Pollution Prevention
Through Good Operating Practices

GOOD OPERATING PRACTICE	PROGRAM INGREDIENTS
Waste Segregation	• Prevent mixing of hazardous wastes with non-hazardous wastes. • Store materials in compatible groups. • Segregate different solvents. • Isolate liquid wastes from solid wastes.
Preventative Maintenance Programs	• Maintain equipment history cards on equipment location, characteristics, and maintenance. • Maintain a master preventative maintenance schedule. • Keep vendor maintenance manuals handy. • Maintain a manual or computerized repair history file.

Training or Awareness Building Programs	• Provide training for:
	  • Operation of the equipment to minimize energy use and material waste.
	  • Proper materials handling to reduced wastes and spills.
	  • Emphasize importance of pollution prevention by explaining the economic and environmental ramifications of hazardous waste generation and disposal.
	  • Detecting and minimizing material loss to air, land or water.
	  • Emergency procedures to minimize lost materials during accidents.

Effective Supervision	• Commit to a strong pollution prevention program at the executive level. • Closure supervision may improve productivity and reduce inadvertent waste generation. • Centralize waste management. Appoint a safety/waste management officer for each department. • Educate staff on the benefits of pollution prevention. • Establish pollution prevention goals. • Perform pollution prevention assessments.
Employee Participation	• Incorporate every phase of the business and involve every department in pollution prevention. • "Quality circles" (free forums between employees and supervisor) can identify ways to reduce wastes. • Solicit and reward employee suggestions for waste reduction ideas.
Production Scheduling/ Planning	• Maximize batch size to reduce clean out waste. • Dedicate equipment to a single product. • Alter batch sequencing to minimize cleaning frequency (e.g., light to dark bath sequence).

GOOD OPERATING PRACTICE	PROGRAM INGREDIENTS
Cost Accounting/ Allocation	• Charge direct and indirect costs of all air, land and water discharges to specific processes or products. • Allocate wastes treatment and disposal costs to the operations that generate the wastes. • Allocate utility costs to specific processes or products. • Require pre-approval for all capitol and property acquisition plans involving chemical use or potential discharges.

Sources:

- Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.
- Fact Sheet: Waste Reduction for the Aerospace Industry, CA DHS Alternative Technology Division, August 1989.

Pollution Prevention Options
For All Industries

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Materials Receiving	Tank Bottoms Off-spec Materials Excess Materials Spill Residues Leaking Pumps Valves Tanks Pipes Damaged Containers Empty Containers	• Use "Just in Time" ordering system (order materials on an as-needed basis). • Establish a centralized purchasing program. • Put one person in charge of ordering, checking, labeling (purchase date, contents) and issuing hazardous material. • Designate one person to accept chemical samples and return unused samples to suppliers. • Order reagent chemicals in exact amounts. • Encourage chemical suppliers to become responsible partners (e.g., accept outdated supplies). • Establish an inventory control program to trace chemical from cradle to grave. • Rotate chemical stock. • Implement first-in, first-out material usage policy. • Develop a running inventory of unused chemicals for use by other departments. • Inspect/test material before accepting a shipment. • Review material procurement specifications. • Mark purchase date on containers and use older material first. • Validate shelf-life expiration dates. • Test effectiveness of outdated material. • Eliminate shelf-life requirements for stable compounds. • Conduct frequent inventory checks. • Use computer-assisted plant inventory system. • Conduct periodic materials tracking. • Properly label all containers. • Set up staff control points to dispense chemicals and collect wastes. • Use dry or damp cleanup methods for spills or leaks where possible (e.g., use broom instead of hose).

Materials Receiving continued		• Buy pure feeds. • Find less critical uses for off-spec material (that would otherwise be disposed). • Purchase supplies in bulk and keep in bulk dispensers. • Change to reusable shipping containers. • Switch to less hazardous raw material. • Use high-performance, longer lasting raw materials (e.g., oils) consistent with manufacturer's instructions. • Reduce number of different brands and grades of chemicals. • Use one multi-purpose solvent or cleaning chemical rather than several different solvents. • Where possible, use suppliers who provide fresh materials and accept used materials for recycling. • Use recycled and recyclable product. • Use drums that can be rinsed or recycled.

Raw Material and Product Storage		• Establish Spill Prevention, Control and Countermeasure (SPCC) plans. • Use properly designated tanks and vessels only for the intended purposes. • Install overflow alarms for all tank and vessels. • Maintain physical integrity of all tanks and vessels. • Install leak detection systems in storage tanks. • Set up written procedures for all loading/unloading and transfer operations. • Install secondary containment areas. • Instruct operators to not bypass interlocks, alarms, or specifically alter set points without authorization. • Isolate equipment or process lines that leak or are not in service. • Use seal-less pumps. • Use bellows-seal valves. • Use a gravity spigot or pump to reduce spills when dispensing bulk liquids. • Always use a spout and funnel when transferring liquids. • Use drip-catchers. • Use dry clean-up methods for spills whenever possible. • Document all spillage so you can take precautionary measures in the future. • Perform overall materials balances and estimate the quantity and dollar value of all losses. • Use double-seal floating-roof tanks for VOC control. • Use conservation vents on fixed roof tanks. • Use vapor recovery (vapor balance) systems. • Store products in locations/under conditions that will preserve their shelf life. • Keep tight fitting lids and bungs on containers (even 'empties.') • Store containers in such a way as to allow for visual inspection for corrosion and leaks. • Stack containers in a way to minimize the chance of tipping, puncturing, or breaking. • Store packages, etc., properly to prevent damage or contamination. Protect items stored outdoors from temperature extremes, rain, snow, wind, etc. • Prevent concrete "sweating" by raising the drum off storage pads (e.g., on pallets). • Maintain Material Safety Data Sheets to ensure correct handling of spills. • Provide adequate lighting in the storage area. • Maintain a clean, even surface in transportation areas. • Keep aisles clear of obstructions.

Raw Material and Product Storage, continued		• Maintain distance between incompatible chemicals. • Maintain distance between different types of chemicals to prevent cross-contamination. • Avoid stacking containers against process equipment. • Follow manufacturer's suggestions on handling and use of all materials. • Use proper insulation of electrical circuitry and inspect regularly for corrosion and potential sparking. • Use large containers for bulk storage whenever possible. • Use containers with height-to-diameter ratio equal to one to minimize wetted area. • Tightly seal all bungs and lids (for empty or full containers). • Empty drums and containers thoroughly before cleaning or disposal. • Reuse scrap paper for note pads; recycle paper.
Laboratories	Reagents Off-spec Chemicals Samples Empty Sample and Chemical Containers	• Use micro or semi-micro analytical techniques. • Increase use of instrumentation. • Reduce or eliminate the use of highly toxic chemicals in laboratory experiments. • Reuse or recycle spent solvents. • Recover metal from catalysts. • Treat or destroy hazardous waste products as the last step in experiments. • Keep individual hazardous waste streams segregated, segregated hazardous wastes from non-hazardous wastes; segregate recyclable wastes from non-recyclable wastes. • Assure that the identity of all chemicals and wastes are clearly marked on all containers. • Investigate mercury recovery and recycling.

Operation and Process Changes	Solvents Cleaning Agents Degreasing Sludge Sandblasting Waste Caustic Scrap Metal Oils Greases from Equipment Cleaning	• Maximize dedication of process equipment. • Use squeegees to recover residual fluid on product prior to rinsing. • Use closed storage and transfer systems. • Provide sufficient drain time for liquids. • Line equipment to reduce fluid hold-up. • Use cleaning system that avoids or minimizes solvents and clean only when needed. • Use two-stage rinsing, or wipe dirty parts with rags prior to rinsing to extend life of solvents. • Use countercurrent rinsing. • Use clean-in-place systems. • Clean equipment immediately after use. • Reuse clean-up solvent. • Reprocess clean-up solvent into useful products. • Segregate wastes by solvent usage. • Standardize solvent usage. • Reclaim solvent by distillation. • Schedule production to lower cleaning frequency. • Use mechanical wipers on mixing tanks. • Use bench scale testing for samples rather than in process baths.
Operation and Process Changes	Sludge and Spent Acid from Heat Exchanger Cleaning	• Use bypass control or pumped recycle to maintain turbulence during turndown. • Use smooth heat exchange surfaces. • Use on-stream cleaning techniques. • Use high-pressure water cleaning to replace chemical cleaning where possible. • Use lower pressure stream.

Sources:

- Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.
- Best Management Practices for Automotive Related Industries, Santa Clara Valley Pollution Control Program, CA.
- Waste Reduction for Metal Finishers, Fact Sheet, California Dept. of Health Services, Alternative Technology Division, 4/90.
- Office of Waste Reduction Fact Sheet: Photoprocessors, Washington State Dept. of Ecology, 11/88.

Pollution Prevention Options for the Aerospace Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Metal Surface Finishing and Plating	Cutting Oils and Fluids Dye Penetrants Solvents Spent Process Baths Sludges Rinse Water	• Replace cutting oils with water-soluble coolants. • Convert to water-based cutting fluids. • Separate dye penetrants from water. • Consider ultrafiltration for water/organic mixtures. • Phase out 1,1,1 trichloroethane and flammable solvents and convert to water based cleaners. • Implement metal recovery with state-of-the-art ion exchange. • Implement electrochemical extraction of heavy metals from water.
Printed Circuit Board Fabrication	Spent Process Baths Sludges Rinse Waters	• Substitute drip pans for rinse tanks. • Extend chemical process bath replacement period through filtration, analysis and maintenance. • Introduce low water demand spray rinses on conveyorized processes. • Provide direct recovery of copper sulfate from etch/strip processes by cooling and crystallization. • Replace common chemical precipitation with electrochemical reduction processes. • Reduce chemical oxidation demand loading of sewer by changing manufacturing process chemistries. • Replace electrochemical reduction with ion exchange, crystallization, and heavy metal extraction/recovery through electrodeposition techniques.
Electronic and Final Assembly	Solvents Coolant and Oils VOC Emissions Shelf-Life Expired Materials	• Utilize in-line solvent recovery on CFC-113 vapor degreasing. • Extend solvent life by using molecular sieve and GC-MS analysis to avoid unnecessary additions of solvent. • Implement recycling of glycol coolants and hydraulic oil. • Change to low VOC coating operations. • Install centralized chlorinates solvent recovery system. • Implement shelf-life sensitive material reduction program.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Details Part Painting	Waste Paint Waste Solvent VOC Emissions Waste Abrasive	• Convert to water-based primers. • Convert to low-volatility paints and solvents. • Use proportional mixers for multi-component paints. • Eliminate all water wall spray booths by using fiber or deep bed-air filters. • Use plastic beads for paint stripping. • Use electrostatic paint application methods. • Use powder-coating systems. • Use low-solvent topcoat paints. • Install solvent recovery system for waste paints and sludges. • Install oxidative destruction system for volatile emissions.
Machine Shop	Cutting Oils and Fluids Dye Penetrants Solvents	• Replace cutting oils with water-soluble coolants. • Convert to water-based cutting fluids. • Separate dye penetrants from water. • Consider ultrafiltration for water/organic mixtures. • Phase out 1,1,1 trichloroethane and flammable solvents and convert to water-based cleaners.

Source: Fact Sheet: Waste Reduction for Aerospace Industry, CA DHS Alternative Technology Division, August 1989.

Pollution Prevention Options for Automotive Refinishing

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Body Repair	Filler Waste Sand Dust	• Control inventory rigidly to minimize Bondo use. • Sweep or vacuum up; don't flush to street or clarifier.
Painting (Application)	Paint Waste Spent Solvent VOC Emissions	• Control inventory rigidly to reduce thinner use. • Practice better housekeeping to reduce leaks and spills. • Mix paint according to need. • Use high transfer efficiency equipment (e.g., equipment with low overspray). • Keep air pressure low and spray gun perpendicular to increase accuracy. • Provide operator training. • Practice proper equipment cleaning methods. • Use fully enclosed gun-cleaning station. • Reuse clean-up solvent in next compatible batch of paint. • Recycle solvent on-site. • Recycle solvent off-site by means of thinner leasing agreements. • Contact waste exchanges. • Make leftover paint available to customer. • Use recyclable paint filters. • Use Styrofoam filters.
Paint Stripping	Solvents Paint	• Avoid unnecessary overspray. • Clean equipment regularly. • Use mechanical paint stripping system such as plastic blast media. • Use non-phenolic or non-acid stripper.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Shop Cleanup	Out-dated Supplies	• Computerize inventory control: use first in, first out policy. • Minimize storage quantities. • Perform routine storage are inspections.
	Dirty Rags Sawdust	• Use good housekeeping measures to reduce leaks and spills. • Lease rags from a laundry cleaning service. • Use rags/absorbents to their limit.
	Alkaline Floor Cleaner	• Use good housekeeping measures to reduce spills and leaks such as award program for worker with cleanest bay. • Use drip trays under leaking cars and removed parts. • Properly store waste materials (use pallet/containment systems and install self-closing non-leak safety faucets on portable waste oil drums).
	Clarifier Sludges	• Use good housekeeping measures to reduce leaks and spills. • Don't flush dust or floor sweeping to clarifier unit.

Sources:

- Guides to Pollution Prevention: The Automotive Repair Industry, US EPA, October 1991, EPA/625/7-91/013
- Guides to Pollution Prevention: The Automotive Refinishing Industry, US EPA, October 1991, EPA/625/7-91/016

Pollution Prevention Options for Automotive Repair Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Shop Cleanup	Out-dated Supplies	• Computerize inventory control; use first in, first out policy. • Minimize storage quantities. • Perform routine storage area inspections.
	Dirty Rags Sawdust	• Use good housekeeping measures to reduce leaks and spills. • Lease rags from a laundry cleaning service.
	Alkaline Floor Cleaner	• Use good housekeeping measures to reduce spills and leaks such as award program for worker with cleanest bay. • Use drip trays under leaking cars and removed parts. • Properly store waste materials (use pallet/ containment systems and install self-closing non-leak safety faucets on portable waste oil drums).
	Clarifier Sludges	• Use good housekeeping measures to reduce leaks and spills. • Use water based pressure steam cleaners with a clarifier instead of solvent based cleaning systems. • Don't flush dust or floor sweepings to clarifier unit.

Parts Cleaning	Solvent Baths Air Emissions Carburetor Cleaner	• Minimize surfaces exposed to grease and oil. • Determine how clean parts need to be. • Use less hazardous solvents (e.g., water-based binders). • Increase cleaning efficiency. • Use liquid spray compositions rather than bars for better control. • Pre-rinse parts using hot tank or jet spray washers. • Use enclosed parts washers with filters that use hot water and detergents. • Use solvents properly (e.g., don't use to clean floors). • Minimize amount of cleaning solution used. • Monitor solvent composition. • Operate solvent sinks properly, keep plugged when not in use. • Use drip trays and allow for more drainage time. • Keep lids closed when not in use. • Don't leave solvent stream running. • Contract with service company to maintain solvent sinks. • Install on-site solvent recovery equipment. • Use re-formulated carburetor cleaner compound without 1,1,1 trichlororethane. • Use drip pans to collect excess cleaning fluids and drains into containers to allow particles to settle out; then reuse.
Parts Cleaning	Aqueous Baths	• Switch from caustic to detergent-based cleaning solutions. • Install lids on tanks. • Use dry pre-cleaning methods such as wire brushing. • Maintain solution quality by monitoring composition. • Maintain equipment in proper working order. • Filter solids from the bath on a continuous basis. • Use filter bag on slipstream from jet spray washes. • Screen solids before they reach the waste sump. • Employ two-stage parts cleaning sequence. • Install or convert free running rinses to still rinse. • Use a hot tank or jet spray washer lease service. • Switch to bake-off ovens (e.g., high temperature ovens used with dry abrasive "shot blast" cleaners).

Automotive Maintenance	Spent Fluid (Oil, Coolant, Transmission	• Segregate to promote potential for recycling (e.g., store used oil in separate oil storage tank, don't contaminate it with

	Fluids)	degreasers or absorbents). • Use recyclable brand of radiator fluid; collect flushing liquid and reuse. • Use brake fluid, transmission fluid, etc., which do not contain chlorinated hydrocarbons. • Install collection/drip pans under vehicles.
	Rebuildable Parts	• Give or sell to a parts manufacturer.
	Batteries	• If unbroken, sell batteries to an off-site recycler. • Use longer-life batteries.
	CFC-12	• Purchase state and locally approved recycling equipment to recover refrigerant (e.g., an airtight machine that collects refrigerant as liquid; then reuse on site or recycle off-site).
	Catalytic Converters	• Recycle for precious metal recovery.

Sources:

- Guides to Pollution Prevention: The Automotive Repair Industry, U.S. EPA, October 1991, EPA/625/7-91/013
- Best Management Practices for Automotive Related Industries, Santa Clara Valley Pollution Control Program, CA.
- Preventing Pollution in the Auto Repair Business, Spring 1992.

Pollution Prevention Options for Chemical Manufacturers

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Material Input, Storage and Handling	Shelf-life Expired, Obsolete, or Contaminated Materials Reacted/Polymerized or Off-spec Chemicals Dust Emissions Empty Containers Tanker Heels	• Control inventory with "first in, first out" material usage policy. • Test materials first to determine whether they can be used in current manufacturing processes. • Return obsolete materials to suppliers. • Segregate waste streams. • Store packages to protect from weather. • Improve quality of feed by working with suppliers or installing purification equipment. • Re-examine the need for each raw material (e.g., reduce or eliminate by modifying process and improving control). • Use off-spec material. • Use inhibitors to prevent unwanted side reactions or polymer formation. • Reformulate products from powder to pellet. • Reuse inert ingredients when flushing solids handling equipment. • Switch to reusable containers, tote-bins or bulk shipments. • Recover product from tank cars and tank trucks. • Use pumps and piping systems to transfer liquids.
Reactors	Off-spec Materials By-products	• Improve physical mixing in reactor by installing baffles, high rpm motor for agitator, different mixing blade design, multiple impellers, pump re-circulation or an in-line static mixer. • Distribute feeds better for better yield conversion, both inlet and outlet. • Improve ways reactants are introduced into reactor (perfect ideal reactant concentrations before feeds enter reactor). • Improve catalyst and continuously upgrade. • Provide separate reactor for recycled streams. • Improve heating and cooling techniques for reactor. • Consider different reactor design (e.g., plug flow instead of stirred-tank back mix). • Improve control to maintain optimal conditions in reactor (e.g., stabilize conditions in operation frequently, use advanced computer controls). • Ensure that rubber gaskets are not cracked or worn.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS

Heat Exchangers	Off-spec Product (e.g., temperature sensitive)	• Reduce tube-wall temperature:
		  • Use lower pressure steam;
		  • De-superheat steam;
		  • Install thermocompressor.
		• Use staged heating (waste heat, then low-pressure steam, then de-superheated high-pressure steam).
		• Use on-line cleaning techniques (recirculation sponge balls and reversing brushes).
		• Use scraped-wall exchanger for viscous streams.
		• Monitor exchange fouling.
		• Use non-corroding tube.

Pumps		• Recover seal flushes and purchase and recycle to process where possible. • Use seal-less pumps (can type or magnetically driven).
Furnaces		• Replace coil, investigate alternative designs. • Replace furnace with intermediate exchanger; use high temperature transfer fluid. • Use existing steam superheat.
Distillation Column	Impure Product Polymerized Waste Vented or Flared Products	• Increase reflux ratio if column capacity is adequate. • Add section to column (e.g., with different diameter, trays, high efficiency packing). • Retray or repack column. • Change feed tray for better separation. • Insulate. • Improve feed distribution, especially for packed column. • Preheat column feed (e.g., by cross exchange with another stream). • Remove overhead products from tray near top of column. • Increase size of vapor line. • Modify re-boiler design (falling film or pumped re-circulation re-boiler, high flux tubes). • Reduce re-boiler temperature (e.g., using lower pressure steam, de-superheated steam, installing thermocompressor, using intermediate transfer fluid). • Ensure that tubes are not blocked. • Lower column pressure. • Improve overhead condensers (retubing, condenser replacement, and supplemental vent condenser addition). • Forward vapor overhead to next column (use partial condenser and introduce vapor stream to downstream column).

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Piping	Leaks and Volatile Emission By-Products Emissions Degraded Product	• Replace leaking valves, pumps and seals. • Monitor major vents (storage tanks, tankers) and flare system and recover vented products (install condenser or vent compressor). • Avoid sending hot materials to storage. • Change metallurgy or use lining. • Avoid overheated lines, vessel tracing and jacketing. • Segregate wastes and recover.
Processing, etc.	Off-spec Product Contaminated Product Spills Dust Emissions Evaporative Loss Samples from Quality Control Testing	• Produce only the amount requested or needed. • Substitute less toxic or non-toxic raw materials. • Improve on-line control (e.g., with computer control system). • Optimize daily operation. • Automate start-ups, shutdowns and product changeover. • Program plant to handle unexpected upsets and trips. • Relocate process equipment and change piping configuration to avoid contamination from other sources. • Find a market for waste product. • Install reusable insulation. • Redesign or modify processes and technologies to recover product and unconverted raw materials. • Reformulate products (e.g. prepare chemicals in pellet form instead of powder to reduce dust emissions). • Segregate and reuse dust emissions in the production process. • Shift from batch manufacturing to continuous manufacturing. • Regenerate catalysts. • Review sampling frequency and procedure to reduce number and quantity. • Recycle samples. • Consider diversion into neutralization tanks if disks rupture on the reactor.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Cleaning and Changeover	Waste Product Spent Cleaners Rinse Water	• Maximize equipment dedication. • Improve scheduling of production of chemicals that use the same production line. • Recover more product (e.g., through scraping down tanks, pigging or blowing lines). • Reuse inert ingredients when flushing solids handling equipment. • Avoid unnecessary equipment cleaning; explore feasibility of eliminating cleaning step between batches. • Consider alternative cleaning methods (mechanical cleaning such as plastic media blasting). • Consider less hazardous cleaners (e.g., ultrasonic cleaning with more biodegradable cleaner). • Standardize cleaning products used. • Use less cleaner (by using high pressure sprays, pressurized air, steam and heated cleaning bath etc). • Reclaim and reuse cleaner if feasible. • Reuse rinse water. • Clean process equipment with process fluids if possible.

Sources:

- Chemical Manufacturing: Pollution Prevention Opportunities Checklist, Industrial Waste Section, County Sanitation Districts of L.A. County, Whittier, CA, 12/90.
- "Use These Ideas to Cut Waste," Hydrocarbon Processing, Ken Nelson, Dow Chemical USA, March 1990.
- Fact Sheet: Pollution Prevention: Strategies for Chemical Production, Center for Hazardous Materials Research, Pittsburgh, PA.

Pollution Prevention Options
For the Coating Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Coating/ Application	Coating material that fails to reach object being coated (overspray) Solvent Emissions	• Pre-inspect parts to avoid coating obvious rejects. • Re-examine the need for coating, as well as available alternatives. • Use longer-lasting plastic coatings instead of paint. • Use high-solids coating formulations. • Use powder coatings. • Use water-based coating formulations. • Use radiation-curable (UV or IR) coating formulations. • Maintain 50% overlap between spray pattern. • Maintain six to eight inch distance between spray gun and work piece. • Maintain gun speed of about 250 feet/minute. • Hold gun perpendicular to surface. • Trigger gun at beginning and end of each pass. • Properly train operators. • Use robots for spraying. • Avoid excessive air pressure for coating atomization. • Use electrostatic spray systems. • Use turbine disk or bell air-assisted airless spray guns in place of air-spray guns. • Make sure spray gun air supply is free of water, oil and dirt. • Install on-site paint mixers to control material usage. • Recycle overspray. • Keep solvent soak tanks away from heat sources. • Control bake oven temperature.
Stripping (Coating Removal from Parts before Applying a New Coat)	Spent Stripper Waste Abrasives	• Avoid adding excess stripper. • Use spent stripper as rough pre-strip on next item. • Use abrasive media paint stripping. • Use plastic media bead-blasting paint stripping. • Use cryogenic paint stripping. • Use thermal paint stripping. • Use wheat starch media blasting paint stripping. • Use laser or flash lamp paint stripping.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Clean-up	Solvents Cleaning Waste	• Use light-to-dark batch sequencing. • Produce large batches of similarly coated objects instead of small batches of different coated objects. • Isolate solvent-based paint spray booths from water-based paint spray booths. • Reuse cleaning solution or solvent. • Standardize solvent usage. • Clean coating equipment after each use.

Source: Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.

Pollution Prevention Options
For the Dry Cleaning Business

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Chemical Storage	Solvent Emissions	• Tightly seal bungs and lids on containers. • Properly label containers. • Use spigots or pumps to dispense new materials. • Use funnels when transferring wastes to storage containers
Dry Cleaning	Spent Solvents Solvent Emissions Sludges Machine Lint & Dust Spent Cartridge Filters Solvent Contaminated Rags	• Regularly replace gaskets/seals on dryer dampers, deodorizers and aeration valves. • Inspect equipment for leaks from gasket and hose couplings, flanges, pumps. • Replace faulty or worn gaskets on button trap and around cleaning machine door. • Adjust in-and-out condensing coil temperatures to within 10 degrees F of each other. • Check air vents for drippage. • Check air relief valves for proper closure. • Repair holes in air and exhaust ducts. • After a filter change, check gaskets and sealing of new filter. • Monitor equipment efficiency (e.g., pounds of clothes cleaned per drum of solvent). • Size loads (neither over nor under-loading) to maximize solvent efficiency. • Make sure cycle is complete before removing clothes from dryer; do not hang-dry clothes. • Clean lint screens regularly to avoid clogging fans and condensers. • Open button traps and lint gaskets only long enough to clean. • Substitute low temperature laundering for dry cleaning for applicable fabrics. • Redesign separator with baffles and decant traps. • Only allow batch discharge of decant water from separator after visual inspection. • Consider using some separator water as a pre-spotter. • Consider a refrigerated "dry-to-dry" unit to replace a wet-to-dry unit to avoid solvent loss in the transfer process. • Steam out carbon absorber frequently and allow carbon bed to dry completely before reuse.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Dry Cleaning, Continued	Spent Solvents Solvent Emissions Sludges Machine Lint & Dust Spent Cartridge Filters Solvent Contaminated Rags	• Recover solvents from filter cartridges by draining the filters (24hrs.) and heating/stripping the cartridges to vaporize and capture additional solvent. • Install or retrofit a solvent recovery system (either carbon adsorption, refrigeration/condenser). • Add water to still bottoms before final boil down to recover additional solvent. • Install solvent leak detectors. • Check with equipment and solvent suppliers for tips on reducing solvent loss.

Sources:

- Preventing Pollution in the Dry-cleaning Business, Fall 1991, U.S. EPA
- Hazardous Waste Reduction Facts: Commercial Dry Cleaners, City of Santa Monica, Dept. of General Services.
- Dry Cleaning Industry Pollution Prevention Option Checklist (WP, Cleaner, Manual), Industrial Waste Section, County Sanitation Districts of L.A. County, Whittier, CA (9/90).

Pollution Prevention Options for the Fabricated Metal Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Machining	Metal Working Fluid	• Use high-quality metal working fluid. • Use demineralized water make-up. • Perform regularly scheduled sump and machine cleaning. • Perform regularly scheduled gasket, wiper and seal maintenance. • Filter, pasteurize and treat metal working fluid for reuse. • Switch to synthetic fluids. • Use a gas coolant for certain applications instead of liquid. • Assign fluid control responsibility to one person. • Standardize oil types used on machining equipment. • Improve equipment scheduling or establish dedicated lines. • Reuse or recycle cutting, cooling and lubricating oils (skimming, coalescing, hydrocloning, centrifuging, pasteurization, downgrading, filtration, dissolved air flotation). • Substitute insoluble borates for soluble borate lubricants. • Reuse high performance hydraulic fluids that no longer meet spec for less stringent spec cutting oils.
Machining	Metal Wastes Dust Sludge	• Segregate and reuse scrap metal.
Parts Cleaning	Solvents	• Install lids/silhouettes on tanks. Cover tanks when not in use. • Increase freeboard space on tanks. • Install freeboard chillers on tanks. • Use less toxic solvents (e.g., dibasic acid esters, terpenes, amines, alcohols). • Standardize type of solvent used in all operations. • Replace solvents with aqueous cleaners. • Replace solvents with mechanical or thermal alternatives (e.g., air blast systems, dry stripping and cleaning with blasting media). • Substitute less hazardous solvent degreasers (e.g., petroleum solvents instead of chlorinated solvents) or alkali washes where possible.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Parts Cleaning, continued	Solvents	• Consolidate cold cleaning operations into centralized vapor degreasing operation. • Locate cold cleaning tanks away from heat sources. • Locate cold cleaning tanks away from drafts, fans, windows or use baffles. Air flow over tanks should not exceed 131 ft/minute. • Control the amount of heat supplied to vapor degreasers. • Install safety limit switches (condenser flow switch and shut-off device for sump heat and a spray safety switch). • Avoid spraying parts above the vapor zone or cooling jacket. • Avoid solvent vapor drag-out by controlling speed of withdrawal (< 11 ft/minute). • Cross-sectional area of workload should not exceed 50% of tank's open area. • Avoid cross-contamination of solvents (e.g., 1, 1, 1 trichloroethane and trichloroethylene). • Avoid water contamination. • Use appropriate make-up solutions for solvent bath. • Remove sludge from solvent tanks frequently. • Extend solvent life by pre-cleaning parts by wiping, using air blowers, or pre-dipping in cold mineral spirits dip. • Reclaim or recover solvent on- or off-site (gravity separation, filtration, distillation, fuel use). • Distribute parts on rack to allow good cleaning and minimize solvent hold-up. • Slow speed of parts removal from vapor zone. • Rotate parts to allow condensed solvent drop-off.
Parts Cleaning	Aqueous Cleaners	• Remove sludge frequently. • Use dry cleaning and stripping methods (e.g., sand or bead blasting). • Use oil separation and filtration to recycle solution
Parts Cleaning	Abrasives	• Pre-clean work pieces. • Use grease-less or water-based binders. • Use an automatic liquid spray system for application of abrasive onto wheel. • Ensure sufficient water use during cleaning by using water level control. • Use synthetic abrasives. • Use re-usable blasting media.
Parts Cleaning	Rinse Water	• Improve rack and barrel system design and operation. • Use water spray, fog nozzle, or chemical rinses. • Use de-ionized water make-up. • Reuse second rinse as primary rinse or as makeup for cleaning solutions. • Agitate rinse bath or part.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Case Hardening	Spent Packing Spent Nitriding and Cyanide Baths	• Employ gas carburizing • Employ gas nitriding.
Surface Treatment and Plating	Process Solutions	• Increase solution life (e.g., with proper design and maintenance). • Control viscosity and surface tension. • Use material or process substitution (e.g., trivalent chromium instead of hexavalent; chemical vapor deposition). • Use low solvent paint for coating. • Use mechanical cladding and coating. • Use cleaning baths as pH adjusters. • Recover metals from process solutions.

Surface Treatment and Plating	Rinse Water	• Reduce drag-out of process chemicals:
		  • Reduce speed of withdrawal;
		  • Allow ample drainage time;
		  • Install drip bars;
		  • Mechanize dragout;
		  • Lower plating bath concentrations;
		  • Reuse rinse water;
		  • Use surfactants to improve drainage;
		  • Increase solution temperature to reduce viscosity;
		  • Position work piece to minimize solution hold-up (e.g., orient surface as close to vertical as possible, rack with longer dimension of work piece horizontal, rack with lower edge tilted slightly from horizontal so run-off is from corner, reduce pockets on parts);
		  • Improve drag-out recovery (e.g., with drain board/drip tank/still rinse tank).
		• Practice metal recovery and water reuse (e.g., evaporation, reverse osmosis, ion exchange, electrolytic recovery, electrodialysis).
		• Consider in system design:
		  • Rinse tank design;
		  • Multiple rinsing tanks;
		  • Conductivity measurement to control rinse water flow;
		  • Fog nozzles and sprays;
		  • Automatic flow controls;
		  • Rinse bath agitation;
		  • Countercurrent rinse.
		• Install foot pump; or photosensor to activate rinse on automatic plating lines.
		• Install bath filter (type which can be unrolled, cleaned and reused) to remove contaminants.
		• Use no-rinse coatings.

Sources:

- Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/r-92/088.
- Guides to Pollution Prevention: The Fabricated Metal Product Industry, U.S. EPA, July 1990, EPA/625/7-90/006.
- Metal Fabricators: Pollution Prevention Opportunities Checklist, Industrial Waste Section, County Sanitation Districts of L.A. County, Whittier, CA.

Pollution Prevention Options for The Fiberglass-Reinforced Composite Plastics Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Raw Material Purchasing And Unloading	Rejected and Excess Raw Material	• Improve inventory control. • Purchase material in smaller containers. • Purchase drums that are returnable or have plastic liners. • Return unused materials to suppliers.
Fabrication	Gelcoat Resin and Solvent Overspray	• Test batch formulation in lab. • Change spray delivered systems (spray re-orientation and equipment modification like air-assisted technology). • Use non-spray resin application methods (e.g., pre-spray fiber reinforcing, in-house resin impregnation, resin roller dispenser, vacuum bag molding processes, closed mold systems).
Curing	Air Emissions	• Improve or modify material application. • Cover solvent containers • Use emulsions or less volatile solvents
Piping and Treater Pan at End of Run	Scrap Solvated and Partially Cured Resins	• Modify resin pan geometry (no more than 10" wider than fabric). • Reduce transfer pipe diameter size.
Equipment Cleaning	Solvents	• Maximize production runs; schedule together to reduce need to clean equipment during batches; schedule families of products in sequence to reduce cleanup between batches. • Clean equipment before resin dries. • Restrict solvent issue. • Replace solvents with emulsifiers. • Use less toxic and less volatile substitutes (biodegradable, water-soluble, resin bed compatible, recoverable). • Reduce rinse solvent usage. • Use small lab-type wash bottles or squeegees for treater pan cleanouts. • Use two-stage cleaning process (first rinse with dirty solvent, then rinse with fresh solvent). • Keep water out of solvents. • Segregate wastes. • Store and reuse cleaning wastes. • Recover on-site.

WASTE ORIGINS	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Clean-up	Resin and Solvent Contaminated Floor Sweepings	• Use recyclable floor sweeping compound. • Reduce solvent and resin spillage and overspray by employing alternate material application and fabrication techniques.

Source: Guides to Pollution Prevention: The Fiberglass-Reinforced and Composite Plastics Industry, U.S. EPA, October 1991, EPA/625/7-91/014.

Pollution Prevention Options for the Marine Maintenance and Repair Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Paint Stripping	Waste Paint Stripper	• Substitute blasting for chemical stripping. • Use non-toxic or less toxic strippers (non-chlorinated, biodegradable, less volatile). • Use better operating practices (e.g., allow dipped parts to drain longer above dip tanks). • Segregate wastes. • Collect, properly store and reuse stripper. • Recycle stripper (e.g., centrifuge or filter).
Blasting	Abrasives Paint	• Use alternate blasting media and techniques (e.g., plastic media blasting, water jet stripping, thermal stripping, dry ice pellets, laser paint stripping, cryogenic stripping). • Segregate grit (e.g., using cyclone/air/water separators or gravity shakers) and recycle blast media. • Use blast dust collection systems.
Painting	Waste Paint Solvent	• Tighten inventory control. • Maximize use of water-based and less toxic coatings. • Use low VOC paints. • Minimize fugitive overspray through improved painting techniques (e.g., air-assisted airless; high volume, low-pressure turbine; air-atomized electrostatic; airless electrostatic application). • Segregate waste. • Reuse and recycle solvents.
Equipment and Parts Cleaning	Solvents	• Use dry pre-cleaning. • Use two-stage rinse (pre-rinse in dirty solvent). • Cover tanks. • Segregate cleaning agents. • Recycle solvents. • Replace solvent cleaners with detergents whenever possible.
Engine Repair	Degreasers Solvents Oils	• Use aqueous degreasers. • Use longer-lasting fluids. • Use dedicated solvent sinks for parts washing. Plug when not in use. • Segregate spent engine and lube oils. • Recycle oils and solvents.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Machining	Cutting and Lubricating Fluids	• Use water-soluble cutting fluids. • Recycle cutting and lubricating fluids.
Vessel Cleaning	Cleaners	• Use detergent cleaning agents
Re-fueling	Spilled fuel	• Watch the fuel tank to avoid overfilling. • Be sure fuel flow has stopped before removing the fuel nozzle from the fill pipe. • Provide a drip pan from the fuel nozzle. • Be sure the proper type of fuel is selected to avoid cross-contamination.

Source: Guides to Pollution Prevention: The Marine Maintenance and Repair Industry, U.S. EPA, October 1991, EPA/625/7-91/015.

Pollution Prevention Options for the Metal Casting Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Air Pollution Control Equipment	Baghouse Dust and Scrubber Waste Contaminated with Lead, Zinc and Cadmium	• Identify the source of contaminants (e.g., coatings on scrap) and work with supplies to find raw materials that reduce the contaminant input. • Install induction furnaces to reduce dust production. • Recycle dust to original process or to another process. • Recover contaminants with pyrometallurgical treatment, rotary kiln, hydrogen reduction or other processes. • Recycle to cement manufacturer
Production of Ductile Iron	Hazardous Slag	• Reduce the amount of sulfur in the feedstock. • Use calcium oxide or calcium fluoride to replace calcium carbide as the de-sulfurization agent. • Improve process control. • Recycle calcium carbide slag.
Casting	Spend Casting Sand	• Material substitution (e.g., silica sand is easier to detoxify than olivine sand). • Separate sand and blast dust. • Improve metal recovery from sand. • Recover sand and mix old and new sand for mold making. • Recover sand by washing, air scrubbing, or thermal treatment. • Reuse sand for construction if possible.

Source: Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.

Pollution Prevention Options for Metal Manufacturing/Finishing

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHOD
Metal Cutting or Machining	Acid/ Alkaline Heavy Metals Solvents Waste Oils	• Improve scheduling of processes that require use of varying oil types. • Standardize oil types used for machining, turning, lathing, etc. • Use Specific pipes and lines for each set of metals of processes that require specific oil. • Extend machine coolant life through use of a centrifuge and addition of biocides. • Install a second high-speed centrifuge on a machine already operating with a singe centrifuge. • Install a chip wringer to remove excess coolant on aluminum chips. • Install coolant recovery system and collection vehicles for machines not on a central coolant sump. • Use a coolant analyzer to control coolant quality. • Use an ultrafiltration system to remove soluble oils from waste streams. • Use disk or belt skimmers to remove way oil from machine coolants. • Design sumps for ease of cleaning. • In cold forming or other processes where oil is used only as a lubricant, substitute hot lime bath or borax soap for oil. • Use a stamping lubricant that can remain on the piece until the annealing process, where it is burned off. • If filtration or reclamation of oil is required before reuse, segregate used oils. • Segregate metal dust or scrap by type. • Improve housekeeping techniques to prevent cutting oils from being contaminated with solvents. • Where possible, recycle oils from cutting/marching operations. • Centrifuge oil scrap mixtures to recovery oil. • Follow-up magnet and paper filtration of cutting fluids with ultrafiltration. • Perform on-site purification of hydraulic oils using commercial "off-the-shelf" cartridge filter system. • Use continuous flow treatment system to re-generate and reuse aluminum chemical milling solutions. • Use a settling tank and a coalescing unit to recover metal working fluids.

Degreasing	Acid/Alkaline Ignitables Solvents Still Bottoms	• Only degrease parts that must be cleaned • Require employees to obtain solvent through shop foreman. • Use less hazardous degreasing agents (e.g., petroleum solvents, alkali washes). • Pre-clean parts (wipe, squeeze, or blow part with air, shot, etc.). • Use countercurrent solvent cleaning (two-stage--first cleaning with dirty solvent, second cleaning with fresh solvent). • Cold clean with recycled mineral spirits before final vapor degreasing. • Increase freeboard height on vapor degreaser above the vapor level to 75% of tank width • Cover degreaser unit (roll-type automatic covers). • Install refrigerator coils (or additional coils) above the vapor zone. • Airflow over top of degreaser should not exceed 131 ft/minute. • Rotate parts before removal from the vapor degreaser/ • Control the speed at which parts are removed (<11 ft/minute) • Install thermostatic heating controls on solvent tanks. • Add in-line filters to prevent particulate build-up. • Add automatic oilers to reduce grease accumulation. • Reuse "waste" solvents from cleaner up-stream operations in downstream, machine shop processes. • Recycle spent degreasing solvents on site using batch stills.

Pickling	Acid/Alkaline
	
	Heavy Metals
		• Increase the number of rinses after each process bath.
		• Keep the rinsing countercurrent to reduce drag-out losses.
		• Recover acids in wastewater by evaporation where possible.
		• Reduce rinse contamination via drag-out by:
		  • Slowing and smoothing removal of parts; rotating them if necessary;
		  • Using surfactants and other wetting agents;
		  • Maximize drip time;
		  • Use drainage boards to direct dripping solutions back to process tanks;
		  • Install drag-out recovery tanks to recapture dripping solutions;
		  • Use fog spray rinsing technique above process tanks;
		  • Use air knives or squeegees to wipe bath solutions off part;
		  • Change bath temperature or concentrations to reduce solution surface tension;
		• Instead of pickling brass in nitric acid, place in vibrating apparatus with abrasive glass marbles or steel balls.
		• Use mechanical scraping instead of acid solution to remove oxides of titanium.
		• For cleaning nickel and titanium alloy, replace alkaline etching bath with a mechanical abrasive system using silk and carbide pad and pressure to "brighten" metal.
		• Clean copper sheeting mechanically with rotating brush machine that scrubs with pumice.
		• Reduce molybdenum concentration in wastewater by using reverse osmosis/precipitation system.

Pickling, Continued		• Replace chromated de-smutting solution with non-chromated solutions for alkaline etch cleaning of wrought aluminum. • Change copper-bright dipping process from cyanide and chromic acid dip to sulfuric acid/hydrogen peroxide dip. • Replace caustic wire cleaner with biodegradable detergent. • Use alcohol instead of sulfuric acid to pickle copper wire. • Send used copper pickling baths to a continuous electrolysis process for regeneration and recovery. • Recover copper from bright brass dipping solutions using commercially available ion exchange system. • Recover metals from solution for resale.

Heat Treating	Acid/Alkaline Cyanide Heavy Metals Waste Oils	• When refining precious metal, maximize reaction time in gold and silver extraction process. • Replace barium and CN salt heat treating with carbonate/chloride carbon mixture or with furnace heating treating. • Replace thermal treatment of metals with condensation of saturated chlorine vapors on the surface to be heated. • Replace cyanurated salt hardening process with one using fluidized bath of nitrogen and corundum. • Recycle oil quench baths by filtering out metals. • Extend life of alkali wash by skimming oil.
Galvanizing, Anodizing, Etching	Spent baths Caustic Solutions	• Replace galvanizing processes requiring high temperature and flux with low temperature non-flux. • Regenerate anodizing and alkaline silking baths with contemporary recuperation of aluminum salts. • Regenerate caustic soda etch solutions for aluminum by using hydrolysis of sodium aluminate.

Metal Finishing and Painting Cleanup	Heavy Metals
	
	Paint Wastes
	
	Ignitable Paint Wastes
	
	Solvents
	
	Still Bottoms
		• Pre-inspect parts to prevent painting obvious rejects.
		• Avoid buying too much finishing material at one time due to short shelf life.
		• For shelf life expired items, return to manufacturer, sell or donate.
		• Sequence painting jobs (light to dark).
		• Always use proper spraying techniques.
		• Use correct spray gun for particular applications:
		  • Conventional air spray gun for thin film-build applications;
		  • Airless gun for heavy film application; air assisted airless spray gun for wide range of fluid output.
		• Ensure that spray gun air supply is free of water, oil and dirt.
		• Change from conventional air spray to electrostatic finishing system.
		• Investigate use of transfer methods that reduce material loss such as dip and flow coating, electrostatic spraying and electrodeposition.
		• Use alternative coatings such as high solid coatings, water-based coatings and powder coatings.
		• Substitute non-fuming cleaners (sulfuric acid, hydrogen peroxide) for chromic acid cleaner.
		• Substitute less toxic cleaners (trisodium phosphate, ammonia) for cyanide cleaners.
		• Use plastic bath media for paint stripping.
		• Use solvent recovery to reduce emissions of volatile organics from curing ovens.
		• Use activated carbon to recover solvent vapors, then recover solvent by steam stripping, then distill the water/solvent mixture.

Metal Finishing and Painting Cleanup continued	Solvents VOC Emissions	• Reuse solvents for the same resin system by first allowing solids to settle out of solution. • Flush equipment first with dirty solvent before final cleaning with virgin solvent, then use as paint thinner. • Use pressurized air mixture with a mist of solvent to clean equipment. • Replace water-based paint booth filters with dry filters. • To prevent spray gun leakage, submerge only front end (fluid section) of gun into solvent. • Recover solvents on-site.
Facility Cleanup	Solvents Still Bottoms	• Install collection or drip pans under machinery and lubrication operations to recover oils. • Use rags to their full oil absorbing capacity.
Electro-plating	Acid/Alkaline Cyanide Heavy Metals Plating Wastes Reactive Wastes Wastewater	• Pre-inspect parts to prevent processing of obvious rejects. • Use less toxic materials whenever possible (e.g., substitute zinc for cadmium in alkaline/saline solutions; nitric or hydrochloric for cyanide in certain plating baths, zinc chloride for zinc cyanide; replace cadmium plating with aluminum ion vapor deposition). • Use high quality raw materials. • Use process chemistries, which are recyclable. • Educate personnel on water conservation. • Use foot pump (or photo sensor for automatic lines) to activate rinse. • Install multiple rinse tanks after process baths. • Use countercurrent rinsing. • Employ countercurrent and conductivity sensor controls on rinse water. • Use static rinses after plating bath, if practical in running rinse. • Use de-ionized water in plating baths. • Reuse acid rinse effluent as influent for alkaline rinse tank. • Install flow restrictors/flow control meters. • Add wetting agents to plating baths. • Increase bath temperature. • Cover surface with blanket of polypropylene balls • Use spray or fog rinsing for non-complex part configurations. • Use reactive rinsing in nickel plating operations. • Use air agitation or work piece agitation in rinse tanks. • Change continuous treatment to batch to account for upsets in effluent levels. • Limit bath mixing to trained personnel. • Continuously filter process baths. • Monitor (pH, conductivity) and reconstitute plating bath when strength has decreased. • Use electrolytic dummying to extend bath life. • Use low concentration plating solutions.

Electro-plating continued	Acid/Alkaline Cyanide Heavy Metals Plating Wastes Reactive Wastes Wastewater	• Position parts on racks to reduce chemical pooling in pockets • Inspect plating racks for loose insulation that would cause increased dragout. • Withdraw parts slowly; lengthen dragout time. Post times to remind employees. • Install rails above plating tanks to hang work piece racks for drainage prior to rinsing. • Mechanize dragout. • Use air knives above process tanks. • Install drain boards, drip guards, drip bars between plating and rinse tanks, routing dragout to plating tank. • Use dedicated dragout tanks after process baths. • Use Kushner and Providence methods of double drag-out followed by treatment or recycling of concentrated drag-out solution. • Use electrolytic cells to recover metals from waste plating solutions. • Segregate wastewater with recoverable metals from other wastewater streams. • Recycle used rinse waters into bath makeup solutions for their respective process baths. • Recycle or reduce the toxicity of wastewater using ion exchange, reverse osmosis, electrolysis, electrodialysis with ion exchange. • Recover phosphate from aluminum bright dipping operations. • Reuse spent reagents from process baths in wastewater treatment process.

Sources:

- Pollution Prevention in Metal Manufacturing: Saving Money Through Pollution Prevention, U.S. EPA Version 1.0 (Draft), October 1989, EPA/530-SW-89-056.
- Waste Reduction for Metal Finishers: fact Sheet, California Dept. of Health Services, Alternative Technology Division, 4/90.
- Metal Finishers Pollution Prevention Opportunities Checklist, County Sanitation Districts of L.A. County, Whittier, CA, 12/90.

Pollution Prevention Options
For Metal Parts Cleaning

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
All Cleaning	Solvent Aqueous Waste	• Avoid the need to clean (e.g., shrink wrap metal parts prior to shipment). • Select the least hazardous medium for cleaning. • Maximize cleaning efficiency (e.g., remove oil contaminants prior to welding). • Segregate cleaning wastes. • Maximize recycling and reuse.

Solvent Cleaning	Spent Solvents	• Use water in place of solvents.
		• Replace solvent with aqueous cleaning medium.
		• Use emulsion cleaners.
		• Use mechanical or thermal methods.
		• Use a less toxic solvent.
		• Standardize solvent use (minimize different types of solvents used).
		• Consolidate cleaning operations into one centralized degreasing operation.
		• Maintain solvent quality:
		  • Avoid contamination (e.g., with moisture);
		  • Segregate solvents;
		  • Maintain equipment (e.g., maintain racks and barrels so as not to introduce corrosion products like rust into solvent);
		  • Monitor solvent (e.g., test and add only specific components required);
		  • Properly add to solvent (e.g., don't cross-contaminate);
		  • Promptly remove sludge; use continuous filtering.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS

Solvent Cleaning, Continued	Spent Solvents	• Increase cleaning efficiency:
		  • Employ manual brushing;
		  • Increase agitation in bath (by use of mechanical agitators; ultrasonic devices, liquid sprays, liquid jet pump-around arrangements).
		• Control evaporative losses:
		  • Select proper location for cleaning operations (e.g., free of drafts);
		  • Use lids on tanks (roll-type covers on vapor degreasers);
		  • Monitor temperature;
		  • Avoid using porous items (ropes/bags) for handling parts;
		  • Use two-stage cleaning (use dirty solvent for first stage, fresh solvent for second stage);
		  • Stage solvent usage depending on level of cleanliness needed (reuse dirty solvent for parts that do not need to get as clean).
		• Recycle solvents on-site (e.g., with gravity separation, filtration, batch distillation, fractional distillation or evaporation).

Cold Cleaning	Solvent	• Reduce drag-out
		  • Use proper racking to minimize solvent trapped in part or baskets;
		  • Increase drainage (e.g., with rest shelf, drainage holes);
		  • Install drain boards;
		  • Use countercurrent rinsing.
		• Cover when not in use.

Vapor Degreasing	Solvent	• Limit entrance and exit speeds (<11 ft/minute).
		• Limit workload size (use baskets with an area <50% of degreaser opening).
		• Avoid work shock.
		• Maintain temperature of solvent.
		• Allow sufficient time in the degreaser.
		• Spray only below the vapor zone.
		• Maintain proper solvent level in sump.
		• Minimize vapor diffusion:
		  • Check parts for excessive water contamination;
		  • Cover water separator;
		  • Check water jacket for proper water flow and temperature on outside of degreaser;
		  • Extend freeboard;
		  • Use cold traps above freeboard chillers;
		  • Locate degreasers away from drafts, windows, fans, or use baffles (airflow over tank should not exceed 131 ft/minute).
		• Cover when not in use.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS

Aqueous Cleaning	Aqueous Cleaning Solution
	
	Rinse Water
		• Use abrasives, water, or steam.
		• Use less hazardous acid or alkaline compounds.
		• Maintain solution quality:
		  • Inspect parts before cleaning;
		  • Pre-clean parts (e.g., with last rinse stage of cleaning operation, using de-mineralized water);
		  • Avoid unnecessary loading;
		  • Provide continuous heating;
		  • Properly make-up solution;
		  • Remove sludge and soils promptly;
		  • Routinely monitor cleaning solution strength;
		  • Maintain equipment (e.g., racks free from cracks, rust);
		  • Reduce drag-out.
		• Increase degree of rinsing efficiency while reducing water use:
		  • Use demineralized water;
		  • Use counterflow rinsing;
		  • Use spray rinsing;
		  • Install fog nozzles.
		• Employ closed loop systems:
		  • Use a synthetic fiber fume filter to recover acid vapors;
		  • Use indirect heating and agitation;
		  • Employ multi-stage countercurrent rinsing sequence;
		  • Use cooling or evaporative crystallizer (to recover ferrous sulfate from spent H_2SO_4 baths).
		• Dry parts properly (e.g., automated drying ovens).

Abrasive Cleaning	Abrasives	• Use grease-less or water-based binders for buffing or polishing • Use liquid spray compositions. • Control water level in mass finishing equipment.

Source: Waste Minimization in Metal Parts Cleaning, U.S. EPA, August 1989, EPA/530-SW-89-049.

Pollution Prevention Options for Paint Manufacturers

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Unloading Materials into Mixing Tanks	Leftover Raw Materials Containers	• Purchase pre-weighed hazardous materials. • Test raw materials before accepting from supplier. • Install high level shutoff and flow totalizers with cutoff. • Purge pipelines before disconnecting when filling tanks. • Use reusable/recyclable drums with liners
Unloading Pigment	Pigment Dusts Leftover pigment in packages	• Use non-hazardous pigments. • Use non-mercury bactericides (for solvent-based paints). • Use paste/slurry form pigments. • Use high solids formulations. • Modify bulk storage tanks (e.g., use conservation vents, floating roof, nitrogen blanketing, refrigerator condensers, lean-oil or carbon absorbers, vapor compressors). • Install dedicated baghouse systems. • Segregate waste pigments so they can be reworked. • Use water soluble bags and liners. • Use recyclable/lined/dedicated containers.
Color Matching	Off-spec Material	• Blend into new products. • Test batch formulation in lab. • Sell at a discount.
Grinding and Mixing	Spills Off-spec Paint	• Increase use of automation. • Use appropriate clean-up methods. • Recycle back into process. • Implement better operating practices.
Filtering	Spent Filter Cartridges and Bags	• Use as small a cartridge as possible. • Use bag or metal mesh filters. • Reuse filter bags. • Improve pigment dispersion. • Increase dedication of filling units.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Cleaning	Waste Rinse Water Waste Solvent Paint Sludge	• Schedule production to minimize need for cleaning (e.g., light to dark batch sequencing). • Increase size of production run. • Avoid unnecessary cleaning. Explore feasibility of eliminating cleaning steps between batches. Disperse pigments only before a batch formulation. • Prevent paint from drying in tanks. • Clean equipment immediately before paint dries. • Use mechanical wipers on mix tanks. • Use high pressure wash systems. • Use efficient nozzles. • Install more efficient mills that would not require multi-pass dispersions. • Install Teflon liners on mix tanks. • Use foam/plastic "pigs" to clean lines. • Use alternative cleaning agents (e.g., water-based). • Reuse equipment cleaning wastes. Collect solvent and use in next compatible batch of paint as part of formulation • Collect solvent and re-distill. • Use countercurrent rinse methods. • Increase spent rinse settling time or use de-emulsifiers on spent rinses to allow continued rinse. • Dewater sludge by filtration or centrifugation to allow continued use of cleaning solution.

Sources:

- Guides to Pollution Prevention: The Paint Manufacturing Industry, U.S. EPA, June 1990, EPA/625/7-90/005.
- Fact Sheet: Waste Reduction for Paint Formulators, CA DHS, Alternative Technology Division, December 1989.

Pollution Prevention Options for the Pesticide Applicators

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Chemical Storage	Damaged Chemicals Expired or Unusable Pesticides Spills Residuals in Containers Empty Containers/ Packages	• Buy only the amount you will use in one growing season. • Store chemicals properly: seal and close; store in original containers; protect from weather in dry, well-ventilated area. • Triple rinse all containers and empty all concentrate into sprayer tank, letting it drain thoroughly (at least 30 seconds) by adding diluent to about 1/4 volume of container, swirl thoroughly, then pour into spray tank. • Purchase chemicals in reusable, returnable containers (dedicated, "mini-bulk" containers). • Purchase chemicals in containers that can be dissolved in the tank. • Employ **Integrated Pest Management (IPM)** techniques such as: crop rotation, use disease or pest resistant crop varieties, use drought resistant cultivars; maintain plant health through proper watering, fertilization, etc.; accelerate crop maturation (e.g., through early planting); avoid excess fertilizer; mechanical cultivation; use organic/natural pest controls. IPM practices for turf include proper site selection, site preparation, grass selection, timing of seeding, fertilization, irrigation, mowing and verticutting, aerifying, and top-dressing.
Tank Filling	Waste Pesticides Spills	• Carefully calculate the volume you will use and load only this amount. • Keep the end of the fill hose above the fluid level in the spray tank to prevent back siphoning.
Application		• Substitute less toxic, less persistent, or less "leachable" pesticides. • Use well-timed spraying only as needed based on accurate pest identification. • Do remedial spraying based on field scouting. Maintain filed maps/records of previous pest problem. • Do not exceed recommended application rates. • Calibrate application equipment. • Make sure application rate is uniform over filed; avoid overlapping. • Use row banding application techniques where appropriate (e.g., corn). • Strategically spot treat where problem exists. • Avoid wind drift. • Make sure equipment is in good working order at all times; check for leaks.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Cleaning	Unused Diluted Sprays Rinse Water	• Use gravity flow system or pressure flow system for rinsing sprayer tank and lines before leaving field, spray on field boarders, row ends or back over portion of the crop as long as labeled rates are not exceeded. • Rinse before pesticide dries on walls of tank and lines.

Sources:
Chemigation Practices to Prevent Groundwater Contamination, Fact Sheet 1; Design for In-Field Sprayer Rinse System to Reduce Pesticide Waste, Fact Sheet 2; Pesticide Container Disposal, Fact Sheet 3; Disposal of Unused Pesticides, Tank Mixes and Rinsewater, Fact Sheet 4; Protecting Mountain Springs from Pesticide Contamination, Fact Sheet 6; Preventing Pesticide Pollution of Surface and Ground Water, Fact Sheet 7; Reducing Pesticides and Saving Money Using IPM, Fact Sheet 8; Protecting Ground Water from Contamination by Pesticides, Fact Sheet 10, 1988, Pesticides and Water Quality, North Carolina Agricultural Extension Service, NC.

Pollution Prevention Options for the Pesticide Formulating Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Unloading of Materials into Blending Tanks and Storage of Chemicals	Leftover Raw Materials Containers Volatile Organic Compounds Floor Spills Pesticide Dust and Scrubber Water from Air Pollution Control Equipment	• Test raw materials before accepting them from the supplier. • Use refillable bulk tote bins. • Return containers to suppliers. • Buy drums with liners versus plastic drums or bags. • Triple rinse containers • Return obsolete raw materials to supplier if possible. • Sweep floor to collect spills for product reformation. • Use dedicated dust collection systems. • Recycle dust into process that generated it. • Use automatic enclosed cut-in hoppers for bags on concentrated pesticide dust/granules. • Control bulk storage air emissions. • Store packages to prevent damage or contamination.
Formulation and Testing	Off-spec Products Lab Analysis Waste	• Practice strict quality control. • Maximize automation. • Use micro-scale glassware for lab tests. • Reformulate off-spec batches.
Filtering and Filling	Waste Filters	• Dedicate filling units. • Dedicate filter units. • Use wire screen filters. • Use bags (not cartridges). • Reuse filter bags.
Area Wash Down	Spillage Rinse Water	• Use dedicated vacuum system. • Use dry cleanup methods for liquid spills. • Use recycled water for initial cleanup. • Use impervious coating in high spillage areas.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Cleaning	Waste Sands or Clays Waste Rinse Water Waste Solvent	• Maximize production runs. • Use sequential formulation. • Maximize equipment dedication. • Avoid unnecessary cleaning. • Use wiper blades and squeegees. • Use low volume, high efficiency cleaning (e.g., high pressure spray nozzles, water knife spray nozzles, portable steam cleaners). • Use plastic or foam "pigs." • Use self-draining piping design. • Segregate, store and reuse cleaning wastes as makeup in subsequent formulations.

Sources:

- Guides to Pollution Prevention: The Pesticide Formulating Industry, U.S. EPA, February 1990, EPA/625/7-90/004.
- Fact Sheet: Waste Reduction for the Pesticide Formulating Industry, CA DHS, Alternative Technology Division, April 1990.
- Pest Control Industry: An Introduction to California's Hazardous Waste Regulations, CA DHS Toxic Substances Control Program, September 1990.

Pollution Prevention Options for The Pharmaceutical Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING OPTIONS
Unloading of Materials into Process Equipment	Containers	• Purchase pre-weighed containers. • Use bulk delivery. • Return empties to supplier. • Thoroughly empty and triple rinse with mineral water. • Use containers with recyclable liners. • Use soluble bags. • Segregate solid waste. • Collect and reuse plastic from in-house molding.
Chemical Storage Tanks, Drums	Air Emissions	• Control bulk storage air emissions (e.g., with internal floating roofs with double seals). • Use dedicated dust collectors and rework dust back into product. • Optimize fossil fuel combustion. • Use dedicated vent condensers and return condensate to source, where possible. • Maintain N2 purge rates at minimum through vapor space of agitated reactors.
Manufacturing And Lab	Spills Area Wash Down	• Use dedicated vacuum systems. • Use dry cleaning methods. • Use recycled water. • Increase automation for material handling and transfer (e.g., conveyor belts for bagged materials).
Manufacturing	Off-spec Products Outdated Products Production Materials	• Increase size of production run. • Formulate sequentially. • Maximize equipment dedication. • Material substitution where possible. • Modify or modernize processes (e.g., to control reaction parameters, increase automation). • Properly design agitator and optimize operating temperatures. • Redesign chemical transfer systems to reduce physical material losses. • Implement fugitive leak detection program (e.g., for flanges).
Solvent Extraction or Washing	Solvents	• Substitute aqueous systems where possible. • Reduce quantity of solvent used. • Regenerate/recover spent solvent on-site.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Equipment Cleaning	Waste Water	• Avoid unnecessary cleaning • Maximize number of campaigns to reduce cleaning frequency. • Use low volume, high efficiency cleansing (e.g., spray heads). • Use final rinse as pre-rinse on next cleaning cycle. • Use wiper blades and squeegees and re-work remainders into products. • Use aqueous-based cleaning solutions. • Use non-chlorinated solvents.

Source: Guides to Pollution Prevention: The Pharmaceutical Industry, U.S. EPA, October 1991, EPA/625/7-91/017.

Pollution Prevention Options for the Photoprocessing Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Raw Materials	Shelf-life Expired or Off-Spec Chemicals	• Control inventories of processing chemicals so they are used before their expiration dates. • Store away from heat and light.
	Off-Spec Paper	• Store paper at cool temperature. • Recover silver.
	Excess Film	• Switch to silver-less film (vesicular, diazo or electrostatic) • Recover silver.
	Cartridges, Cassettes and Spools	• Recycle to film manufacturer.
Processing	Defective Proofs	• Install meters (e.g., densitometer) on cameras to ensure good proofs the first time.
	Contaminated Process Baths	• Avoid mixing dry chemicals in areas where airborne particles could contaminate other solutions. • Don't leave excess chemicals on films to extend life of developing solution. • For non-automated equipment, use squeegees to wipe excess liquid from film and paper to reduce chemical carryover from one process bath to the next. • Use air blades to reduce dragout from chemical bath to rinsewaters. • For automated equipment, regularly inspect squeegees/squeegee rollers at the exit of each process bath; replace parts and adjust tension as necessary. • Use non-absorbent "twin-checks." • Use acid stop bath prior to fixing bath. • Keep chemical baths covered (e.g., use floating lids on developer containers). • Protect process baths that spoil easily by keeping them containerized.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Processing	Aqueous Waste	• Stop water flow when processing is halted. • Use water demand valves to control water use. • Use recommended rates and check for leaks. • Accurately monitor solution strength and replenish chemicals. • Control temperature and pH of fixing bath. • Use plumbing-less mini-labs. • Change the geometry of processing containers. • Segregate fixer from developer waste for silver recovery. • Add acetic acid to fix bath. • Reuse fixer. • Install electrowinning unit on fix bath of photoprocessor, on first rinse, and on developer waste streams. • Regenerate developer. • Substitute less environmentally harmful, iron complexed bleaches for ferricyanide bleach where possible. • Regenerate bleach (e.g., ferricyanide through ozone oxidation, electrolysis, use of persulfate salts or liquid bromine). • Regenerate bleach fix (e.g., through electrolytic or ion exchange systems). • Employ countercurrent washing sequence instead of parallel rinse systems. • Recycle rinse water. • Recover silver from spent solutions and rinse water through metallic replacement, electrolytic recovery, precipitation, reverse osmosis, ion exchange or evaporation. • Use two chemical recovery cartridges in a series to maximize silver recovery. • Add ammonium thiosulfate to silver contaminated baths.

Sources:

- Pollution Prevention Guides: The Photoprocessing Industry, U.S. EPA, October 1991, EPA/625/7-91/012.
- Fact Sheet: Waste Reduction in the Photoprocessing Industry, Central Contra Costa Sanitary District and DEH.
- Facility Pollution Prevention Guide, U.S., EPA, May 1992, EPA/600/R-92/088.
- Waste Reduction Makes Good Business Sense for Photofinishers, Alaska Health Project, 1987.
- Photoprocessing Pollution Prevention Opportunities Checklist, County Sanitation Districts of L.A. County, Whittier, CA.
- Hazardous Waste Reduction Facts: Photographic Processors, City of Santa Monica, Dept. of General Services.
- Waste Reduction Fact Sheet, Vol. 1, Issue 5, Waste Minimization in Photographic Processing, Virginia Dept. of Waste Management.

Pollution Prevention Options for the Radiator Service Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Preparation **Draining**	Motor Oils Coolants Antifreeze	• Collect, segregate and recycle.
Draining	Radiator Fluid	• Drain radiator well.
Boil Out		• Remove as much oil as possible from oil cooler using compressed air to minimize dragout. • Provide hang bars over tank. • Provide drain board between tanks; divert liquid bank into source tank. • Pre-rinse radiator over boil out tank using fog spray (high pressure, low water flow rate). • Maintain and monitor boil-out tank. • Use compressed air to blow out residual alkaline solution after removing from boil-out tank, collect and return to tank. • Use washwater as make-up to boil-out tank. • Increase temperature (e.g., to 160 degrees F) to increase evaporation. • Carefully monitor and only add minimum required types and quantity of chemicals. • Use chemical/physical treatment system to remove oil, metals and solids and reuse water.
Flushing Booth	Contaminated Rinse Water	• Blow out residual caustic solution to tank using compressed air to minimize drag-out to flushing booth. • Reuse flushing booth rinses for boil-out tank make-up. • Use high pressure and lower water flow.
Testing	Tank Cleanout Sludges Test Tank Dumps	• Reuse test tank water in flushing booth. • Use smaller test tanks for efficient operation. • Correct cloudiness (too much solid deposition) by improving rinsing of radiator before placing radiator in test tank. • Filter (using simple bag or cartridge filter) or settle solids from solution instead of dumping.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Soldering	Used Solder Waste Flux	• Reduce use of flux containing complexing or chelating compounds. • Use a low zinc flux. • Solder in a separate area (not over test tank) or catch before solder falls into tank.
Painting	Waste paint Spent Solvent VOC Emissions	• Control inventory rigidly to reduce thinner use. • Practice better housekeeping to reduce leaks and spills. • Mix paint according to need. • Use high transfer efficiency equipment (e.g., equipment with low over-spray). • Keep air pressure low and spray gun perpendicular to increase accuracy. • Provide operator training. • Practice proper equipment cleaning methods. • Use fully enclosed gun cleaning station. • Reuse clean-up solvent in next compatible batch of paint. • Recycle solvent on-site. • Recycle solvent off-site by means of thinner leasing agreements. • Use recyclable paint filters. • Use Styrofoam filters.
Other	Scrap Metal/ Radiators Process Tank Dumps	• Collect, segregate and recycle. • Before dumping tank, remove liquid to another tank and filter solids or settle, then return liquid portion to tank.

Sources:

- Radiator Repair Industry: Pollution Prevention Opportunities Checklist, Industrial Waste Section, L.A. County Sanitation Districts, Whittier, CA, 10/90.
- Pollution Prevention Tips, Waste Reduction Options: Radiator Service Firms, NC Dept. of Environment, Health and Natural Resources, Office of Waste Reduction, Raleigh, NC.

Pollution Prevention Options for the Printed Circuit Board Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
PC Board Manufacture	General	• Substitute surface mount technology. • Substitute injection molded substrate and additive plating.
Cleaning and Surface Preparation	Solvents	• Use abrasives. • Use non-chelated cleaners. • Use mild chelators if chelators are required in the process. • Extend bath life. • Improve rinse efficiency. • Use countercurrent cleaning. • Recycle or reuse cleaners and rinses.
Pattern Printing and Masking	Acid Fumes Organic Vapors Vinyl Polymers Spent Resist Removal Solution Spent Acid Solution Waste Rinse Water	• Use aqueous processable resist. • Do screen printing versus photolithography. • Use dry photo-resist removal. • Recycle or reuse photoresist stripper.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS

Electroplating and Electroless Plating	Plating Solutions
	
	Rinse Water
	
	Sludges
		• Eliminate mechanical board production process.
		• Use non-cyanide baths and non-cyanide stress relievers.
		• Design and maintain rack properly to extend bath life and reduce drag-in:
		  • Use better pre-cleaning or rinsing;
		  • Use demineralized water as make-up;
		  • Store solutions properly.
		• Extend bath life and reduce drag-out:
		  • Minimize bath chemical concentration, then over time gradually add reagents to prolong life until full strength is achieved;
		  • Increase bath temperature;
		  • Use wetting agents;
		  • Use proper positioning in rack;
		  • Slow withdrawal and sample drainage;
		  • Computerize or automate systems;
		  • Use airstream or fog to rinse plating solution into the tank;
		  • Collect drips between process and rinse tanks with drain boards;
		  • Recover drag-out.
		• Extend bath life; maintain bath solution quality:
		  • Monitor solution activity;
		  • Control temperature;
		  • Use mechanical agitation;
		  • Use continuous filtration/carbon treatment, electrolytic dummying;
		  • Remove impurities.

Elecroplating and Electroless Plating, continued		• Properly design and operate equipment.
		• Use closed-circuit rinses, spray rinses and fog nozzles.
		• Increase agitation; use air agitation or work piece agitation.
		• Conserve water:
		  • Install turbulence devices;
		  • Increase contact between water and the board;
		  • Reuse acid rinse effluent as influent for alkaline rinse tank.
		  • Turn off rinse water when not in use;
		  • Use countercurrent rinsing;
		  • Apply flow restriction devices such as pH controlled and pressure controlled shut-offs.
		• Use de-ionized water to reduce sludge volume.
		• Ask supplier to recommend chemicals that generate less sludge.
		• Recover metal values.
		• Segregate waste streams.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Etching	Etching Solutions Rinse Waters	• Eliminate differential plating. • Use dry plasma etching. • Use non-chelated etchants. • Use non-chrome etchants. • Use thinner copper cladding. • Use pattern instead of panel plating. • Use additive instead of subtractive method. • Reuse or recycle etchants (e.g., through filtration and regeneration).

Sources:

- Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.
- Hazardous Waste Reduction Facts: Printed Circuit Board Industry, City of Santa Monica, Dept. of General Services.
- Fact Sheet: Printed Circuit Board manufacturers, CA DHA Alternative Technology Division, August 1989.

Pollution Prevention Options for the Printing Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Material Handling and Storage	Empty Containers Used Film Packages Outdated Material	• Label all containers with contents and use information. • Test age-dated material (if expired) for effectiveness. • Recycle empty containers. • Recycle spoiled photographic film and paper. • Develop a working relationship with a single vendor to facilitate "deals" on bulk purchases and to return old, off-specification products or to return containers for refill if possible.
Image Processing	Photographic Chemicals Silver	• Use silver-free films, such as vesicular, diazo or electrostatic types for contact operations. • Use electronic pre-press system to prepare copy. • Install meters (e.g., densitometer) on cameras to ensure good proofs the first time. • Install waterless ("plumbingless") paper and film developing units. • Use water-developed litho plates or wipe-on plates. • Protect process baths that spoil easily by keeping them containerized. • Don't leave excess chemicals on films and plates to extend life of developing solution. • Use squeegees to reduce carryover. • Extend bath life (e.g., monitor temperature and pH of fixing bath). • Employ countercurrent washing. • Use an acid stop bath prior to the fixing bath. Add acetic acid to the fixing bath to keep pH low. • Use floating lids on bleach and developer containers. • Add ammonium thiosulfate to silver contaminated baths. • Segregate fixer from developer waste. • Recover silver and recycle chemicals (e.g., metal replacement, chemical precipitation, electrolytic silver recovery systems, ion exchange). • Install electrowinning unit on fix bath of photoprocessor; on first rinse and developer waste streams.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Plate Making	Damaged Plates Developed Film Outdated Material	• Use electronic imaging. • Use laser plate making. • Use automatic plate processors that monitor both bath conditions and automatically replenish chemicals. • Use pre-sensitized lithographic plates processed with water only. • Use plastic or photopolymer plates processed with a water based solution. • Use flexographic process. • Use electrostatic-paper plates made directly from art work and used on copier/duplicator presses. • Use water based developers. • Use non-chromate etchants. • Prolong oxidation process baths by reducing air exposure. • Remelt/recycle spent plates.
Plate Making, continued	Acids Alkali Solvents Plate Coatings Developers Rinse Water	• Use washless processing systems. • Use better operating practices (e.g., frequently monitor bath pH, temperature, and solution strength to extend life). • Use floating lids on bleach and developer tanks. • Use countercurrent washing sequence instead of parallel rinse systems. • Reduce drag-out (e.g., use drain boards; remove plates slowly and smoothly, place parts on racks to maximize drainage, maximize drip time to the extent that plate quality is not affected). • Use squeegees to reduce carryover. • Substitute iron-EDTA for ferrocyanide. • Remove heavy metals from waste water. • Recover silver and recycle chemicals.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Makeready	Waste Ink Waste Paper	• Use automatic plate benders, scanners or other plate fitting parameters affecting proper registration. • Use automatic plate scanners for web or sheet-fed off-set presses. • Use automatic ink key setting systems. • Use automatic (computerized) registration systems for gravure, web offset, etc. • Use ink/water sensors to optimize ratio. • Install web break detectors. • Use automatic web splicers. • Implement accurate counting methods. • Prepare only the quantity of ink needed for a press run. • Clean ink fountains only when different color is used or when ink might dry out between runs. • Return unemulsified inks to their containers. • Donate unemulsified inks to trade schools, colleges, etc. • Use water-based ink or water-borne inks instead of solvent-based inks when possible. • If you must use solvent-based inks, choose low VOC inks. • Use inks with low or zero levels of toxic metals (lead, barium, cadmium, chromium). • Use soybean oil inks if possible. • Use UV-curable ink. • Use Electron Beam Drying on web presses. • Prevent ink drying and skin formulations through non-drying aerosol sprays. • Test use of non-skinning ink formulations. • Store and reseal ink properly. • Save old inks and market as "house" colors. • Recycle waste ink (e.g., to make black ink). Smaller operations-coordinate with large plants/newspapers (using rubber/oil based ink) to recycle. • Return liquid ink to supplier to be recycled as feedstock.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Printing	Lubricating Oils Waste Inks Clean-up Solvent Rags	• Use fountain solutions that do not contain isopropyl alcohol (IPA) or have low concentrations of IPA. • Use automatic ink leveler. • Schedule runs to reduce color change over (e.g., use standard ink sequence to eliminate the need to change ink rotation, fountain cleaning). • Designate a press exclusively for inks with hazardous pigments or solvents. • Use automatic blanket cleaning systems. • Use alternative solvents (e.g., less-toxic or less flammable blanket washes-acetic acid, hexane or detergent based). • Use soaps and detergents where possible instead of solvents. • Wipe excess ink off before cleaning equipment with solvents. • Use solvents only for cleaning inks and oils. • Draw only enough solvent needed to complete cleaning task. Control solvent use by using plunging cans that moisten but do not soak towels, or squeeze bottles to moisten towel. • Apply solvent directly to roller blanket with squeeze bottle. • Use press wipes as long as possible; use dirty ones for the first pass, clean ones for the second. • Physically dry wiper rags (squeegee or spin, use hand operated or mop ringer, explosion proof centrifuge, hand squeeze); recover or recycle squeezings and drippings, send dirty rags to approved industrial laundries. • Install solvent hoods to recapture solvent losses from presses. • For silkscreen operations, recapture printing ink by squeezing screen prior to washing. • Clean trays with a parts-washing unit using recirculating solvent. • Segregate solvent according to color and type of ink. Reuse collected wastes to thin future batches of same ink. • Recycle waste solvent. • Segregate and recycle used oil.
Printing	Test Production Bad Printings Empty Ink Containers Used Blankets	• Install web break detectors. • Monitor press performance. • Check roller blade condition and angle. • Use better operating practices. • Improve start-up procedures.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Finishing	Paper Waste from Damaged Product	• Reduce paper use. • Recycle waste paper.

Sources:

- Facility Pollution Prevention Guide, U.S. EPA, May 1992, EPA/600/R-92/088.
- Guides to Pollution Prevention: The Commercial Printing Industry; U.S. EPA, August 1990, EPA/625/7-90/008.
- Hazardous Waste Management for Printers, New York DEC, Division of Hazardous Substances Regulation, Bureau of Pollution Prevention, September 1991 Draft.
- Hazardous Waste Reduction Facts: General Commercial Printers, City of Santa Monica, Dept. of General Services.
- Pollution Prevention Opportunities in Printing, U.S. EPA Region III, October 1990.
- Fact Sheet: Waste Reduction for the Commercial Printing Industry, CA DHS, Alternative technology Division, April 1990.
- Printing: Pollution Prevention Opportunities Checklist, Industrial Waste Section, County Sanitation Districts of L.A. County, Whittier, CA 12/90.
- Hazardous Waste Reduction Facts, General Commercial Printers, City of Santa Monica Dept. of General Services.
- Pollution Prevention Opportunities in Printing, U.S. EPA Region III, 10/90.
- Pollution Prevention: Strategies for the Printing Industry, Canter for Hazardous Materials Research.
- Fact Sheet: Removing Solvent and Ink from Printer Shop Towels and Disposable Wipes, MNTAP, 8/91-37.
- Fact Sheet: Waste Reduction for the Commercial Printing Industry, CA Dept. of Health Services, Toxic Substances Control Program, Alternative Technology Division, 4/90.
- Waste Reduction Tips for Printshops, Alaska Health Project, 1987.

Pollution Prevention Options for Research and Educational Institutions

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Laboratories Science Departments	Various Chemicals Acids Bases Unused Chemicals Metals Reaction Products from Experiments	• Establish centralized purchasing program. • Share surplus chemicals. • Computerize inventory--keep a running inventory of unused chemicals for use by other departments. • Buy smaller quantities of reagent chemicals. • Properly label containers. • Use first-in, first-out. • Return excess material to supplier. • Scale down experiments. • Pre-weigh chemicals. • Increase instrumental analyses over wet chemistry. • Eliminate toxic chemical use. • Substitute less toxic chemicals (e.g., sodium hypochlorite for sodium dichromate, alcohols instead of benzenes, cyclohexane for carbon tetrachloride, stearic acid for acetamide). • Use specialty detergents (instead of chromic of sulfuric acid) to clean glassware. • Standardize solvents. • Keep individual waste streams segregated. • Recycle solvents. • Recover metal from catalyst.
Arts, Theater Arts, Scenery Shop, Printing	Oil-based Paints Solvents Inks Acids Metals in Glazes Silver, developing and fixing chemicals	• Eliminate oil-based paint--replace with water-based paint. • Use proper spray paint techniques (e.g., use high transfer efficiency guns; overlap spraying pattern by 50%; maintain a distance of 6-8" from work piece; hold gun perpendicular to surface; trigger the gun at the beginning and end of each stroke). • Use fully enclosed gun cleaning station. • Reuse clean-up solvent in next compatible batch of paint. • Use less hazardous cleaners (e.g., biodegradable aqueous or detergent cleaners). • Recover photographic silver. • Eliminate use of lead-based glaze.

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Maintenance **Industrial Arts** **Other Vocational Courses**	Stains Solvents Wood Preservatives Dyes Ketones Metal Dust Degreasing Solvents Oil Grease Pesticides Paints	• Eliminate oil-based paint use--replace with water-based paint. • Use proper spray techniques. • Standardize machine oil. • Use water-based cutting fluids. • Properly manage coolants. • Use alkalize or less hazardous solvent degreasers. • Keep vapor degreaser covered. • Operate degreaser properly. • Avoid unnecessary cleaning of parts. • Use two stage cleaning (use dirty solvent for initial cleaning, fresh solvent for final cleaning). • Use solvent sink, keep plugged when not in use. • Recycle pesticide rinse water. • Use dry pesticide or irrigation injection. • Recover mercury.

Source: Guides to Pollution Prevention: Research and Educational Institutions, U.S. EPA, June 1990, EPA/625/7-90/010.

Pollution Prevention Options for the Steel Industry

WASTE ORIGIN	WASTE TYPE	POLLUTION PREVENTION AND RECYCLING METHODS
Receiving	Scrap Steel	• Use steel scrap with low lead and cadmium content as raw material if possible.
Foundry Work	Slag	• Eliminate generation of reactive desulfurization slag by using less hazardous material in place of calcium carbide.
Furnaces **Melting** **Annealing**	Structural Defects Furnace Dust Air Pollution Control Equipment Wastes	• Use induction-heated holding furnace following electric arc furnace to feed metal in molten state to multiple continuous casting machines. • Convert tar-decanter sludge (and other tar-based coke plant wastes) into fuel suitable for open hearth and blast furnaces. • Dewater and recycle mill scale, and recharge slag into melting furnaces. • Recover zinc from electric arc furnace dust by pyro- or hydrometallurgical processes. • Recover zinc from galvanized steel prior to charging as scrap to electric arc furnace. • Switch to induction melting furnaces for grey iron melting.
Hot and Cold Rolling	Oils Greases	• Recycle or reuse.
Pickling	Spent Pickle Liquor Sulfuric Acid	• Recover ferric sulfate or ferric chloride through crystallization. • Employ spray roaster, fluid bed, or sliding bed to separate HCl From iron oxide and recover acid. • Use bipolar membrane/electrodialytic process to separate acid from metal by-products in spent NHO_3-HF pickle liquor. • Recover sulfuric acid using low temperature separation of acid and metal crystals.
Cooling Rinsing	Waste Waters	• Replace single-pass wastewater systems with closed-loop systems.

Sources:

- Fact Sheet, Pollution Prevention: Strategies for the Steel Industry, Center for Hazardous Materials Research, Pittsburgh, PA.
- Pollution Prevention Opportunities in the Steel Industry, U.S. EPA Region III, Philadelphia, PA October 1990.

More Information on Waste Minimization and Pollution Prevention

Waste Minimization methods include:

- **Source reduction or POLLUTION PREVENTION.** Prevent waste generation through improved maintenance practices, by modifying equipment, or changing production/manufacturing processes. Manufacturing process changes may include either eliminating a process that produces a waste or altering the process so that it no longer produces the waste.

- **Source separation (or segregation).** Keep hazardous waste from contaminating nonhazardous waste through management practices that prevent the wastes from coming into contact with each other. This is the cheapest and easiest method of reducing the volume of hazardous waste to be disposed of, and is widely used by industry. In addition to reducing disposal costs, source separation reduces handling and transportation costs.

- **Reusing, recycling or recovering wastes.** Recycling is the process of removing a substance from a waste and returning it to productive use. Generators commonly recycle solvents, acids, and metals.

- **Substitution of raw materials.** Replace a raw material that generates a large amount of hazardous waste with one that generates little or no hazardous waste, which can substantially reduce the volume of hazardous waste generated. Substitution may offer the greatest opportunity for waste reduction.

- **Good housekeeping practices.** Avoid spills. Properly manage waste in tanks and containers, etc.

POLLUTION PREVENTION activities are those that cause a net reduction in the use of raw materials or that cause a net reduction in the generation of waste. Pollution prevention begins at the source and results in reduced quantities of materials used, reduced toxicity of materials and waste products, and reduced quantities of waste. Congress passed the Pollution Prevention Act of 1990 and reinforced the Environmental Management Hierarchy below as national policy. Public Act 91-376 established pollution prevention as the public policy of Connecticut.

With regard to selecting the best waste management method that is available to and affordable to industry, "best" is defined as Number 1 below, with Number 4 being the least desirable waste management option.

Waste Management Hierarchy

1. Pollution should be prevented or reduced at the source wherever feasible (i.e., the top priority is **source reduction**);

2. Pollution that cannot be prevented should be **recycled in an environmentally safe manner** wherever feasible (on-site recycling is preferable to off-site recycling);

3. Pollution that cannot be prevented or recycled should be **treated in an environmentally safe manner** wherever feasible; and

4. **Disposal** or other release into the environment should be employed only as a last resort and should be conducted in a manner **that minimizes the impact to the environment** to the greatest extent possible.

Benefits of Pollution Prevention

There are many benefits associated with pollution prevention. They include:

- Reduced regulatory requirements;
- Cost savings (through more efficient use of resources, materials, reduces waste treatment, and disposal costs);
- Improved competitive advantage;
- Potential reduction in hazardous-waste- related liabilities at both on and off-site treatment, storage, and disposal facilities and for worker safety (the less hazardous waste you generate, the lower your potential for negative environmental impacts);
- Enhanced public image in the community and among your employees;
- Improved operations;
- Protection of the environment, and the health and safety of your employees and the public.

For More Information

The booklets, "Waste Minimization Environmental Quality and Economic Benefits" and "Recommended Methods for Handling Hazardous Waste" provide detailed information on waste minimization procedures. Both are available from the Bureau of Waste Management free of charge. EPA has also developed a "Facility Pollution Prevention Guide;" excerpts from this guide and industry specific pollution prevention checklists are available through the Waste Management Bureau. Additional pollution prevention reference materials, such as DEP's Statement on Pollution Prevention and a DEP Pollution Prevention series of factsheets and case studies are available through the Office of Pollution Prevention.

For more information concerning waste minimization and pollution prevention, you may wish to contact the following:

Office of Pollution Prevention, Planning and Standards Division, Waste Management Bureau, CT DEP (860) 424-3297: The DEP Office of Pollution Prevention provides technical assistance for pollution prevention including lawn and ornamental plant pesticide applicators, furniture stripping and repair, dry cleaning, and automotive repair and refinishing. Contact this unit for further information. Information is also available on the CT DEP website at http://dep.state.ct.us/waste/.

Northeast Waste Management Officials Association (NEWMOA) Pollution Prevention Clearinghouse provides technical assistance information for most industries. Contact NEWMOA at (617) 367-8558 or via the web at www.newmoa.org.