Poor handling practices can result in the loss of as much as 30 percent of solvents and degreasing agents. This can be a significant cost, as these chemicals would otherwise be re-used.

Environmental Issues: VOC's contribute to air pollution in the lower and upper reaches of the atmosphere.

Community and Occupational Health and Safety Issues: VOCs can cause serious health problems for workers.

In general, some sort of pollution control investment will be necessary to fully control air emissions from metal finishing facilities. Cleaner production can help reduce air pollution by preventing solvents from escaping into the air (i.e., volatilizing) and improving the efficiency of pollution control systems.

Use the following questions and answers to identify specific causes of excess air pollution and the corresponding RECP methods that address them.

How are solvent/degreasing tanks managed to reduce volatilization?

Cover the degreasing unit during idle or down times to prevent solvent from volatilizing.

Use a speed of 10 feet per minute or less to remove parts from solvent in order to minimize disturbance of the "vapor line"—the volume of air above the surface of the solvent that is saturated with solvent vapor. Rapid movement of the parts or basket disrupts the vapor zone, which allows new air to mix in with the vapor and then to escape the degreaser or bath, taking some of the vapor with it. Increasing the freeboard height above the vapor level to 50–100 percent of tank width will also help keep air from mixing with the vapor and reduce loss of solvent.

Are exhaust vents filtered?

Exhausts should be treated to reduce VOCs and heavy metals before venting to the atmosphere. Carbon filters can both reduce VOC levels and allow employees to recover solvent using steam stripping and distillation.

Use mist collection and scrubbing systems to control vapors and mists from process baths.

Can solvent-rich paints (which outgas while drying) be replaced with less polluting paints?

Use waterborne, powder, UV-curable, or high-solids paints instead of solvent-borne options. If solvent-based coatings must be used, consider alternative application technologies such as roller/curtain coating; tumbling, barreling, and centrifuging; or HVLP sprays.

AREA 4: TREAT AND REUSE WASTEWATER

Business Issues: Metal finishing, especially electroplating, generates large quantities of wastewater, primarily from rinsing between process steps.

Cleaner production can best help reduce impacts of wastewater by reducing the toxicity of the wastewater at the source (which saves material costs, and has been discussed in previous sections). Once options for reducing source pollution are used, however, it will still be necessary to build or share use of a wastewater treatment plant. In order to be effective, wastewater treatment plants need to be properly designed for the types of wastes to be treated and the volumes of wastes generated. Operating such plants can be costly, although in areas where water is scarce or expensive, treating wastewater may help pay for itself by permitting re-use of water in facility operations.

Environmental Issues: As mentioned in previous sections, discharging waste streams that contain toxic materials can impact local ecosystems.

Community and Occupational Health and Safety Issues: Because of the hazards to the community associated with the chemicals involved in metal finishing operations, wastewater should always be treated before disposal into ground or surface waters. Improperly treated wastewater can contaminate water for drinking, bathing, cooking and irrigation and commercial/industrial supplies, with long-term consequences for the health of the local population, including employees and ecosystem services.

Use the following questions and answers to identify specific causes of poor management of wastewater and the corresponding RECP methods that address them.

Is waste treated safely?

Separate waste streams. If cyanide and acidic wastewaters mix, it can generate lethal hydrogen cyanide gas. Also, nickel solutions must be separated from cyanide and ammonium solutions in order to allow nickel to precipitate out of solution.

Does waste treatment have the capacity to remove or destroy all the kinds of waste being generated?

A waste treatment plant should treat wastewater to destroy cyanide, equalize flows, neutralize pH, and remove toxic metals.

Are metals being precipitated for reuse?

Use a reducing agent such as a sulfide to reduce wastewater containing hexavalent chromium, which is water-soluble, to trivalent chromium, which is insoluble. Add lime to the wastewater to precipitate out the chromium, and dispose of the solids in a sanitary landfill.

Use sodium sulfides and iron sulfates to remove metal from rinsewater instead of tartarates, phosphates, EDTA and/or ammonia.

Sludge from water treatment operations must be treated before disposal in order to control metals. Use electrolytic methods to recover metals from the sludge when metal concentrations are high. Sludges should be thickened, dewatered, and stabilized with lime before disposal in a controlled landfill.

Oxidize chromium acid wastes with sodium bisulfite and sulfuric acid. Use magnesium oxide instead of caustic soda to adjust pH.

Treat degreasing baths separately, since the oils and grease in the wastewater will interfere with any metal precipitation processes.

AREA 5: WATER USE

Business Issues: Metal finishing requires water in almost every stage of the process. Many metal finishing businesses have yet to seize major opportunities to reduce their water use. Water efficiency also has numerous financial advantages for an MSE, most notably the decrease in the water bill and in wastewater treatment costs. There are various cost-effective ways for metal finishing enterprises to reduce their water use that could provide substantial savings.

Environmental Issues: Inefficient use of water resources for metal finishing can leave insufficient or highly polluted waters in lakes, rivers and wetlands, degrading their ability to perform crucial economic and ecological functions.

Community and Occupational Health and Safety Issues: Often, limited water resources in an area must satisfy the needs for public drinking water, sanitation, irrigation, river transport and industrial needs.

Use the following questions and answers to identify specific causes of excess water use and the corresponding RECP methods that address them.

What type of rinsing technique is currently being employed?

Ensure the proper design of rinse tanks in order to improve rinsing efficiency, reduce water use, and reduce drag-out. Tanks should be the smallest size necessary for all parts/products that will be used in them, in order to reduce water usage. Using a static rinse tank before a running rinse tank will reduce drag-out in the running rinse tank, using less water for the same degree of cleanliness.

Carefully placing water inlets and outlets on opposite ends of the tank will maximize water mixing in the tank, improving the effectiveness of the rinse. Inlet flow baffles, diffusers, distributors or spray heads can also help control the injection of freshwater into the rinsing tank and aid in mixing the water. Also, adding air blowers, mechanical mixing, or pumping/filtration systems can improve mixing by agitating tank water. However, mechanical agitation is preferable to air agitation, since air blowers can introduce contaminants like oil into the bath.

Change the mechanics of the rinsing process. Rinsing is more effective when the parts are dipped into the rinsing tank multiple times than when parts are dipped once and agitated while submerged. Dipping parts twice in rinse baths is 16 times more effective at reducing drag-out than dipping once.[4]

[4] Source: *CP Manual for the Metal Finishing Industry*, 1998.

Is fresh water used in every new bath? Could some water be reused?

Instead of fresh water for each bath of products, or continuously flowing water, flow control techniques can be used. Three effective flow control techniques are flow restrictors, flow cut-off valves, and conductivity meters and controllers. Flow restrictors ensure that excessive water is not fed to the process line. Flow cut-off valves are simple mechanisms that shut off water flow to rinse tanks when the process lines are not in use. Conductivity meters and control valves reduce rinse water flow and retain a set standard of water purity in the tank (electrical conductivity increases as the concentration of contaminant ions increases).

Re-use treated wastewater for minor rinsing steps, such as after alkaline cleaners and acid pickling steps. Note: Caution should be exercised in re-using wastewater that has been conventionally treated (via hydroxide precipitation) as it can introduce high amounts of dissolved solids into the plating line.

Is there a system in place that measures the number of liters or gallons of freshwater used at various stages of the metal finishing process?

Measure usage at individual production points. Flow meters indirectly conserve water by allowing careful monitoring of usage and can identify optimum water usage (or excessive waste), leaks, and system failures. Install an inexpensive flow meter or accumulator on the main water feed line (leading to the process line) or on individual rinse tanks.

Have you considered alternatives to tank rinsing?

Tank rinsing may not be the most water-efficient solution for rinsing certain types of parts. Consider spray rinsing instead of immersion for flat-surfaced parts. Ultrasonic rinsing works well for cleaning parts with small crevices or irregular shapes.

Counter-current rinsing: This is a process where rinse water is circulated through a series of rinse tanks. Fresh water (preferably deionized) is fed into the rinse tank farthest from the process tank and overflows to the rinse tank closest to the process tank. The work piece is dipped in the cleanest water last. Counter-current rinsing uses significantly less water than a single flowing rinse. Two counter-current rinse tanks can reduce water use by 90 to 97 percent.

Reactive rinses and reuse: This system diverts the overflow from an acid rinse to an alkaline rinse tank. The reuse of acid rinse baths for alkaline cleaner rinses makes the alkaline cleaner rinse more effective, typically reducing water consumption by 50 percent.

Spray rinsing: Spray rinsing reduces the water needed for final rinsing by spraying drag-out back into its process tank or into a concentrated holding tank. Spray rinsing works best for flat sheets, or in conjunction with immersion rinsing for irregular objects.

Community & Occupational Health & Safety Issues: Increased air pollution, particularly from incomplete combustion, can cause and worsen respiratory illnesses in workers and the surrounding community. Depletion of fuelwood adversely affects communities, particularly women and girls.

REFERENCES AND RESOURCES

- The International Cleaner Production Information Clearinghouse (ICPIC) at http://www.uneptie.org/PC/cp/library/icpic.htm.

  The ICPIC was developed by the UN Environment Programme's Division of Technology, Industry, and Economics (DTIE) for the effective promotion of CP worldwide. The ICPIC contains a compilation of CP case studies, CP contacts, profiles of CP-related national policies and CP publications. Case studies used in preparing this fact sheet include:

  - EP3: Pollution Prevention Assessment for a Metal Finishing Facility http://www.p2pays.org/ref/10/09356.htm.
  - Toxic Waste Reduction in Chrome Plating http://www.p2pays.org/ref/10/09381.htm.
  - Cleaner Production for Reducing Water Consumption at a Metal Plating Industry http://www.p2pays.org/ref/10/09110.htm.
  - Eco-efficiency at a Metal Finishing Factory in the Czech Republic http://www.p2pays.org/ref/10/09160.htm.

- Management Options for Old Paint and Paint-Related Materials (1995). Minnesota Technical Assistance Program (MnTAP) Fact Sheet. http://www.p2pays.org/ref/01/00609.pdf.

  This fact sheet provides information on how to effectively reduce and manage wastes from painting operations. These include (1) ignitable wastes, such as solvents and other cleaners; paints and paint thinners; and adhesives and glues, and (2) toxic wastes with heavy metals.

- National Metal Finishing Resource Center. http://www.nmfrc.org/.

  The National Metal Finishing Resource Center (NMFRC) is an Internet-based organization established in 1995 under a program jointly funded by the U.S. Commerce Department's National Institute of Standards and Technology (NIST) and the U.S. Environmental Protection Agency (USEPA). Their site is a comprehensive collection of environmental and technical resources for pollution prevention in metal finishing, including a searchable technical database containing over 5,000 articles, papers and reports; specifications (with index) used in metal finishing; shop, supplier and people directories containing over 6,000 entries; and online calculators designed for finishing needs.

  Their "Ask the Expert Question-and-Answer Archives" on wastewater treatment were used in creating this fact sheet. http://www.nmfrc.org/wwarchive/aug02b.cfm.

- North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance. http://www.p2pays.org/.

  This Web site offers an extensive collection of resources on CP and pollution prevention for a variety of industry sectors. The page on waste reduction in electroplating houses an excellent online collection of technical resources for the metal plating industry. Several "Fact Sheets" linked to this Web site that were used in preparing this CP fact sheet include:

- Water Efficiency, Industry-Specific Processes: Metal Finishing. http://www.p2pays.org/ref/04/03097.pdf.
- Water Conservation for Electroplaters: Counter-Current Rinsing http://www.p2pays.org/ref/01/00051.htm.
- Pollution Prevention Tips: Drag-out Management for Electroplaters http://www.p2pays.org/ref/01/00222.pdf.
- Ben Graves. Never Dump Cleaner. http://www.p2pays.org/ref/02/01366.htm.
- Virginia Waste Minimization Program (1995). Fact Sheet: Waste Reduction for Metal Finishers, 1 (4). http://www.p2pays.org/ref/11/10308.htm.

- Northeast Waste Management Officials' Association (1998). Pollution Prevention in Metal Painting and Coating Operations: A Manual for Pollution Prevention Technical Assistance Providers. http://www.p2pays.org/ref/01/00777/toc.htm.

  The Northeast Waste Management Officials' Association (NEWMOA) designed this manual to provide environmental assistance staffers with a basic reference on metal finishing-a single publication to jump-start their research on pollution prevention for companies with which they are working. The manual is explicitly designed to be useful both to assistance professionals with experience working with metal platers and to those who have never encountered metal finishing before. The USEPA Pollution Prevention Division funded this manual as a model of a comprehensive packet of information on a single industry.

- Pallen, Dean (1997). Environmental Sourcebook for Micro-Finance Institutions. Asia Branch, Canadian International Development Agency. http://www.microfinancegateway.org/gm/document-1.9.28909/1914_Pallen_Dean.pdf.

  This sourcebook describes the environmental impacts of a variety of important MSE sectors. It is designed to help micro-finance institutions improve the environmental performance of their lending activities, and offers guidance for improving MSEs' economic performance as well.

- Pennsylvania Department of Environmental Protection (1997). Pollution Prevention Opportunities for Painting and Coatings Operations. http://www.p2pays.org/ref/01/00151.pdf.

  This fact sheet describes alternatives for reducing releases of volatile organic compound (VOCs) from solvents, as well as good operating practices for painting operations.

- U.S. Environmental Protection Agency (1994). Guide to Cleaner Technologies: Alternative Metal Finishes. EP/625/R-94/007. http://www.p2pays.org/ref/02/01052.pdf.

  This guide presents information on process alternatives that can reduce or eliminate generation of some wastes and emissions from metal finishing operations. It is particularly applicable to firms that apply cadmium and chromium finishes, as well as to finishers that use cyanide-based baths or copper/formaldehyde solutions.

Other Resources

- Business Assistance. Metal Finishing Industry Resources http://pprc.org/hubs/toc.cfm?hub=24&subsec=7&nav=7.

This site catalogs a variety of metal finishing resource sites. It maintains links to several metal finishing trade associations as well as a database of current research projects. A joint project of the Business Assistance Programs in Alaska, Idaho, Oregon and Washington, the site is funded by a grant from USEPA.

- Cleaner Production in the Metal Finishing Industry (2000). http://www.svti.sk/CleanVOC.htm.

  This website presents an annotated guide to resources available on the Internet for metal finishers.