Hazardous Waste Minimization Checklist & Assessment Manual for the Metal Finishing Industry

CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

OFFICE OF POLLUTION PREVENTION AND TECHNOLOGY DEVELOPMENT

TECHNOLOGY CLEARINGHOUSE UNIT

Third Edition - October, 1993

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This third edition of the *Checklist* was prepared by Thomas S. Barron, P.E., G. James Miille, REA, and Patrick J. Burt (Acteron Corporation/NAMF) with significant input from a number of metal finishers, consultants, equipment suppliers and others involved with waste minimization in this industry. Much of the development work for the third edition was accomplished in various projects undertaken by the authors for Alameda County, Santa Clara County, and the San José / Santa Clara Water Pollution Control Plant.

Contents of the original Metal Finishing *Checklist* have been reorganized and then supplemented by both new materials and extensive passages taken directly from later U.S. EPA and Department publications, notably checklists for other industries and waste audit studies for fabricated metal products, metal finishing, and printed circuit board manufacturing.

We acknowledge the important contribution to this *Checklist* made by the authors and sponsors of these other publications.

DISCLAIMER

The mention of commercial products, commercial services, their sources or their use in connection with material reported herein is not to be construed as actual or implied endorsement by the Department of such products or services.

CORRECTIONS & COMMENTS

The authors ask that readers send any comments and suggested corrections to:

Thomas S. Barron, PE
P.O. Box 370
Walnut Creek, CA 94597

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INTRODUCTION

Waste minimization is a two pronged attack plan for reducing the amount of wastes generated by your plant or shop. It consists of 1) source reduction and 2) recycling and resource recovery. Alternative treatment is also a viable option for reducing wastes although not considered to be waste minimization.

These measures can involve simple and easily implemented strategies, or complex, state-of-the-art technologies. The extent to which you can use any of them in your hazardous waste minimization program depends upon your plant's or shop's particular operations and procedures. This *Checklist* is a tool for you to use in evaluating your waste minimization choices.

Waste minimization can help you comply with regulatory requirements. In some instances it might even allow small quantity generators to drop out of the regulatory loop altogether. Waste minimization may also be able to reduce the fines or fees assessed by Publicly Owned Treatment Works (POTWs) by reducing your loads on their treatment systems. And, having a waste minimization plan such as this *Checklist* is now required by SB14, The Hazardous Waste Source Reduction and Management Review Act of 1989.

This assessment manual was originally developed by the Technology Clearinghouse of the Alternative Technology Division, now within Cal-EPA's Department of Toxic Substances Control, to aid metal finishers in evaluating waste minimization opportunities. This revised edition of the manual has been expanded and reorganized by the authors to include information from later publications from the Department, the U.S. EPA, and other sources.

Section 1 is a checklist which can aid you in evaluating your waste reduction opportunities. These opportunities are presented in a question and answer format, with the preferred answers in **bold print**. Comments appear next to the ✓checkmarks.

Section 2 is comprised of tables listing the waste reduction options from the *Checklist* and providing four areas for you to evaluate:

- Waste Minimization Hierarchy (WMH)
- Implementation Potential (IP)
- "Type of Option"
- "Cost of Option"

Each of these areas has a different point value scale which will be explained in Section 2. The total scores of the options will allow you to prioritize which ones to undertake first.

Section 3 has economics worksheets which will help you decide which options are cost effective for implementation into your shop.

Appendices provide forms, definitions, and sources of additional information.

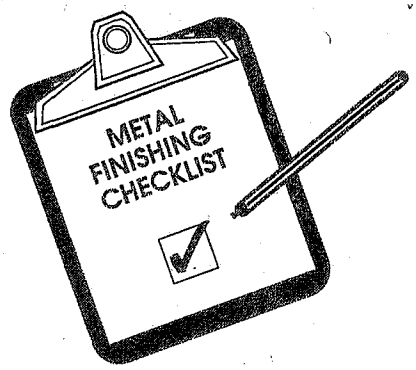
Throughout the checklist blank pages and wide margins are provided for you to make notes. Insert additional pages where you need more space.

SECTION 1: METAL FINISHING CHECKLIST

Once you have completed this checklist and have identified potential waste minimization techniques available for your shop, you should evaluate them based on ease of implementation and economic feasibility. Section 2 of this booklet will help you identify the techniques that show the most promise in terms of implementation. Section 3 contains an economics worksheet to help you determine the feasibility of the chosen waste reduction options.

The checklist will focus on:

- **Material Storage & Handling**
- **Production Processes**
- **Resource Recovery**
- **Treatment Alternatives**



INFORMATION ABOUT YOUR COMPANY

Note below the information you will need later to identify when this checklist was prepared, and what part of your shop it applies to:

Company Name _____

Address _____

SIC Code & Type of Business _____

Time Company Has Been at Site _____

Major Products or Services _____

Number of Employees _____

Checklist Prepared By _____

Date Prepared _____

WHAT METAL FINISHING WORK DO YOU DO?

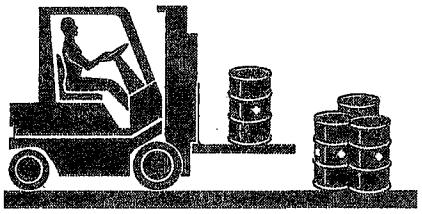
Draw an overall diagram of your metal finishing operation, or write a list of the plating operations that you do. Include support activities such as parts cleaning, plating quality control, research and development, materials receiving and storage, and waste disposal. Use extra insert pages if you need more space.

WHAT HAZARDOUS WASTES DO YOU GENERATE?

List below the general types and amounts of hazardous and extremely hazardous wastes that you generate. Separately identify any waste that is 5% or more of the total waste that you generate. Refer to the list of waste types and California Waste Codes in Appendix B.

Name of Each Waste Stream	Calif. Waste Code	Waste Type	How Often Generated	Quantity Generated
Example: *Filter Press Sludge with Metals*	*171*	*Solid*	*Daily*	*200 lbs.*

Notes:



MATERIAL STORAGE AND HANDLING

Many wastes are generated by the way that chemicals are stored, and by degradation of raw materials, improper mixing of solutions, and by spills. Proper material handling and storage is an easy and economical way to prevent waste generation. Losses from improperly handled materials can be minimized without incurring large capital costs. Often a simple change in policy or procedure is all that is necessary for reducing this waste, and achieving significant savings in chemical purchases.

This section of the *Checklist* will cover:

- Storage Area Layout
- Material Degredation
- Sample Management
- Spills
- Chemical Mixing & Handling
- Inspections.

Storage Area Layout

You may generate additional hazardous waste if you store raw materials or hazardous wastes improperly. Store them in covered containers. A locked, covered, indoor area with a concrete floor and curbs for spill containment would be ideal for storage. Inspect the storage area often, at least once a week, to look for leaky containers or improper storage. Some of these suggestions are also required by law.

1. Are materials and/or wastes kept in proper storage areas?

☐ **Yes** ☐ No

✓ Proper storage areas can help you reduce wastes generated due to spills, cross-contamination, or leaks. It should also include adequate lighting, insulated electrical circuitry (checked frequently for corrosion to prevent potential sparking), covered from rain, and aisles clear of obstructions.

2. Is there space between rows of stored drums?

☐ **Yes** ☐ No

✓ Providing space between rows of drums will allow for visual inspections of each container for corrosion and/or leaks.

3. Do you stack containers of materials?

☐ Yes ☐ **No**

✓ Do not stack containers higher than recommended by the manufacturer, or in such a manner where they can tip over, tear, puncture, or break. Also do not stack equipment against material containers so as to avoid damaging the containers.

4. Are materials segregated?

☐ **Yes** ☐ No

✓ Maintain distance and berms between different types of chemicals to prevent cross-contamination and reactions, in case of spills or leaks.

5. Are storage areas clear and surfaces even and sloped to drain?

☐ **Yes** ☐ No

✓ Maintaining clear and even surfaces in areas used by personnel when moving materials or equipment, will help decrease the incidence of spills due to accidents.

6. Are drums stored on pallets or gratings?

☐ **Yes** ☐ No

✓ Storing drums on pallets or raised gratings will raise them off of the concrete floor which will prevent corrosion of the drums through "sweating" of the concrete.

7. Is the storage area provided with containment?

☐ **Yes** ☐ No

✓ Providing curbing or diking around process storage tanks and waste storage areas will contain leaks and prevent further contamination.

8. Does the layout of your facility require a heavy amount of traffic through the storage area?

☐ Yes ☐ **No**

✓ Heavy traffic increases the potential for contaminating raw material, and for causing spilled materials to become dispersed throughout the facility. How can you modify your storage area so as to reduce traffic?

9. Does your layout also require that chemicals be carried through non-bermed areas enroute to their point of use?

☐ Yes ☐ **No**

✓ Examine your shop layout to see the best ways to move chemicals with the least chance of spills or contamination.

Notes:

Use Table 1 for making additional notes about your chemicals storage area.

TABLE 1: How do you store your hazardous waste or materials?

Storage	Hazardous Wastes	Raw Materials	Comments
Location Indoors Outdoors			Some fire departments recommend storing flammable wastes outdoors to reduce fire danger, but remember to follow the other storage requirements.
Roofing Covered Uncovered			Covered storage is important because rain water can increase your waste volumes or contaminate raw materials. Exposure to sunlight or cold can change the characteristics of raw materials or dangerously increase the pressure inside sealed containers. Also, keep individual containers covered to prevent evaporation and spills.
Surface Concrete Asphalt Epoxy Coating			A diked concrete pad will contain spills better than asphalt or dirt. Epoxy-coated concrete provides the best seal.
Security Locked Unlocked			Without secure storage facilities unauthorized persons may enter the storage area and harm themselves or spill the waste, or even dump their waste into your containers.

Notes:

Material Degradation

1. Are off-specification materials generated due to material exceeding its shelf life?

☐ Yes ☐ **No**

✓ Material that no longer has a useful shelf life is considered a hazardous waste which must be properly disposed.

Track the purchasing and receiving dates for all chemicals in storage. Where possible, determine the actual manufacture date and use that instead. Work with your local supplier or directly with the source to learn this date. It may appear as codes on the containers, or may only be your best estimate.

2. Are inventories conducted on a periodic basis?

☐ **Yes** ☐ No

✓ Conduct inventories on a periodic basis to identify any accumulation of material that may be nearing the end of its shelf life. This policy allows you to keep smaller quantities on hand without encountering shortages.

3. Does your shop use a first-in first-out material usage policy?

☐ **Yes** ☐ No

✓ Using materials on a first-in first-out basis will help prevent them from deteriorating in storage.

4. Do you verify that this policy is followed?

☐ **Yes** ☐ No

✓ Put up signs to remind your workforce, and conduct periodic checks.

5. Do you minimize inventory to prevent material degradation due to prolonged storage?

☐ **Yes** ☐ No

✓ Both materials degraded by prolonged storage and off-specification materials must be disposed as hazardous waste. Keep materials at a level which will allow them to be used up just as the new materials are arriving. Identify the quantity needed to make-up one batch of your solutions, and set that amount as the minimum inventory to maintain.

6. Is access to raw materials limited?

☐ **Yes** ☐ No

✓ By limiting access, inventory can be better monitored. Also, if it is more difficult to access products, employees will be less likely to waste them.

7. Are materials bought in the right quantities?

☐ **Yes** ☐ No

✓ Consider using larger reusable containers for frequently used chemicals. Alternatives to 55 gallon drums include fiberglass or polythylene/wire mesh containers. If smaller quantities are used, buy only what you need.

Notes:

Samples

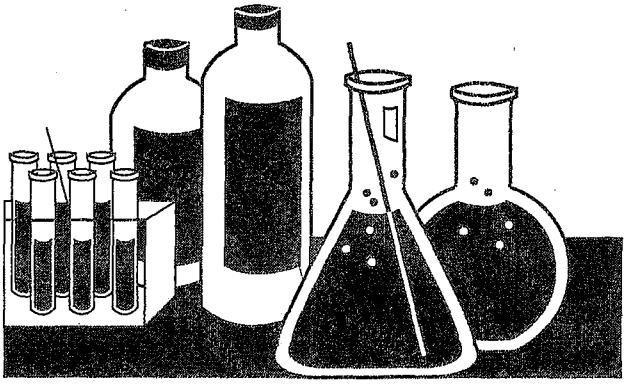
1. Does your shop accept unsolicited samples from chemical suppliers?

☐ Yes ☐ **No**

✓ Samples supplied by chemical manufacturers can become hazardous waste if they are not used, and thereafter will have to be managed as a hazardous waste. Unused samples must ultimately be disposed of properly. Therefore, it is important that you use all of the samples you receive or make sure you do not accept any samples you cannot use.

2. If yes, do you use all of the samples?

☐ **Yes** ☐ No



3. Are samples tested on a bench-scale basis?

☐ **Yes** ☐ No

✓ Testing the samples on a bench-scale basis rather than in a process tank can reduce the volume needing disposal if the process solution does not meet your requirements.

4. Have you designated a person to approve the acceptance of chemical samples?

☐ **Yes** ☐ No

✓ It is important to control the number of samples accepted by your shop, so that unneeded samples do not accumulate and add to your waste disposal load. Designating one person to control samples is an effective way of reducing the amount of this waste.

5. Are suppliers asked to take back the unused samples they provide?

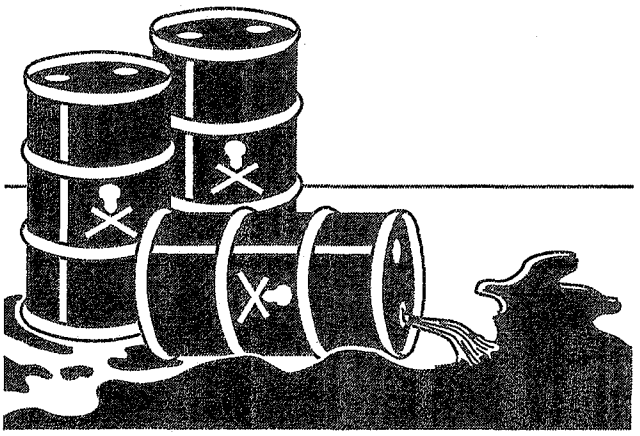
☐ **Yes** ☐ No

✓ You should establish a policy for accepting samples, and negotiate with suppliers to accept return of any samples they provided that are unused. Unused samples can become hazardous waste and must be handled as such.

Some suppliers will work with you to test your metal coupons at their location, instead of sending you chemical samples for initial testing.

Notes:

Spills



1. Does your shop periodically generate waste due to spills during material handling and storage?

☐ Yes ☐ **No**

✓ Shop operational practices and procedures should address minimizing spills through training personnel in proper handling and storage of materials. You should also provide your workers with the proper equipment to move drums and other containers, and to safely transfer chemicals out of these containers.

2. Are personnel trained to ensure proper handling and storage of materials?

☐ **Yes** ☐ No

✓ Quick and proper response to leaks and spills will minimize the volume which has to be managed as a hazardous waste. Training of personnel in spill response is also a legal requirement.

3. Is spill containment provided around areas where spills might occur?

☐ **Yes** ☐ No

✓ Providing spill containment can minimize the amount of cleanup materials needed to contain and cleanup spills. Also the hazardous materials spilled become hazardous waste and must be managed as such.

Other Things to Consider in Spill Management:

- use a mop, bucket and wringer instead of absorbents to clean up spills whenever possible
- use drip pans or trays to collect spillage during material transfer
- have absorbent pillows available to contain spills and prevent their spread
- perform preventive maintenance on pipes and fittings
- strive for employee awareness of best spill cleanup methods
- use spouts and/or funnels when transferring fluids to reduce spills

Notes:

Chemical Mixing and Handling

1. Are process bath solutions mixed by designated and properly trained personnel?

☐ **Yes** ☐ No

✓ Designating a limited number of personnel to mix chemicals will improve the consistency of the baths and minimize wastes.

2. Are inventory or other controls used to assure that chemicals in a container are completely used prior to opening a new container?

☐ **Yes** ☐ No

✓ Complete use of material in opened containers can reduce the amount of wasted raw materials that adds to the total volume of waste.

3. Are empty containers returned to the supplier?

☐ **Yes** ☐ No

✓ Empty containers should be returned to the suppliers where possible, although some firms will not accept return of drums that held proprietary chemicals. Proper management and handling of empty containers previously containing hazardous materials can reduce the volume of hazardous waste generated. It may be illegal to dispose of empty containers in the dumpster.

4. Are empty containers triple-rinsed, and are container rinse solutions used for process bath mixing?

☐ **Yes** ☐ No

✓ Provided that they are uncontaminated and are handled in a timely manner, container rinses may be used to mix the next batch of solutions, or may in some cases be placed directly into the process bath.

5. Are standard procedures used for process bath mixing?

☐ **Yes** ☐ No

✓ Following an established routine with set quantities leads to consistent results, and less waste. It is also important to take care so as not to mix up chemicals with similar names.

6. Do you have Material Safety Data Sheets for all chemicals that you use?

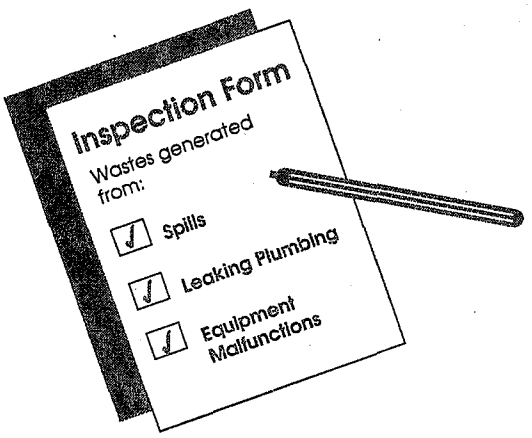
☐ **Yes** ☐ No

✓ Effective worker training, chemicals use and spill response depend upon a thorough understanding of the chemicals you use. It is also important to avoid confusing chemicals with similar names but that have different properties. For example, a trichloroethylene solution can be rendered unusable by very small amounts of 1,1,1-trichloroethane.

Notes:

Inspections

Wastes generated from spills, leaking plumbing and equipment malfunctions can be reduced by an active inspection program. For greatest effectiveness, inspections should be regular, standardized, and conducted by someone trained to not mentally overlook things that were recently seen.



1. Do you have a formal shop inspection plan?

☐ **Yes** ☐ No

✓ Inspections of your shop's production, storage, and waste treatment facilities should be conducted regularly to identify leaks and improperly functioning equipment, which may lead to waste generation and to a hazardous work environment.

2. Are inspections conducted of the chemical storage area, process areas, and waste treatment areas?

☐ **Yes** ☐ No

✓ Frequent inspections can identify problems before they become significant. These inspections should include piping systems, storage tanks, defective racks, air sparging systems, automated flow controls, and even operators' production procedures. These inspections should be coordinated with the maintenance schedule to reduce your waste generation and improve your operating efficiency. They should also be documented to allow for follow up inspections to ensure that required repairs were completed.

3. Are malfunctions in equipment, or leaks in storage vessels and piping corrected as soon as they are found?

☐ **Yes** ☐ No

4. Are identified malfunctions or leaks followed up to ensure they are corrected?

☐ **Yes** ☐ No

✓ Keep a current list of repairs needed, and note when each is completed.

5. Are containers checked to insure that labels are not deteriorated?

☐ **Yes** ☐ No

✓ Frequently, unlabeled containers end up as hazardous waste because of the uncertainty of their contents. Therefore, re-label containers or use them before the labels deteriorate.

Notes:

PRODUCTION PROCESSES

The term "production processes" refers to the cleaning, plating, and rinsing that you do. A number of waste minimization opportunities exist for these production processes, including:

1) New operating procedures;
2) Process modifications;
3) Material modifications or substitutions;
4) Recycling technologies; and
5) Reuse techniques designed to recover a waste stream for reuse as a raw material for a different process.

This section of the *Checklist* addresses source reduction methods applicable to:

- Parts preparation;
- Process baths;
- Rinse operations; and
- Recycling and reuse opportunities.

Most of these methods can be applied to an individual process tank or rinse system. Some require coordination between processes.

Source Reduction - Parts Preparation Steps

Earlier you drew an overall diagram of the operations in your plating shop. Expand that diagram here to show the details of your parts cleaning work. Note the specific stages of cleaning that you do, and the types of equipment that you use.

Notes & Diagrams:

Source Reduction - Parts Preparation Steps (Continued)

1. Do the parts that you handle arrive at your shop needing to be cleaned?

☐ Yes ☐ No

✓ Inspect parts as they arrive from your customers. Determine if parts cleanliness varies from one shipment to the next. Identify why and how the parts become contaminated.

2. If yes, are there things your customers could do to reduce the amount of cleaning needed?

☐ **Yes** ☐ No

✓ Mention it to your customers if you think a simple change in their operations would significantly reduce the cleaning that you must do. Review the DTSC *Fabricated Metal Products Waste Audit Study* for ideas to recommend.

3. Are the ways that your people handle parts adding to the amount of cleaning that needs to be done?

☐ Yes ☐ **No**

✓ Observe how parts are unpacked, handled and stored. Take steps to prevent contamination from occurring. For example, keep the parts boxed until needed, and have workers use clean gloves to avoid fingerprints.

4. Is the area where you receive parts in the open, or subject to heavy traffic?

☐ Yes ☐ **No**

✓ Move your receiving area to a new location if you find that parts are being contaminated at its present location.

5. Do you use a number of cleaning processes, each designed specifically for the different contaminants you encounter?

☐ **Yes** ☐ No

✓ You must know the composition and history of contaminants on the metal surface in order to design the proper cleaning steps. When parts are contaminated by several materials, the sequencing of your cleaning operations is important.

6. Are these cleaning processes compatible with the metal in the parts?

☐ **Yes** ☐ No

✓ Contaminants must be removed without adversely affecting the metal substrate. Reactivity of different metals with alkaline and acid cleaners varies, and thus cleaners that are appropriate for one metal may not be for another.

7. Does the level of cleaning you try to reach match the requirements of the plating process that follows?

✓ Metal surfaces must be very clean for nickel plate to adhere. A zinc-cyanide bath can be effective with less pre-cleaning. Experiment with different cleaning approaches to find which ones work, and also satisfy customer requirements. Keep current with changing specifications in this area.

Notes:

8. Is there a delay between the cleaning and plating of parts?

☐ Yes ☐ **No**

✓ Observe how long parts are held before plating starts, and where they are stored during this time. Schedule work differently if contamination received during this waiting period often forces parts to undergo a second cleaning.

Specific Cleaning Methods

Five different kinds of cleaning media are used to prepare metal parts for finishing:

- Solvents (halogenated and non-halogenated)
- Alkaline Cleaners
- Acid Cleaners (Surface Preparation Solutions)
- Abrasive Materials
- Water

Alkaline and acid cleaners are frequently referred to as aqueous cleaners, and may be used by themselves or in combination with a solvent. Other chemical additives may be present in the cleaner to make it more effective, easier to use, or less harmful to the metal surface.

9. Does the type of cleaning you use match the type, size, and shape of parts you handle?

☐ **Yes** ☐ No

✓ Work to find the combination of cleaning agents, equipment and procedures that best prepare your parts for finishing, yet generate the least waste. Test your cleaner solutions frequently, and replace these solutions just before the point where increased part rejects are likely to occur.

Solvent Cleaning

Common types of solvent cleaning operations are wiping (used mostly on large work pieces), soaking, and vapor cleaning. The most common piece of equipment used for solvent cleaning is the soak tank, followed by the vapor degreaser. Ultrasonic cleaning may be added to a solvent soak tank, and in some cases the tank can be changed to use an alkaline cleaner. The key ways to reduce wastes generated by each of these systems are to minimize evaporation vapor losses and to maintain solvent quality.

10. Is each of your cleaning tanks equipped with a closable lid?

☐ **Yes** ☐ No

✓ Lids should be placed upon all tanks when they are not in use. Vapor degreaser solvent losses can be reduced by 25% to 50% by such a lid. Additional reduction can be accomplished by installing a "silhouette entry" that allows parts to enter the tank while the lid remains closed. Covers should be designed to slide horizontally over the tank so as to minimze air currents that would disturb the solvent vapors.

Notes:

11. Do your tanks have adequate freeboard space above the solvent vapor zone?

☐ **Yes** ☐ No

✓ Empty freeboard space above the solvent vapor zone should be at least 75% to 100% of the tank width.

12. Have you installed an air chiller in the freeboard space above the solvent vapor zone?

☐ Yes ☐ No

✓ Chilled air is more dense than room-temperature air, and provides an effective barrier to solvent vapors. Care must be taken that water condensed from the air by this chiller does not mix with and contaminate the solvent. This contamination risk is greatest with water soluble solvents such as alcohol.

13. Do you take steps to avoid water contamination of the solvent?

☐ **Yes** ☐ No

✓ Water contamination increases the loss of solvent through evaporation, and can acidify the solvent solution to the point where it is no longer usable. Check the tank's water separator to be sure that it is cleaned and operating at the right temperature. Also, take care that parts entering the tank are as free of water as possible. Do not spray parts too far above the solvent or vapor level in the tank.

14. Do you routinely remove sludge that builds up at the bottom of the tank?

☐ **Yes** ☐ No

✓ Solid contaminants can absorb solvents, disolve into solution, and reduce cleaning efficiency. Soak tanks require sludge removal when the contaminants reach about 10% of the solvent quantity. Vapor degreasers may be operated up to a solids contamination level of about 25%. Specific levels vary according to the solvent and contaminants involved.

15. Do you allow sufficient draining time so that parts do not drag out cleaning solvent as they are removed from the tank?

☐ **Yes** ☐ No

✓ The amount of draining time depends upon the size and shape of the parts being cleaned. In addition, rapid movement of very large parts can act like a piston and force solvent vapors out of a degreaser.

16. Do you analyze cleaning bath chemistry, and add just those make-up chemicals needed to renew the bath?

☐ **Yes** ☐ No

✓ As a bath is used the various chemicals in it are depleted at different rates. For example, if stabilizer chemicals are low, then add just these materials rather than new solvent. The increased cost of making the necessary tests will be at least partially offset by savings in solvent use.

Notes:

17. Can you use the same kind(s) of solvent in all of your cleaning systems?

☐ **Yes** ☐ No

✓ Standardizing on one or a few solvents increases the potential for recycling, and reduces the chances of cross-contamination. Having all cleaning work done at one place in your shop can also reduce the number of different solvents used, and may thereby reduce the amount of solvent waste you generate.

18. Is solvent recycling feasible for your shop?

☐ **Yes** ☐ No

✓ Solvent recycling stills are available for many organic solvents. These units should be considered when your new solvent costs more than about $3.00 per gallon, or the quantity used is greater than 5 gallons per hour. Otherwise consider use of an off-site solvent recycling facility or a local pick-up service.

To make recycling feasible:

- Make changes in the types of solvent you use before you purchase recycling equipment.
- Use recycling equipment best suited for the utilities and space in your shop.
- Keep waste solvents separate from each other.
- Avoid adding water and garbage to the waste solvent stotage drum.
- Label each container, and note the composition and history of the waste solvent.
- Pay attention to storage date regulations.

19. Do you use solvents as a drying aid after water cleaning?

☐ Yes ☐ **No**

✓ As an alternative, consider the use of air blast dryers that blow water droplets off of the parts. Also consider aqueous-based rinsing aids.

20. Can you change to cleaning agents that are less toxic, are biodegradable, or are aqueous?

☐ **Yes** ☐ No

✓ Toxic solvents can often be replaced with safer alternatives. For instance, consider using 1,1,1-trichloroethane for either perchloroethylene or trichloroethylene. Or, replace the use of benzene and other aromatic hydrocarbon solvents with aliphatics such as naphtha (Stoddard Solvent).

Other less-toxic solvents are being developed. Terpene plant oil, such as limonene, is one example that works reasonably well in some soak tank cleaning applications. Aqueous cleaners are discussed in the next section.

You may need to obtain customer pre-approval for any cleaner change, particularly if the parts are covered by DoD specifications.

Notes:

Aqueous Cleaning and Surface Preparation

Aqueous cleaners include alkaline and acid solutions. Alkalines are used to remove oils and other organic contaminants, and can replace solvent cleaners in many instances. Acid cleaners are used to remove oxidation and scale. Most aqueous cleaning operations are done in heated soak tanks, and in some applications are enhanced by electrochemical cleaning and ultrasonic cleaning.

21. Are your aqueous cleaner tanks heated?

☐ Yes ☐ No

✓ Aqueous cleaners generally are more effective, and parts dry faster when tanks are operated at elevated temperatures. Consider shifting to aqueous cleaners that are effective at lower temperatures, and then obtain better drying by using forced air blowers.

22. Do you use water nozzles?

☐ **Yes** ☐ No

✓ Spray nozzles of the correct design can significantly improve the effectiveness of aqueous cleaners, and can reduce the amount of drag-out that occurs. However, overspray and misting must be avoided as these create air pollution, operator exposure, and contamination of floors and adjacent tanks.

23. Do you routinely remove sludge that builds up on the bottom of the soak tank?

☐ **Yes** ☐ No

✓ Cleaner tank sludge removal can be handled by continuously filtering, or on a batch basis.

24. Do you use deionized water in your aqueous cleaner?

☐ **Yes** ☐ No

✓ Tap water can introduce contaminants that limit the useful life of cleaner solutions. A deionized water system should be considered, particularly if there are several other uses for it in your shop.

25. Do your cleaning tanks have ultrasonic units in them?

☐ **Yes** ☐ No

✓ Ultrasonic waves create small vacuum bubbles in the liquid. When these bubbles collapse they cause a strong cleaning action on nearby parts. Ultrasonic cleaning is particularly useful for parts with hard to reach surfaces, and may allow operation at a lower temperature.

26. Do you recycle your used aqueous cleaners?

☐ **Yes** ☐ No

✓ Some aqueous cleaners contaminated with oily wastes can be recycled with oil/water separators. These units use gravity and filtration to make this separation.

Notes:

Other Cleaning Methods

27. Can you use skimmers to continuously remove floating materials from cleaning tanks?

☐ **Yes** ☐ No

✓ Install skimmers in your cleaning tanks where you notice floating contaminants that need to be removed.

28. Can you use electrocleaning?

☐ **Yes** ☐ No

✓ Electrocleaning produces its improvement over regular cleaning through the agitation on the parts surface. This agitation is caused by bubbles of either hydrogen (cathodic cleaning) or oxygen (anodic cleaning) produced by electrolysis of the water.

29. Can you shift to reusable cleaners?

☐ **Yes** ☐ No

✓ Some non-chleated cleaners may be used as make-up chemicals in your waste treatment plant.

30. Can you shift to abrasive cleaners?

☐ **Yes** ☐ No

✓ In some instances sand, plastic beads, and synthetic abrasive powders can be used in place of aqueous cleaners. Switching to these materials may reduce the amount of waste that is generated, and the waste may prove to be more easily recycled than liquid cleaners.

Notes:

Source Reduction - Process Bath Solutions

This section of the *Checklist* covers the actual plating work that you do. The next section will look in detail at how you rinse parts between plating steps, and after plating is completed.

As a first step, draw a diagram that shows each of your plating lines. In this diagram show individual tanks, complete with any drip boards, air agitation, and similar features you have installed. Add extra pages if needed to complete your diagram.

Notes/Diagrams:

Source Reduction - Process Bath Solutions (Continued)

Waste minimization opportunities for plating solutions include:

- Decreasing Drag-out of Bath Chemicals
- Decreasing Drag-in of Contaminants
- Extending Bath Life by Purification
- Changing Bath Chemistry, Geometry, and Operating Practices

Decreasing Drag-out

Drag-out refers to bath solution lost from the plating tank when it adhers to the parts being removed. Minimizing drag-out reduces the amount of rinsing that needs to be done after plating, and saves bath chemicals. However, drag-out removes contaminants from the bath, which is a benefit. Therefore it is important to include a way of removing these impurities as part of your drag-out reduction project.

With careful operator attention, the amount of drag-out can be reduced by:

- Lowering surface tension and viscosity of the plating solution
- Paying attention to the physical shape and size of the parts being plated
- Using appropriate type of parts rack or barrel
- Orientating parts for best drainage when removed
- Decreasing speed of parts removal
- Draining parts for enough time and in the best location
- Using air blasts to force solutions off of parts more quickly
- Spraying over the tanks

1. Are process baths operated at the lower end of the manufacturer's suggested range of operating concentrations?

☐ **Yes** ☐ No

✓ Operating baths at lower concentrations can reduce the amount of drag-out both directly in the amount of chemicals involved, and indirectly because the viscosity will be lower.

2. Are fresh process bath solutions operated at a lower concentration than replenished process bath solutions?

☐ **Yes** ☐ No

✓ Fresh baths can be operated at lower concentrations than used baths. Make-up chemicals can be added to the used bath to gradually increase the concentration. These practices also keep the bath viscosity low for as long as possible, but do have the downside effect of producing bath dumps that are more concentrated.

3. Have you experimented with various bath chemistries to see which ones work at the least concentrations?

☐ **Yes** ☐ No

✓ Chemical manufacturers may recommend operating concentrations that are higher than necessary to perform your particular plating work. For each of the various available plating solutions determine the lowest concentration that will provide adequate product quality.

Notes:

4. Can any of the chemical process tanks be operated at higher temperatures without causing an unsafe environment or adversely affecting product quality?

☐ Yes ☐ No

✓ Operating baths at temperatures above ambient will reduce the viscosity of the process solution, allowing the solution to drain from the workpiece faster, and therefore reducing the volume of drag-out. Elevated temperatures also increase the evaporation rate, allowing the addition of water from sprays to maintain the proper chemical concentration.

Warming also allows consideration of operating at lower concentrations because of the increased chemical activity at higher temperatures.

WARNING: Increasing temperatures can cause volatization of cyanide, hexavalent chrome and other toxic fumes, thus creating a worker health hazard.

5. Can surfactants be added to the process tanks in order to lower surface tension without adversely affecting product quality?

☐ Yes ☐ No

✓ Non-ionic wetting agents may prove effective in reducing the surface tension of plating solutions. Usually only small amounts of these agents need be added. However, it is important to check that the agents used are not degraded by electrolysis in the bath, and that plating quality is not affected.

6. Can you reduce drag-out by changing the way that parts are handled?

☐ Yes ☐ No

✓ Place parts on racks so that:

- The largest draining surface is as near to vertical as possible;
- The longer dimension of the part is horizontal, so the solution has the shortest distance to flow; and
- The lower edge is slightly tilted, so that runoff is from a corner.

Experiment to find ways to place parts to obtain the best draining. Where possible use racks rather than barrels to hold parts, as racks often produce less drag-out. Try different kinds of racks as well. Train your workers to think about drag-out reduction when they are preparing and racking parts.

7. Have you determined an optimal removal rate and drainage time for workpiece racks for each process bath?

☐ Yes ☐ No

✓ The faster a workpiece rack is removed from the process bath, the thicker the film on the workpiece surface, which increases the drag-out volume. By slowing down the removal rate, the volume of drag-out will be reduced.

Notes:

8. Do you work with your customers to design their parts for both improved plating and better drainage?

☐ Yes ☐ No

✓ Adding drain holes and modifying geometry often can be included in parts design to promote better drainage. Also, parts can be designed to optimize the "throw" of metals in the plating bath.

9. Can bars or rails be installed above the process tanks?

☐ Yes ☐ No

✓ Installing bars or rails will allow operators to hang workpiece racks above process tanks to ensure that adequate drainage occurs prior to rinsing. These bars help reduce operator back strain, and therefore are more likely to be used than manual draining.

10. Are personnel trained to consistently follow proper workpiece rack removal rates and drainage times?

☐ **Yes** ☐ No

✓ Training personnel on the proper procedure for positioning workpieces on the racks and proper withdrawal rates can help you reduce the amount of drag-out that is taken from the process tanks.

11. Are personnel re-trained periodically to assure these procedures are followed?

☐ **Yes** ☐ No

✓ The passage of time and the hiring of new people make waste minimization re-emphasis important. Install reminder signs in the plating area, and emphasize the impact of waste minimization upon company success. Your platers are the key to obtaining real waste minimization results.

12. Are spray rinses used above heated process baths?

☐ **Yes** ☐ No

✓ Spray rinses above heated baths can be used to recover drag-out solutions by draining the drag-out back into the process tank. Also, by adjusting the rinse flow rate to equal the evaporation loss rate, the spray rinse can be used to replenish the bath. Use De-ionized water to maintain bath purity. Refer to Table 2.

13. Is there space between process tanks and their associated rinse tanks?

☐ Yes ☐ **No**

✓ A space between the baths and their rinses can allow drag-out of process chemicals to drip onto the floor and enter the wastewater treatment system when the floor is washed down. By installing drain boards that direct drainage back into the process bath, this can be eliminated.

TABLE 2 - Benefits of Dripping and Spraying Over Tanks

Effect	Benefit
Quality Control	
1) Greater solution stability	= Improved quality control
2) Less frequent solution analysis	= Lower quality control labor
3) Less chemical usage	= Lower chemical cost and less labor for chemical additions
4) Less chemical storage due to fewer needed additions	= Lower inventory and smaller storage area
5) Cleaner rinses	= Better product quality
Waste Treatment Costs	
6) Less water usage	= Lower water bills
7) Less sewer discharge	= Lower sewer bills
8) Less chemical usage in waste treatment	= Lower material usage and less chemical storage
9) Better wastewater treatment quality from longer settling time	= More consistent treatment results
10) Less sludge generation and less sludge cake shipped off-site for disposal	= Less treatment labor and lower disposal costs (drums, transport, TSD fees, taxes, documentation & long-term liability)
Improved Regulatory Compliance	
11) Lower sewer water volume	= Potential to go below 10,000 gpd, which is one of the POTW and Permit by Rule cutoff levels.
12) Produce less waste volume, and comply with effluent standards and SB14 waste minimization requirements	= Achieve good community standing, stay in business, reduce waste disposal fees, taxes, and permit costs. Avoid fines for non-conformance to waste handling and documentation requirements.

Source: NAMF (1990)

14. Do you have drain boards between each of the tanks in your plating line?

☐ **Yes** ☐ No

✓ Drain boards between tanks capture the dripping solution off of parts, and route it back to the bath. Depending upon bath chemicals, drip boards may be made of either metal or plastic. Drain boards should be hinged to allow access between the tanks. Also consider a drip tank between the plating and rinse tanks. Parts are hung at this position long enough for plating solution to drip into this empty tank, from which it can be returned to the plating bath.

15. Do process tanks operating at elevated temperatures have static drag-out tanks as the initial rinse following the bath?

☐ **Yes** ☐ No

✓ Use of static drag-out tanks after the process bath is another way to capture process chemicals that adhere to the workpiece, which then can be returned to the bath to compensate for the evaporative losses. These tanks increase the efficiency of the final rinse.

16. Have you studied the possibility of using drag-out solution for replenishing process bath?

☐ **Yes** ☐ No

✓ As workpieces continue to be passed through the drag-out tanks, the concentration of chemicals in the tanks will increase. After a time, the concentration will increase to a point where the solution can be used to replenish the process bath. Pretreatment such as filtration can remove contaminants from the drag-out solution before it is added to the bath.

Decreasing Drag-in and Other Contaminants

The useful life of a plating bath can also be shortened by impurities that are introduced. One type of impurity comes from "Drag-in," which refers to previous bath solutions or contaminants brought with the parts to the plating tank. Minimizing drag-in extends bath life.

17. Do you have the proper rinsing step before each plating bath?

☐ **Yes** ☐ No

✓ The amount of drag-in can be reduced by better rinsing of parts before being introduced in to each bath.

18. Does the way you handle parts contribute to Drag-in?

☐ Yes ☐ **No**

✓ The amount of drag-in can also be reduced by keeping any dust or other contamination off of the parts. This can occur if the shop has airborne dust, if parts are placed upon dusty surfaces, or if parts are allowed to dry.

19. Are each of your tanks clearly labeled?

☐ **Yes** ☐ No

✓ Large, bold, and color-coded labels help keep your workers from placing the wrong chemicals or parts into a plating tank. Some plating shops use tanks and drain boards of various colors to emphasize differences between plating lines.

Notes:

20. Have you tried to use high-purity anodes?

☐ Yes ☐ No

✓ Impurities present in the anodes will stay behind in the plating solution as the anodes dissolves with use. Use of high purity anodes decreases contamination from this source. Use of corrosion-resistant racks is also important.

21. Do you use deionized or distilled water to mix your chemicals, to add to baths for evaporation make-up, and to rinse parts?

☐ Yes ☐ No

✓ Impurities are present in most tap waters. Using "DI" water or distilled water can significantly extend bath life.

Extending Bath Life Through Purification

Bath life can often be extended by removing the impurities. Microfiltration, reverse osmosis, ion exchange and other techniques are available for this purpose. It is important to test the method on your specific bath chemistry as the purification process may remove some chemicals that the bath needs in addition to the undesirable impurities.

22. Are process baths tested on-site by laboratory analyses?

☐ Yes ☐ No

✓ Testing of the process baths for pH, metal content, and other indicator parameters will allow you to determine the need for adding additional chemicals or removing metal contaminants. Understanding the effects of contaminants on the production process and the monitoring of these contaminants can reduce the frequency of dumping process baths.

23. Are process baths filtered to remove particulates?

☐ Yes ☐ No

✓ Filtration systems can be used to remove solids that build up in process baths and reduce the effectiveness of the baths. Continuous filtration can remove these contaminants and allow the bath to have a longer service life. Filtrates may have to be managed as hazardous wastes.

24. Are process baths treated periodically to remove metal contaminants?

☐ Yes ☐ No

✓ Electrolytic dummying, carbon filtration or chemical precipitation are treatment processes that can remove metal contaminants and extend the bath life, which reduces the frequency of mixing new baths and the associated costs. The challenge with these treatments is to remove just the contaminants, and not some of the bath chemicals as well.

25. Are process baths replenished to increase bath life prior to dumping?

☐ Yes ☐ No

✓ As the effectiveness of a bath decreases, try dumping out only a portion of it and adding fresh chemicals and water to replenish it. This approach will reduce the frequency of bath dumping and the amount of wastes needing disposal.

Changing Bath Chemistry, Geometry & Operating Practices

Changing your plating chemistry can lead to a reduction in the hazardous wastes that are generated. Such a change may be to a new plating solution that uses the same type of metal, or may be a shift to a completely new metal that serves the same function. Chemistry changes may include shifts in:

- Soluble anion and cation metal salts;
- Conductivity-enhancing salts;
- Wetting agents for avioding pitting;
- Buffers that slow down pH shifting; and
- Additives that provide brightness and levelling.

Pilot testing of alternatives may be required before substitute chemistries can be effectively used. Recognize that in the short term this testing may generate hazardous waste that you are not set up to handle on-site yet.

Changes in bath geometry may include new electrode sizes, shapes, locations and composition. For example, auxilliary anodes or ones made of new materials may be tried. Non-conducting shield barriers and multiple cathodes may be added to the bath to improve operation.

Operating practice changes include using better voltage and current controls, scheduling periodic operation at reversed current, operating at temperatures above ambient, and using a dummying electrode that selectively removes metal ion impurities.

1. Does your shop generate spent process bath wastes that are not treated onsite due to a concern for upsetting the treatment process?

☐ Yes ☐ **No**

✓ Process baths that cannot be treated onsite must be shipped offsite for treatment and disposal. This is expensive due to ever-increasing transportation, treatment and disposal costs. Therefore, you should look to reduce your wastes wherever possible.

Substitute with recyclable materials or treat onsite to reduce amount going offsite (See Table 3). Many shops handle spent bath solutions in a separate batch treatment system.

2. Has your shop attempted to replace some process bath chemicals, which are considered hazardous waste when spent, with chemicals that can be treated or recycled on-site?

☐ **Yes** ☐ No

✓ Recycling or treating wastes on-site can greatly reduce your hazardous waste management costs, due to the reduction of costs related to offsite treatment and transportation.

Check with your regional office of the Department of Toxic Substances Control to determine if the treatment will require a permit.

Also contact your local chemical suppliers and your industry trade association for information on recyclable materials available.

3. Has your shop replaced chelated process chemistries with non-chelated process chemistries?

☐ **Yes** ☐ No

✓ Chelating compounds in a waste stream inhibit the precipitation of metals, requiring that additional chemicals be added to precipitate the metals. These extra chemicals end up in the sludge, contributing to the total volume of hazardous waste sludge generated.

4. Have you replaced cyanide plating chemistries with cyanide-free chemistries?

☐ **Yes** ☐ No

✓ Cyanide-bearing waste streams must undergo an additional treatment step to destroy the cyanide before they can be treated with the other wastes. This step adds to the sludge volume generated. By replacing cyanide with non-cyanide baths, you can decrease your disposal costs and reduce employee exposure.

Notes:

TABLE 3 - Chemical Substitutes - Zinc Plating

Polluting	Substitute	Comments
Zinc Cyanide	Zinc Chloride (esp. for cast iron)	Acid Form requires special equipment. Both alkaline and acid forms require more attention to process quality control. May have chelating agents and higher metal concentrations.
Zinc Cyanide	Zinc Fluoborate	Poor throwing power, and a less-bright finish unless additives used.
Zinc Sulfate with Cyanide	Zinc Sulfate without cyanide, and with protein additives	Poor throwing power, and a less-bright finish unless additives used.
Zinc Cyanide	Low-Cyanide Zinc	About 20% of the amount of cyanide may be used with suitable results in some applications.

TABLE 3 (Continued) Chemical Substitutes - Nickel Plating

Polluting	Substitute	Comments
Nickel Sulfate (Watts)	Bath with lower nickel concentration	Promotes drag-out reduction.
Electroless Nickel Strike	Electrolytic nickel strike	Prolongs bath life. Use where the throwing power of elecroless nickel is not needed.

TABLE 3 (Continued) - Chemical Substitutes - Chrome Plating

Polluting	Substitute	Comments
Hexavalent Chrome	Trivalent Chrome	Less air emissions, easier to treat in wastewater. Suitable for decorative chrome work, but not for applications needing hard finish. Requires longer plating time. Appearance may differ from hexavalent chrome - requires customer acceptance. Better throw, but hard to control.
Chrome-based Anti-Tarnish	Benzotriazole (0.1-1.0% solution in methanol) or water-based proprietaries	Nonchrome substitute. Extremely reactive, requires ventilation. Caution: Flammable!
Hexavalent Chrome	Cobalt-based solutions	eg, Boeing's proprietary Cobamine process, or Jackson Lea's Alu-Film.
Black Chrome	Black nickel	
Hexavalent Chrome	Nickel-Tungsten-Silicon Carbide	May not have the same performance in all applications.

TABLE 3 (Continued) - Chemical Substitutes - Copper Plating

Polluting	Substitute	Comments
Heavy Copper Cyanide Plating Bath	Copper Sulfate	Excellent throwing power with a bright, smooth, rapid finish. A copper cyanide strike will still be necessary for steel, zinc, or tin-lead base metals. Requires good pre-plate cleaning. Noncyanide process eliminates carbonate build-up in tanks. More drag-out can occur.
Copper Cyanide	Copper Pyrophosphate	Not accepted yet for many Mil-Spec applications. Requires more pre-cleaning. Finite bath life. Puts ammonia into waste system.
Copper Cyanide Strike	Copper Pyrophosphate Strike	Same or better shear strength. Requires more pre-cleaning. Finite bath life. Puts ammonia into waste system.
Copper Cyanide	Copper Fluoborate	Expensive. Very corrosive.
Copper Cyanide	Alkaline Copper	More expensive to operate. Difficult to use for plating zinc die castings.

TABLE 3 (Continued) - Chemical Substitutes - Cadmium Plating

Polluting	Substitute	Comments
Cadmium	Zinc Graphite, Titanium Dioxide, Aluminium	Special processes such as vapor deposition needed for some of these substitutes. Many have not yet obtained mil-spec approval.
	Zinc-Nickel	Finding increased use throughout the industry.
	Zinc-Cobalt	For fasteners.
	Zinc-Iron	For fasteners.
	Zinc-Tin	For electrical connectors.
	Cadmium Oxide	Doesn't need complexing agents. Is highly carcinogenic.
	Cadmium Fluoborate	Operates at low pH, therefore is highly corrosive. Expensive.

TABLE 3 (Continued) - Chemical Substitutes - Cleaners

Polluting	Substitute	Comments
Cyanide Cleaner	Trisodium-Phosphate or Ammonia	Noncyanide cleaner. Good degreasing when hot and in an ultrasonic bath. Highly basic. May complex with soluble metals if used as an intermediate rinse between plating baths where metal ion may be dragged into the cleaner and cause wastewater treatment problems. Ammonia affects treatment plant as well.
Chromic Acid Pickles, Deoxidizers, & Bright Dips	Sulfuric Acid Pickle, Hydrogen Peroxide DeOx, and Potassium Permanganate Bright Dip	Nonchrome substitute. Nonfuming. No anti-tarnish film substitute. Desmearing may be a problem for circuit boards.
Fire Dip (NaCN)	Muriatic Acid with additives Alkaline Activators	Slower acting than NaCN traditional fire dip. Requires periodic reverse current.
Halogenated Solvents	Aliphatic Hydrocarbons, terpenes, or aqueous cleaners	Higher boiling points make many of these unsuited for vapor degreasers.
Nitric Acid Pickle for Aluminium	Ferric Sulfate	Less hazardous and lasts longer.

TABLE 3 (Continued) - Miscellaneous Chemical Substitutes

Polluting	Substitute	Comments
Chelated Strippers	Non-chelated, or electrolytic strippers	
Gold Cyanide	Gold Sulfite	Limited availability.
Silver Cyanide	Non-cyanide Silver	Cannot be plated directly to nickel. Needs thorough rinsing, and careful bath chemistry control. Limited availability.
Chemfilm	Trivalent Chrome or Non-chrome Solutions (eg: Molybdenum)	May not pass Mil-Spec or spot color test. Poor color uniformity. Obtaining good throw is a problem.
Tin-Nickel		
Sodium Cyanide Bright Dip	Ferric Chloride or Zinc Sulfate	For removing stains from copper parts.

TABLE 3 (Continued) - Miscellaneous Chemical Substitutes

Polluting	Substitute	Comments

Source Reduction - Rinse Systems

This section of the *Checklist* covers your rinsing systems. Most of the hazardous waste from your metal finishing shop comes from the treatment of wastewater generated by rinsing. Therefore it is important to look closely at your plating operations, and identify as many ways as possible to obtain effective rinsing with less water. Some of these ways require an investment in new tanks or control equipment. Others can be put to use with minimial expense. For example, spraying over rinse tanks conserves water. It has the additional benefit of promoting better wastewater treatment because the concentration of wastes in the water is lower and doesn't fluctuate. Better wastewater treatment in turn produces a sludge of consistently high metals content that is more readily recycled.

However, all waste minimization involving rinse waters require on-going committment and attention by you and your production people in order to be effective.

As a first step, draw a diagram showing the rinsing systems that you use today in your plating shop. Indicate fresh water make-up, water recycling, in-tank agitation, and other features in your present system. Also indicate the water and air flow rates where these are known.

Notes/Diagrams:

Source Reduction - Rinse Systems (Continued)

Obtaining good plating quality in the least time is the key goal for most shop personnel. In many instances, more rinse water is used than is necessary to meet this goal. How can the same plating quality be assured but with less rinse water? The answers are different for each shop, but will include three basic strategies:

- **Minimize the amount of material that has to be rinsed off of the parts.** Careful drag-out reduction at the preceeding plating step makes rinsing easier and more effective. Take these measures first. Refer back to Page 36 for details.

- **Make best use of the time that parts are in contact with rinse waters.** Rinsing type, agitation, parts orientation, and tank design all contribute to rinsing effectiveness. Some of these techniques are automatic, and work in the background with little operator involvement. Many, however, rely upon training and operator attention in order to get results. Take these measures second, before proceeding with projects that require spending more or rearranging your shop.

- **Increase the number of times that rinse water is used.** Reuse and recycling can both decrease the needed amount of make-up rinse water to a small fraction of previous levels. Take these measures last after having reduced the overall quantity of water that you use in the individual rinse tanks.

The following specific steps can be taken to reduce the amount of rinse water used:

- Improve Rinse Tank Design
- Install Conductivity Sensors and Flow Controls to Limit Water Use
- Use Water Spray Nozzles and Air Knives
- Increase Turbulence in Rinse Tanks
- Reuse Rinse Water in Multiple Rinse Tanks, and Spray over Tanks

Improve Rinse Tank Design

Optimize the size, shape and internal elements of rinse tanks.

1. Have you evaluated how water flows inside your rinse tanks ?

☐ **Yes** ☐ No

✓ Tank size, shape and internal baffles should be such that rinse waters circulate thoroughly and do not "short-circuit" from the inlet directly to the outlet. Where possible, locate the influent piping at the bottom of the tank, away from the point where parts enter the tank. Be sure to provide backflow prevention if you arrange your piping this way.

2. Do your rinse tanks have splash guards and drain boards?

☐ **Yes** ☐ No

✓ These features help collect and return splashed water back to the tank.

Notes:

Install Flow Controls to Limit Water Use

Flow control can be accomplished with flow meters, conductivity meters, or timers.

1. Are the flow rates of each rinse system based on the rinsing needs of the process chemistry?

☐ Yes ☐ No

✓ Determining the most efficient flow rate for each single stage rinse system can reduce the volume of wastewater generated, and also save in water usage fees, sewer fees, and sludge handling costs.

2. Does your shop use flow restrictors, flow control meters, or other devices to regulate water flow through rinse tanks?

☐ Yes ☐ No

✓ Rinse water flow control devices can be used to increase the efficiency of the rinse systems and also reduce your water usage.

A ***flow restrictor*** can be installed at one point upstream of all rinse water systems and set at a flow rate that is less than that required amount to operate all rinsing lines together. This restrictor will force operators to turn off lines not in use to allow proper functioning of the lines they are using. Next, observe how much water is needed by each rinsing system. Once the best rinse water flow rate is determined, take out the main flow restrictor and replace it by installing separate flow controls at individual tanks to maintain their own optimal flow rate.

Conductivity probes or pH meters can also be used to control fresh water flow through a rinse system, allowing fresh water into the tanks when needed to reduce the concentration buildup of contaminants in the rinse tanks. Meters of this type require frequent inspection and maintenance, but they are the best alternative because they provide better product quality and consistent contaminant removal, which in turn promotes better wastewater treatment results.

Flow rate meters, timers and control valves can be used in cases where the rinsing is predictable from one batch of parts to the next.

3. Are pipes properly sized to carry the required water flows?

☐ Yes ☐ No

✓ Oversized pipes can carry more water than is necessary for proper rinsing, therefore increasing the volume of water wasted. Pressure reducing valves can be installed upstream of the rinse tanks in the water influent lines to decrease the flow. Pressure reduction through a nozzle in the rinse tank can be used to provide a source of agitation.

Notes:

4. Are rinse water flows turned off when not needed?

☐ Yes ☐ No

✓ Foot switches or timers may be used to turn off water flows when an operator is not present at a rinse tank. Some shops turn on water flows based upon pressure switches that detect when a parts rack is lowered into the rinse tank.

5. Are rinse tanks turned off during break periods?

☐ Yes ☐ No

✓ Include turning off rinse water flows during break periods in your operational procedures to save energy and water.

Use Water Sprays and Air Knives

Spraying can remove contaminants from workpieces with much less water than immersion rinsing. Spraying is effective except for some hard-to-reach areas of complicated parts. This limitation can be overcome by spraying first, and then finishing the rinse in a dip tank.

1. Does your shop use sprays over rinse tanks?

☐ Yes ☐ No

✓ Spray rinses save time, require less space than counter-current rinses, and use one-eighth to one-fourth the volume of water flowing into a dip tank. Spray rinsing above the dip rinse tank can be done in conjunction with immersion rinsing. This combination permits lower water flows in the rinse tanks because the spray rinse removes much of the drag-out before the workpiece is immersed in the dip rinse tank.

Alternatively, consider using a spray rinse by itself over a tank meant only to catch the draining water. Refer to Figure 1 (Page 64) for an example of such a stand-alone recirculating spray rinse tank.

2. Can you use spray rinses above heated plating tanks?

☐ Yes ☐ No

✓ Spray nozzles can be installed above heated process tanks provided the volume of rinse water from the spray system is less than or equal to the volume of water lost to heat evaporation.

3. Can you use air knives above plating or rinse tanks?

☐ Yes ☐ No

✓ Air knives are a better choice when the bath evaporation rate is too low to accommodate the water that spray nozzles would add. Air pollution control and protection of operator health must be considered in the evaluation of air knives.

Spray rinses and air knives must be designed to:

- Evenly distribute the water or air across the parts,
- Carefully control the volume of water used,
- Avoid splattering, overspray, and misting onto the floor and into adjacent tanks,
- Be located out of the way so as not to snag parts.

Notes:

Example - Spray Rinse System

Spray rinses can also be installed as recirculating spray rinse systems. A recirculating rinse system was installed by the Navy, into three of their hard chrome plating lines. The prototype rinse system was installed using an existing rinse tank (see Figure 1).

A foot-activated pump recirculates rinsewater through eight high velocity spray nozzles located along the inside of the rinse tank. Fresh rinse water is available through the hand held spray rinse. During the course of the day rinsewater from the rinse tank can also be pumped through a filter to the plating bath to make up for evaporation losses. Therefore this system can be considered to be a "zero-discharge" plating system.

Fog nozzle rinse systems can be used to rinse workpieces directly over the process tank, but a limiting factor is the evaporation rate of the process liquids in the tank.

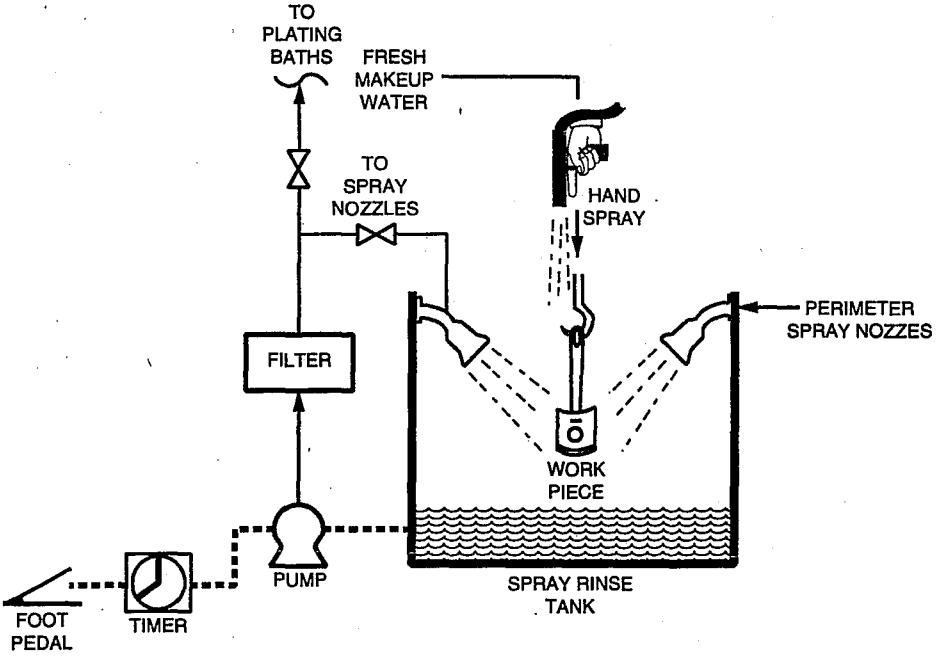


FIGURE 1: Recirculating Spray Rinse System

Increase Turbulence in Rinse Tanks

Rinsing can be made more effective by having the water flow quickly past the parts. Air or water may be injected into the rinse tank for this purpose. If these techniques are not feasible, then some degree of turbulence can be created by the operator moving the parts rack in the tank. Ultrasonic vibration of the liquid is also effective.

1. Do the rinse systems use forced air or forced water as a means of agitating the rinse solution?

☐ **Yes** ☐ No

✓ Providing turbulence between the workpiece and the rinse water increases the rinse efficiency of your system. This is done by pumping air or water into the immersion rinse tank. Air agitation provides the best rinsing because the air bubbles create the best turbulence for removing the chemical process solution from the workpiece.

The air must be free of oil and other contaminants. A centrifugal blower is best for providing this air because it is oil free and also heats the rinse (rather than cools it as would a stream of compressed air).

2. If no, are workpiece racks agitated manually in the rinse solutions?

☐ **Yes** ☐ No

✓ If you operate hand lines you can create the needed turbulence by having the operators move the workpiece racks manually while submerged in the rinse tanks. The effectiveness of this method depends on the cooperation and training of the line operators.

It is usually more effective to dip and withdraw racked parts than it is to swirl the rack around in the rinse tank. And when barrels are used, keeping part of the barrel above the water surface increases rinsing effectiveness. But agitating the water in the rinse tank by using forced air or water is overall the most efficient method for creating turbulence.

Notes:

Example - Multiple Counter-flow Rinse Tanks

Multiple rinse tanks can be used to provide sufficient rinsing while significantly reducing the volume of rinse water needed. A multi-stage countercurrent rinsing system can use up to 90% less rinse water than a conventional single-stage rinse system. As shown by Figure 2, workpiece flow moves in an opposite direction to the rinse water flow. Water exiting the third rinse tank (the last tank that the workpiece is immersed into) becomes the feed water to the second tank. After being used, this water feeds the first rinsetank, and so on for the number of tanks in the line. The diagram below illustrates the use of a triple-stage counter-current rinse system. The effectiveness of this multi-stage system in reducing rinse water usage is illustrated in the following example.

A plant operates a process line where approximately 1 gallon of drag-out per hour results from a chemical process bath. The process requires a dilution rate of 1,000 to 1 to maintain acceptable rinsing in the tank. Therefore, the flow rate through the tank is 1,000 gallons per hour. If a double stage countercurrent system were used, a rinse flow rate of only 30 to 35 gal/hr would be needed. Using a triple stage would reduce it to 8 to 12 gal/hr.

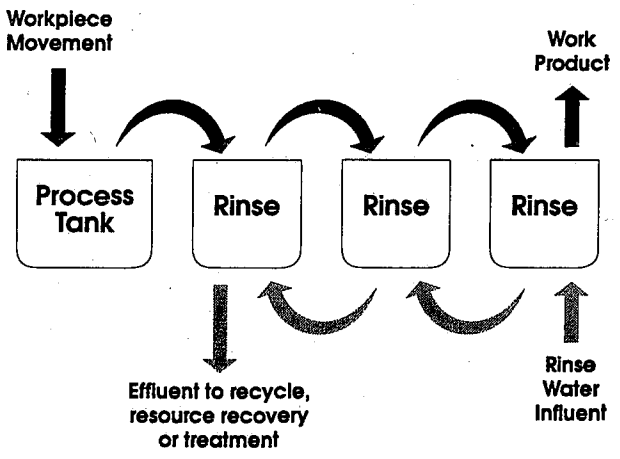


FIGURE 2: Countercurrent Rinse System

1. Does your shop have available space to install multiple rinse tanks in any rinsing stations?

☐ Yes ☐ No

✓ Multiple rinse tanks can provide sufficient or even improved rinsing while significantly reducing the volume of rinse water used. The volume of rinse water used in a multi-stage countercurrent rinsing system can be as little as a few percent of that used in a single-stage system. Plan on obtaining a 6:1 to 10:1 reduction in water use for every added stage of rinsing that you install.

2. Have you evaluated changing the production process layout to more efficiently use space?

☐ Yes ☐ No

✓ Installing a multi-stage countercurrent rinse system usually requires additional floor space, so if you can reconfigure your process layout to install a countercurrent rinse system, it can help you reduce your water usage.

3. Can the size of existing rinse tanks be reduced to allow for additional rinse tanks to be installed?

☐ Yes ☐ No

✓ If you cannot alter your process layout, you might be able to acquire floor space by installing new tanks that are smaller in size, or by adding sprays over the tanks. Sprays of this type further reduce the amount of water used.

4. Are the existing rinse tanks big enough that internal walls can be installed to create additional rinse tanks?

☐ Yes ☐ No

✓ Segregating the existing tanks into multiple compartments and using a cascading system may prove feasible if your existing tanks are sufficiently large. Another approach is to add a spray rinse step in the open space above the rinse tank.

Notes:

RESOURCE RECOVERY

Resource recovery involves both material reuse and recycling. Material reuse, a form of source reduction, occurs when the waste from one process is directly used as raw material for the same or another process. Recycling involves the purification, separation or concentration of valuable material from a waste stream before the waste is disposed of. The material is then used by the originating process, or by another process at the same site. Recycling may take place either on-site or elsewhere through an off-site service.

Waste material reuse includes:

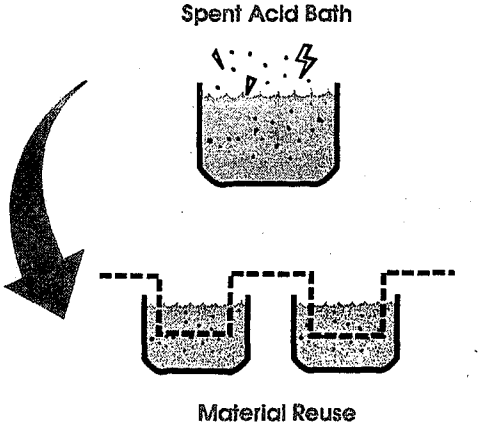
- Drag-out Return
- Rinsewater Return
- Reactive Rinsing
- Countercurrent Rinsing
- Wastewater Treatment

Recycling opportunities include:

- Plating Bath Purification
- Rinsewater Reclamation
- Metals Recovery

Resource Recovery - Material Reuse

Understanding the chemical properties of your waste stream is critical to assessing the potential for reuse of the waste as a raw material. Although the chemical properties of a process bath or rinse water solution may render them unacceptable for their original use, they may still be used in other applications. Evaluate waste streams for the properties that make them useful instead of for the ones that make them a hazardous waste.



1. Do you generate rinse water effluents from rinse tanks that follow mild and/or strong acid cleaners or etchants?

☐ Yes ☐ No

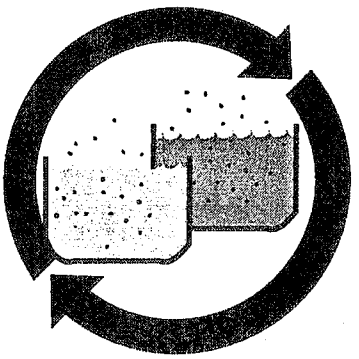
✓ You might consider reusing the acid rinse solution back into the rinse systems following the alkaline cleaning baths or returning the strong acid rinse solution back into the rinse following the mild acid cleaning bath. (See Figure 3 on Page 72.)

2. Do you generate spent acid and/or spent alkaline solutions?

☐ Yes ☐ No

✓ Spent acid and/or alkaline solutions may be used to adjust pH or for neutralization in your treatment systems. Spent acids may be used for chromium reduction. Reuse of your spent materials in this way will help you reduce both your chemical purchases and waste disposal costs.

Notes:



Resource Recovery - Recycling

In the past, metal recovery from metal finishing was not considered to be economical. But with increased regulatory requirements for pretreatment of effluent, and increased disposal costs of hazardous waste, you might now find it economical to recover metals and metal salts from spent process baths and rinse water, or even reuse rinse water.

3. Does your shop currently use any recycling technologies applicable to your waste streams?

☐ **Yes** ☐ No

✓ Material recycling can significantly reduce the volume of waste material generated or can render the residuals nonhazardous. Chemicals lost through drag-out may also be recovered using some of these techniques while at the same time reducing the waste volume generated.

4. Do you lose drag-out to the rinsing system?

☐ Yes ☐ **No**

✓ Refer to earlier discussions of drag-out recovery and reuse.

5. Can waste streams be segregated?

☐ **Yes** ☐ No

✓ To facilitate the use of resource recovery techniques or processes, you should segregate your wastes.

6. Have you explored possible recovery systems available for your processes?

☐ **Yes** ☐ No

✓ Some of the treatment system technologies that are available for resource recovery applications are evaporation, reverse osmosis, ion exchange, electrolysis, and electrodialysis. Most of these can be installed in a closed- or open-loop system.

7. Do you use any of these treatment technologies to recycle rinse water?

☐ **Yes** ☐ No

✓ Rinse water make-up can usually be obtained as a useful byproduct of these treatment systems. Prefiltration may be needed.

8. Have you evaluated the potential for closed loop or open loop rinse water systems?

☐ **Yes** ☐ No

✓ A closed loop system will usually significantly reduce your rinse water treatment needs.

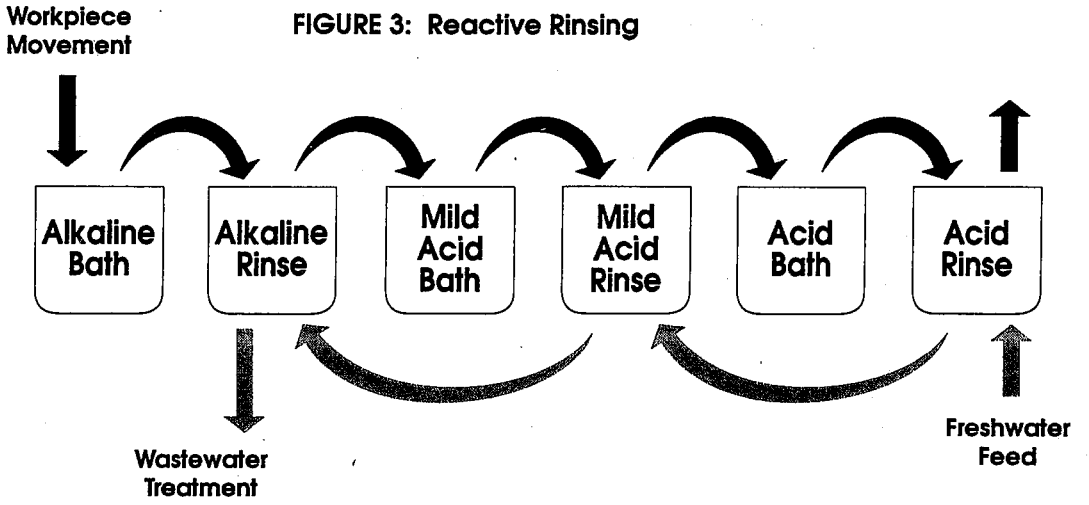
Notes:

Example of Material Reuse - Reactive Rinsing

Effluent from a rinse system following an acid cleaning bath can be reused as influent water to a rinse system following an alkaline cleaning bath. If both rinse systems require the same flow rate, 50% less rinse water would be used to operate them. If three rinsing steps are involved, as shown below, the water use reduction is 67%.

In addition, reusing water in this way can improve rinse efficiency for two reasons. First, the chemical diffusion process is accelerated because the concentration of alkaline material at the drag-out film and surrounding water interface is reduced by the neutralization reaction, and secondly, the neutralization reaction reduces the viscosity of the alkaline drag-out.

FIGURE 3: Reactive Rinsing



If each of the three tanks operated at the same flow rate, total water usage would be reduced by 67% of separate once-through rinse systems.

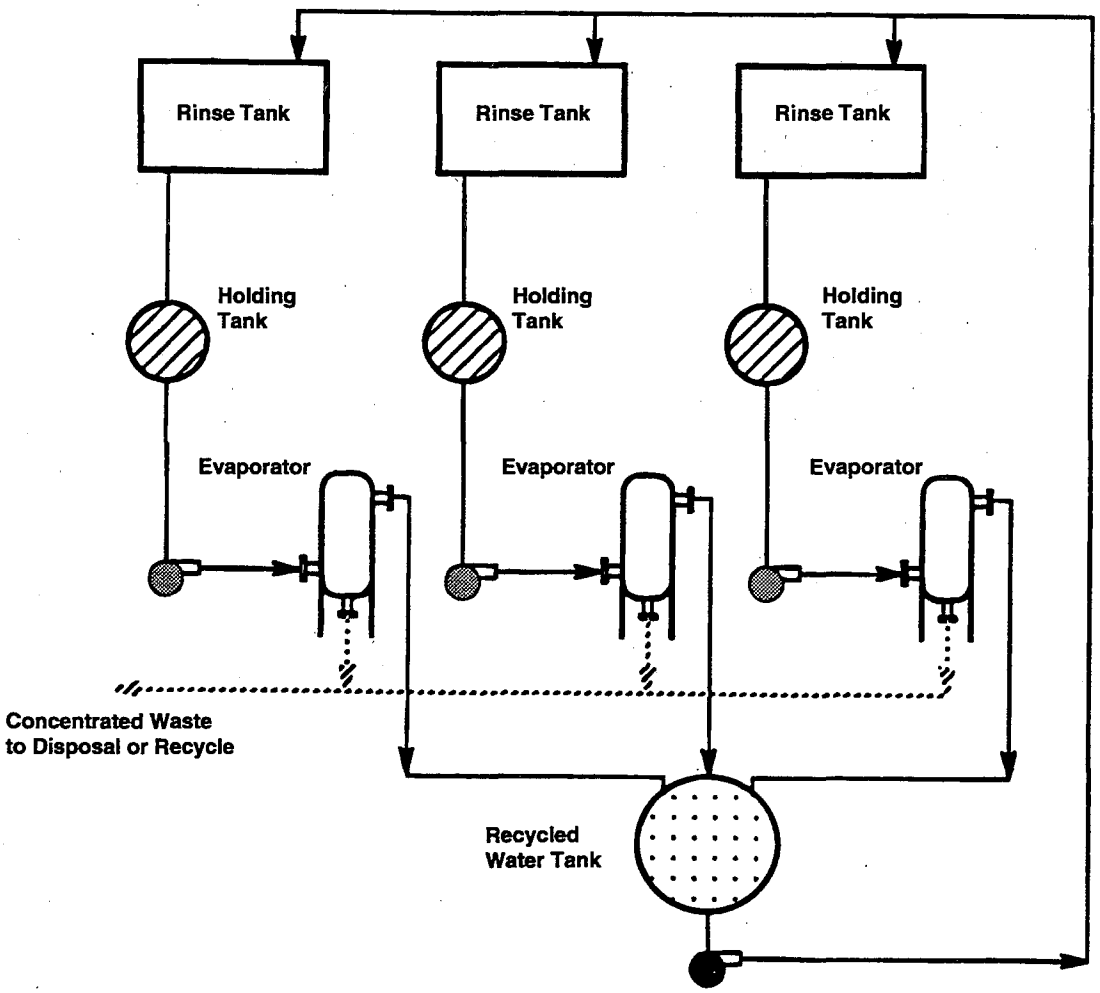
Notes:

Example of Rinse Water Recycling

Effluent from one or more rinse systems may be recycled through evaporators or ion-exchange columns. One such system is reported by the Lawrence Livermore National Laboratory, Material Fabrication Division.

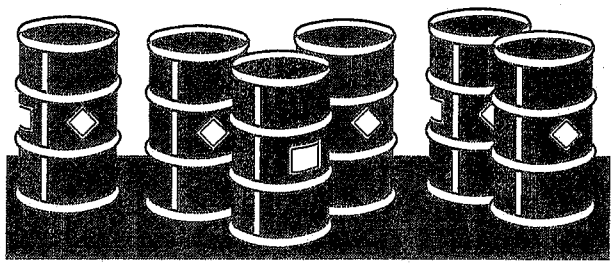
In this closed-loop system, each of five waste streams are segregated by separate drain lines, holding tanks, dirty water tanks and evaporator chambers (See Figure 4 below). The concentrated, dirty-water streams are collected in separate tanks and periodically shipped to the site waste management unit for handling. The clean water condensed from each evaporator is collected in a clean water tank, from which it is pumped as make-up back to the plating rinsewater systems. As a next step, the Material Fabrication Division plans to recycle specific metals and cleaners from the dirty water.

FIGURE 4: Rinsewater Recycling



Solvent Recycling

Solvent wastes generated by the metal finishing industry are a significant waste management problem.



1. Do you use halogenated or hydrocarbon solvents?

☐ Yes ☐ No

✓ Refer to earlier discussions regarding solvent use reduction and recycling (Page 28).

2. Have you considered using non-solvent based cleaners?

☐ **Yes** ☐ No

✓ It may be possible for your pre-cleaning or degreasing operations to be accomplished using aqueous cleaning solutions instead of solvents. Spent aqueous cleaning solutions can be batch treated onsite or in an existing treatment system.

3. Have you considered recycling solvents onsite?

☐ **Yes** ☐ No

✓ If shifting to an aqueous cleaner is not feasible, and you must use solvents, then solvent distillation equipment is available for on-site recycling.

Batch distillation equipment is available in sizes from 3 gallons to 260 gallons. Some vendors also lease various sizes of degreasing equipment, supply the solvent, and take the waste solvents off-site for recycling.

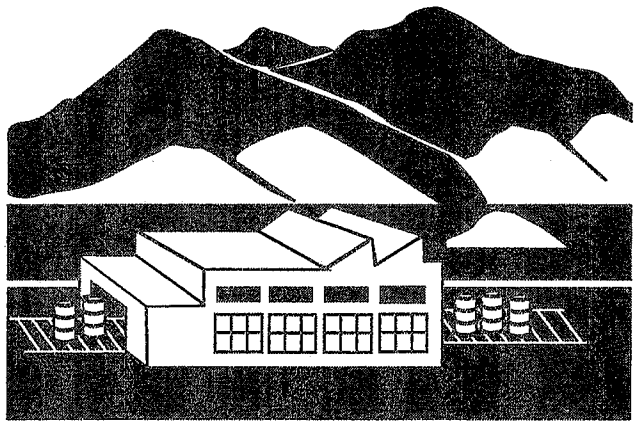
The appropriateness of solvent recycling for your shop depends upon a number of factors, such as:

- which solvents you use;
- how many different solvents are used;
- what quantity you use;
- what each solvent costs;
- utility needs of distillation equipment; and
- air quality permit requirements.

Notes:

TREATMENT ALTERNATIVES

Although treatment alternatives usually produce a residual hazardous waste, many of them can be used to reduce the amount of hazardous waste generated. This can lead to a reduction in the associated costs for waste handling and disposal. Alternative treatment technologies designed to reduce the volume of hazardous waste include pretreatment of process water, conventional treatment process modifications, and alternative treatment technologies.



Process Water Pretreatment

1. Do you pretreat water prior to its use in production processes?

☐ **Yes** ☐ No

✓ Pretreat your process water to remove the natural contaminants such as phosphates and carbonates, which contribute to the total volume of sludge generated as hazardous waste during your eventual waste treatment. Removing these contaminants will also increase your rinsing efficiency, therefore helping you reduce the volume of water needed.

Conventional Wastewater Treatment Modifications

2. Does your shop operate an industrial waste treatment facility?

☐ Yes ☐ No

✓ Familiarize yourself with recently enacted regulations covering the permits needed for these treatment systems. The most common treatment system used by metal finishers is chemical treatment to remove metals and to destroy cyanides. Many also use filtration to dewater the sludge produced by the treatment.

3. If yes, does it use standard chemical precipitation technologies that produce a hazardous waste sludge?

☐ Yes ☐ No

✓ Use alternative treatment chemicals for chemical precipitation to reduce the volume of sludge generated. Try substituting caustic soda or magnesium hydroxide for lime in the precipitation step, or use polyelectrolytes as coagulating agents instead of alum or ferric chloride. Operate your wastewater treatment system to produce the minimum amount of sludge, but that has characteristics that make it acceptable to off-site recyclers.

Notes:

4. Do you use chelators in any process baths?

☐ Yes ☐ No

5. Do you segregate waste streams containing chelators?

☐ **Yes** ☐ No

✓ Segregate chelating-containing wastes from other wastes so you can give them special treatment. This approach will reduce the required amount of chemicals needed to break down the metal complexes. Reduction in chemical usage decreases the volume of sludge generated.

6. Do any of your process chemistries contain cyanide?

☐ Yes ☐ No

7. Do you keep them separate from other wastes?

☐ **Yes** ☐ No

✓ Cyanide-containing wastes need to be treated separately from other wastes because they must undergo chemical oxidation to destroy the cyanide. But you also need to explore alternative treatment and recycling opportunities. For example, use electrolysis instead of alkaline chlorination for concentrated waste streams containing more than 1% cyanide.

8. Do you use process baths containing hexavalent chromium?

☐ Yes ☐ No

9. Do you segregate these wastes before performing chrome reduction?

☐ **Yes** ☐ No

✓ Waste streams requiring specialized treatment should be kept separate to ensure that you only treat those wastes requiring the specialized treatment, and not all of the wastes, which could increase your chemical usage and sludge volume.

10. Are waste streams needing only neutralization kept separate from those requiring metal removal?

☐ **Yes** ☐ No

✓ Acidic or alkaline waste streams that do not contain metals may only need to be neutralized prior to discharge without having to undergo metal removal treatment. This will save on chemical usage and costs.

Notes:

11. Is the industrial waste treatment sludge dewatered prior to offsite disposal?

☐ **Yes** ☐ No

✓ Dewatering of sludge can reduce its volume. Mechanical dewatering equipment can achieve 35% solids in sludge. Increasing the solids content from 3% to 35% represents a reduction in volume of 8 to 1, from 20% to 35% a 2 to 1 volume reduction. Volume reduction decreases your disposal costs.

12. Have you considered using sludge dryers?

☐ **Yes** ☐ No

✓ Sludge dryers can further reduce the volume of your sludge. For instance sludge dryers can increase solids content from 35% to 90%, which represents an additional sludge volume reduction of 3 to 1.

Alternative Waste Treatment

13. Have you tried using alternative treatment methods for your waste streams?

☐ **Yes** ☐ No

✓ Many alternative treatment systems can be used for treating a plants total waste stream or to batch treat selective waste streams.

Many of these treatment methods produce a residue that requires disposal as a hazardous waste, but the volumes generated are typically much lower than the volume of the sludge generated by conventional treatment methods. Some of these alternative treatment methods are ion exchange, evaporation and electrolytic metal recovery.

Notes:

Notes:

SECTION 2:
EVALUATION OF WASTE MINIMIZATION OPTIONS

After completing the checklist in Section 1, note your Waste Minimization Options in Table 4 that starts on Page 86. Then use the following scores to evaluate your options further. Each option will be rated and given a point score in four areas:

1) Where does the option fit in the *Waste Minimization Hierarchy*?	- 1 to 5 points
2) What is the option's *Implementation Potential*?	- 0 to 4 points
3) What is the *type* of option?	- 1 to 4 points
4) How much does the option *cost*?	- 1 to 4 points

Add up the point scores for each option. In Section 3 you will examine more closely those specific waste reduction options that score the highest. And, you can drop from further consideration any options that have no implementation potential.

1) Waste Minimization Hierarchy

The waste minimization hierarchy (WMH) consists of the following, which are listed in the preferred order. The Waste Minimization Fact Sheet for Metal Finishers can help you identify an option's place within the waste minimization hierarchy.

SR	=	Source Reduction	=	5 pts.
RR	=	Resource Recovery	=	4 pts.
RI	=	Recycling (in-process)	=	4 pts.
RE	=	Recycling (end-of-pipe)	=	3 pts.
TI	=	Treatment (in-process)	=	2 pts.
TE	=	Treatment (end-of-pipe)	=	1 pt.

2) Implementation Potential

The implementation potential (IP) is the chance that you believe an option has of being used in your shop:

High	=	4 pts.
Medium	=	3 pts.
Low	=	2 pts.
None	=	0 pts.

For options that you evaluate as "none" or having no potential of being implemented into your shop, no further evaluation is necessary. However, keep track of such options because you may wish to reconsider them at a later date if circumstances at your shop have changed.

3) Type of Option

"Type of option" refers to what the option consists of, and what level of effort is required to put it to use. Four classes or types of options were developed by the original authors of this *Checklist*. You may feel that a further breakdown is necessary, or may want to establish your own classes. Feel free to make changes since only you know about your individual shop practices. The four classes are:

P/P	=	Policy or Procedural Change	=	4 pts.
PM	=	Process Modification	=	3 pts.
EM	=	Equipment Modification	=	2 pts.
NE	=	New Equipment	=	1 pt.

4) Cost of Option

"Cost of option" refers to a rough idea of what you believe it will cost to implement each waste reduction option. Specific cost details will be estimated later in Section 3.

None or no cost	=	4 pts.
Low cost	=	3 pts.
Medium cost	=	2 pts.
High cost	=	1 pt.

Total Point Score

Evaluate each option in the four areas, add up their scores and complete the table. Review the table to identify the options with the highest scores. A score of 17 is possible.

This is a preliminary analysis of the options to quickly identify those which are desirable for implementating into your shop. A more detailed study into the costs of each option should be conducted in Section 3 to see exactly how the option will affect your shop financially and the option's payback period.

The above classes and point values for each area were determined by the original authors of this document. As such, they are not hard and fast rules, only guidelines. If you feel you have more than four ways to evaluate options, develop your own classes and their respective point values.

Remember, the primary purpose of this part of the *Checklist* is to stimulate your thinking about which waste minimization options make the most sense within your shop.

Example: Waste Minimization Option Evaluation

Example: Evaluate the following two options to determine the Waste Minimization option that would be the most attractive.

1) Start a First-in First-out Material usage policy.
2) Install Ion-Exchange in-process to recycle rinsewater.

Waste Minimization Technique	WMH Scored by authors	IP H (4) M (3) L (2) N (0)	Option Type P/P (4) PM (3) EM (2) NE (1)	Option Cost N (4) L (3) M (2) H (1)	Option Total
1. First-in First-out Material Policy	SR (5)	H (4)	P/P (4)	N (4)	**(17)**
2. Install Ion Exchange	RI (4)	L (2)	NE (1)	H (1)	**(8)**

After totaling the scores you can see that implementing a first-in first-out policy should be implemented before installing an ion-exchange unit. The next step is further evaluation of the economic feasibility and associated payback period using the worksheets in Section 3.

Note: The waste minimization options listed in Table 4 originated with the first edition of this *Checklist*, and were subsequently revised as part of a project conducted by the authors for the San José/Santa Clara Water Pollution Control Plant.

TABLE 4: Waste Minimization Option Evaluation Worksheets (16 Sheets)

(Courtesy Of The San José/Santa Clara Water Pollution Control Plant)

Waste Minimization Option Evaluation

(Page 1 of 16)

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR = 5 MR/RI = 4 RE = 3 TI = 2 TE = 1	IP Score High = 4 Med = 3 Low = 2 None = 0	Option Type Change Procedure = 4 Change Process = 3 Change Equipment = 2 New Equipment = 1	Option Cost None = 4 Low = 3 Med = 2 High = 1	Total Score
1. MATERIAL STORAGE & HANDLING								
1.1 Improve Storage Area Layout								
• Space between containers to allow inspection				SR(5)				
• Cover over area to prevent deterioration of materials				SR(5)				
• Sealed concrete floor to prevent leaks				SR(5)				
• Spill containment dike to contain leaks and prevent further contamination				SR(5)				
• Containers on pallets or grating to prevent corrosion of the containers				SR(5)				
• Access & traffic control to reduce potential for contaminating raw materials or causing spills				SR(5)				
•								
•								
•								
•								
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
1.2 Prevent Material Degradation								
• First in—first out inventory control used to prevent material deterioration				SR(5)				
• Order quantities matching use. Consider using larger reusable containers for frequently used chemicals. If smaller quantities are used buy only what you need.				SR(5)				
• Conduct frequent inventories to identify any accumulation of material that may be nearing the end of its shelf life.				SR(5)				
• Reseal partially used containers to prevent deterioration				SR(5)				
•								
•								
•								
•								
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR=5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High=4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment=1	Option Cost None=4 Low=3 med=2 High=1	Total Score
1.3 Carefully Manage Samples								
• Test new ideas at bench-scale to reduce the volume of waste needing disposal				SR(5)				
• Designate sample control person to minimize the number of samples that are accumulated				SR(5)				
• Return unused samples to supplier to avoid collecting excessive materials that may need disposal				SR(5)				
•								
•								
1.4 Plan Ahead For Spill Control								
• Train workforce in proper handling and storage techinques and proper spill control				SR(5)				
• Provide containment dikes to minimize the amount of cleanup materials need for spills				SR(5)				
• Provide spill cleanup kits for quick respones to spills				SR(5)				
•								
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
1.5 Improve Bath Formulation								
• Designate mixing personnel to improve consistency of the baths and minimize wastes				SR(5)				
• Control opening of new containers to reduce the amount of wasted raw materials				SR(5)				
• Rinse and return empty containers to avoid having to dispose of them				SR(5)				
• Mix baths to standard recipes to give consistent results and less waste and to avoid mixing up chemical names				SR(5)				
• Have Materials Safety Data Sheets available to assist in proper spill cleanup and to avoid confusing chemicals				SR(5)				
•								
•								
•								
•								
•								

Waste Minimization Option Evaluation

(Page 5 of 16)

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
1.6 Conduct Frequent Inspections								
• Inspect piping systems, storage tanks, defective racks, air sparging systems, automated flow controls, and production procedures weekly to reduce waste generated				SR(5)				
• Maintain inspection logs to ensure items are corrected				SR(5)				
• Immediately repair malfunctions to reduce the amount of waste that is generated				SR(5)				
• Track items noted but not fixed				SR(5)				
• Fix deteriorated labels so that the material does not end up as hazardous waste because of the uncertainty of the container's contents				SR(5)				
•								
•								
•								
•								
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2. PRODUCTION PROCESSES								
2.1 Review Parts Preparation								
• Get customers to clean parts better so there will be less cleaning waste				SR(5)				
• Handle & store parst better to avoid contaminnating them				SR(5)				
• Prevent water contamination of solvents which can inccrease the loss of solvent through evaporation and can acidify the solvent to the point where it is no longer usable				SR(5)				
• Allow sufficient draining time to minimize the amount of solvent drag-out				SR(5)				
• Change h alogenated solvents to less toxic non-halogenated solvents, e.g. to: —Hydracarbon solvents —Organic solvents (e.g. terpenes) —Aqueous solvents				SR(5)				
• Change hydrocarbon solvents to less toxic non-hydrocarbon solvents, e.g. to: —Organic solvents —Aqueous solvents				SR(5)				

Waste Minimization Option Evaluation

(Page 7 of 16)

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR=5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High=4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment=1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2.1 Review Parts Preparation (continued)								
• Change degreasers: —To include a closeable lid to reduce evaporation —To include a refrigerated vapor space to reduce evaporation				SR(5)				
• Change cleaner soak tanks: —To include spray rinsing above tank which will reduce drag-out —Add ultrasonic system to increase efficiency of cleaning tank —Use air/liquid agitation in tank to increase cleaning efficiency				SR(5)				
• Use spray cleaning instead of soak tank to increase cleaning efficiency				SR(5)				
• Use DI water to make cleaner solutions to extend the useful life of the bath				SR(5)				
•								
•								
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2.2 Improve Process Baths								
• Change bath chemistries to reduce the toxicity of waste generated, e.g.: —Shift to non-chelated solutions —Shift to non-cyanide solutions —Shift to non-chrome solutions				SR(5)				
• Reduce drag-out of process solutions: —Lower bath concentration to reduce viscosity allowing the solution to drain better —Increase bath temperature to reduce the solution viscosity —Use surfactants to lower surface tension and allow better draining —Orient parts to allow better draining —Remove parts more slowly to allow more draining —Install rack hangars so operators can hang racks above tank to ensure adequate drainage —Install drain boards that will catch solution and direct it back to process tank —Install dragout drip tanks to capture chemicals before they are dragged out, and return them to process tank				SR(5)				

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost: Dollar Amount To Implement	% Metals Reduction: Percent of Total Metals for Facility	WMH Score: SR =5, MR/RI=4, RE=3, TI=2, TE=1	IP Score: High =4, Med=3, Low=2, None=0	Option Type: Change Procedure=4, Change Process=3, Change Equipment=2, New Equipment =1	Option Cost: None=4, Low=3, med=2, High=1	Total Score
2.2 Improve Process Baths (continued)								
• Reduce drag-in of process solutions: —Pre-rinse parts to remove all of solution before moving the part to the next tank to avoid cross contaminating solutions —Label all tanks to prevent workers from placing the wrong chemicals or parts into a tank —Use high purity anodes to minimize the amount of contaminant that is added to a tank —Use DI water for make-up of solutions to reduce the amount of contaminants in the plating solutions —use corrosion-resistant racks to minimize the amount of contaiminats entering the plating solutions				SR(5)				
• Purify baths rather then dump them to minimize the amount of hazardous waste to treat: —Conduct lab test to determine just the right chemicals to add to the solution —filter out particulates from baths to maintain the bath's efficiency —remove metal contaminants through electrolytic dumming, carbon filtration, chemical precipitation, or other purification step to extend the bath life				RI(4) RE(3)				

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2.2 Improve Process Baths (continued)								
• Change bath chemistry to reduce the generation of hazardous waste: —Metal salts to less hazardous material —Conductivity-enhancing salts to allow more efficient plating —Wetting agents to avoid pitting and off-spec material —pH buffers to better maintain quality of bath —Brightness and leveling agents that maintain bath and avoid off-spec material				SR(5)				
• Change bath geometry to improve operating efficiency: —New electrode sizes, shapes, etc. to increase plating efficiency —Multiple ;cathodes to increase plating efficiency				SR(5)				
• Change bath operations to improve plating efficiency: —Improve voltage and current control to allow better plating and less off-spec material —Use a dummying electrode to remove metal ion impurities and extent life of bath				SR(5) MR(4)				
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2.3 Improve Rinse Systems								
• Change rinse tank design to minimize drag-out: —Improve size, shape and water flow to allow better rinsing —Add splash guards to collect and return splashed water back to the tank —Add drain boards to collect and return drag-out water back to the tank				SR(5)				
• Add flow controls to limit water use: —Adjust flow rate to match need thus reducing the volume of wastewater generated —Install main flow restrictor which will force workers to conserve water —Use pipes of right size to advoid excess use of water —Use rack sensor switches to turn water off when no parts are present —turn rinses off manually when tank is not in use				SR(5)				
• Add fog/spray/air rinses to improve rinsing: —Use fog rinse over heated process tank to keep most of solution in bath —Use spray rinse over rinse tank to minimize wastewater —Use air knives to remove solution from parts as they are removed from the bath				(SR(5)				

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
2.3 Improve Rinse Systems (continued)								
• Provide turbulence in rinse tanks to maximize rinsing efficiency: —Add air agitation to assist in removing the plating solution from the workpiece —Use water circulation by pumping to agitate —Use ultrasonic agitation to remove plating solution from the workpiece				SR(5)				
• Reuse rinse waters —Add countercurrent rise tanks to reduce the volume of water used —use smaller rinse tanks to allow more floor space for multiple rinse tanks (countercurrent) —Add baffles in existing tanks to convert them into countercurrent rinse tanks —Use reactive rinsing such as combining acid and alkaline rinses in services to help neutralize the solutions and thus reduce the need for treatment chemicals —Add spray rinse above rinse tank to further reduce the metal drag-out				SR(5)				
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
3. RESOURCE RECOVERY								
3.1 Material Reuse								
• Local reuse of rinse water by mixing acid and alkaline rinses to neutralize them				MR(4)				
• Local reuse of acid/alkaline cleaners to adjust pH in your neutralization step of your waste treatment				MR(4)				
3.2 Recycling								
• Solvent recycling through on-site reclaim equipment or off-site reclaim service				RE(3)				
• Metals recycling through off-site reclaimers				RE(3)				

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost: Dollar Amount To Implement	% Metals Reduction: Percent of Total Metals for Facility	WMH Score: SR = 5, MR/RI = 4, RE = 3, TI = 2, TE = 1	IP Score: High = 4, Med = 3, Low = 2, None = 0	Option Type: Change Procedure = 4, Change Process = 3, Change Equipment = 2, New Equipment = 1	Option Cost: None = 4, Low = 3, Med = 2, High = 1	Total Score
3.2 Recycling (continued)								
• Bath chemicals recycling by recovering the metals or purifying the bath through the use of one of the following techniques: —Ion exchange—recovery of metals from the resin —Reverse osmosis—purification of the bath by removing contaminants —Electrolytic plate out of metals from the bath —Electrodialysis—purification of the bath by removing contaminants —Evaporation—reconcentrating the bath through distillation				RE(3)				
• Rinse water recycling by removing the contaminants from the water through the use of one of the following techniques: —Ion exchange—removal of metals onto a resin —Reverse osmosis—purification of the water for reuse —Electrolytic plate out of metals from the water —Electrodialysis—purification of the water for reuse —Evaporation—removal of metals through distillation				RE(4) RE(3)				

Waste Minimization Option Evaluation

(Page 15 of 16)

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
4. RESOURCE RECOVERY								
4.1 Use Alternative Chemicals For Waste Treatment								
• Change to treatment chemicals that make less sludge or minimize the amount of chemicals added				RE(5)				
• Use spent process chemicals such as acids and caustics in treating your wastes rather than using fresh chemicals				RE(4)				
•								
4.2 Recycling								
• Segregate chelate-containing wastes so you can give special treatment to just those wastes				SR(5)				
• Segregate cyanide-containing wastes so only the minimum amount of treatment chemical is added				SR(5)				
• Segregate metal streams to allow recycling of precipitated metals				SR(5)				
• Keep waste streams needing only neutralization segregated from those requiring metal removal				SR(5)				
•								

Waste Minimization Option Evaluation

Waste Minimization Technique	Done Yet? (Yes/No)	Cost Dollar Amount To Implement	% Metals Reduction Percent of Total Metals for Facility	WMH Score SR =5 MR/RI=4 RE=3 TI=2 TE=1	IP Score High =4 Med=3 Low=2 None=0	Option Type Change Procedure=4 Change Process=3 Change Equipment=2 New Equipment =1	Option Cost None=4 Low=3 med=2 High=1	Total Score
4.3 Reduce Sludge Volume								
• Filter sludges to remove excess water				TE(1)				
• Dry sludges to minimize the amount for disposal				TE(1)				
• Pretreat process water to remove carbonates and phosphates which contribute to sludge volume				TE(5)				
•								
•								
•								
•								
•								
•								
•								
•								

SECTION 3: PROFITABILITY WORKSHEET

Use the worksheets in this section to make rough estimates of required investments, annual savings, and payback periods for each waste reduction option that you wish to evaluate. Compare both the investment amounts and payback periods for the options when deciding which ones make the most sense for your shop. Photocopy these forms if you need extras.

Refer to Appendix A for an optional, more extensive worksheet for evaluating in more detail the costs of your waste minimization projects. Instructions for the use of this extended worksheet appear in the DTSC publication: *Waste Audit Study - Fabricated Metal Products Industry.* Refer also to available accounting references on project cost estimates.

These worksheets do not take into account amortization, depreciation, the cost of money, or tax factors. You may wish to consider these elements for options where the capital expenditure is significant, or outside financing is required.

Notes:

TABLE 5: Evaluation of Costs and Savings

Waste Reduction Technique: _____

Capital Investment:

Equipment Cost	_____	
Freight & Handling	_____	
Installation	_____	
Shop Modification & Utilities	_____	
Construction Materials	_____	
Other	_____	
Installation Costs:		_____
Training Cost	_____	
Initial Spare Parts	_____	
Value of Lost Production Time	_____	
Other Costs:		_____
Total Capital Investment:		_____

Annual Cost Savings:

Material or Service	Present System ($/Year)	New System ($/Year)	Estimated* Savings ($/Year)
Utilities			
Chemicals			
Operation/Maint. Labor			
Repair Supplies			
Waste Handling			
Fees/Penalties			
Misc.			
Total Annual Amounts			

(*Use negative numbers to indicate costs that will increase.)

$$\text{Payback period} = \frac{\text{Capital Investment}}{\text{Total Annual Savings}} = \_\_\_\_\_ \text{ Years}$$

Notes / Diagram:

APPENDIX A:

EXPANDED WASTE MINIMIZATION COST EVALUATION

The following pages are from Appendix D of the *Waste Audit Study for the Fabricated Metal Products Industry*. These pages cover the evaluation of waste minimization project costs and benefits. For a complete copy of this publication, see the order form in Appendix D.

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 1 of 6 Page ___ of ___

WORKSHEET 17a

COST INFORMATION

Waste Minimization Option Description _____

CAPITAL COSTS - Include all costs as appropriate. TOTALS

☐ Purchased Process Equipment

- Price (fob factory) _____
- Taxes, freight, insurance _____
- Price for Initial Spare Parts Inventory _____ _____

☐ Estimated Materials Cost

- Piping _____
- Electrical _____
- Instruments _____
- Structural _____
- Insulation/Piping _____ _____

☐ Estimated Costs for Utility Connections and New Utility Systems

- Electricity _____
- Steam _____
- Cooling Water _____
- Process Water _____
- Refrigeration _____
- Fuel (Gas or Oil) _____
- Plant Air _____
- Inert Gas _____ _____

☐ Estimated Costs for Additional Equipment

- Storage & Material Handling _____
- Laboratory/Analytical _____
- Other _____ _____

☐ Site Preparation _____

(Demolition, site clearing, etc.) _____

☐ Estimated Installation Costs

- Vendor _____
- Contractor _____
- In-house Staff _____ _____

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 2 of 6 Page ___ of ___

WORKSHEET 17b

COST INFORMATION

(continued)

CAPITAL COSTS (Cont.) TOTALS

☐ Engineering and Procurement Costs (In-house & outside)

- Planning _____
- Engineering _____
- Procurement _____
- Consultants _____ _____

☐ Start-up Costs

- Vendor _____
- Contractor _____
- In-house _____ _____

☐ Training Costs _____ _____

☐ Permitting Costs

- Fees _____
- In-house Staff Costs _____ _____

☐ Initial Charge of Catalysts and Chemicals

- Item #1 _____
- Item #2 _____ _____

☐ **Working Capital** [Raw Materials, Product, Inventory, Materials and Supplies (not elsewhere specified)].

- Item #1 _____
- Item #2 _____
- Item #3 _____
- Item #4 _____ _____

☐ Estimated Salvage Value (if any) _____

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 3 of 6 Page ___ of ___

WORKSHEET
17c

COST INFORMATION

(continued)

CAPITAL COST SUMMARY

Cost Item	Cost
Purchased Process Equipment	
Materials	
Utility Connections	
Additional Equipment	
Site Preparation	
Installation	
Engineering and Procurement	
Start-up Cost	
Training Costs	
Permitting Costs	
Initial Charge of Catalysts and Chemicals	
Fixed Capital Investment	
Working Capital	
Total Capital Investment	
Salvage Value	

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 4 of 6 Page ___ of ___

WORKSHEET 17d

COST INFORMATION

(continued)

☐ **Estimated Decrease (or Increase) in Utilities**

Utility	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time
Electricity			
Steam			
Cooling Process			
Process Water			
Refrigeration			
Fuel (Gas or Oil)			
Plant Air			
Inert Air			

INCREMENTAL OPERATING COSTS - Include all relevant operating savings. Estimate these costs on an incremental basis (i.e., as decreases or increases over existing costs).

☐ **BASIS FOR COSTS** Annual _____ Quarterly _____ Monthly _____ Daily _____ Other _____

☐ **Estimated Disposal Cost Saving**

Decrease in TSDF Fees _____

Decrease in State Fees and Taxes _____

Decrease in Transportation Costs _____

Decrease in Onsite Treatment and Handling _____

Decrease in Permitting, Reporting and Recordkeeping _____

Total Decrease in Disposal Costs _____

☐ **Estimated Decrease in Raw Materials Consumption**

Materials	Unit Cost $ per unit	Reduction in Quantity Units per time	Decrease in Cost $ per time

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 5 of 6 Page ___ of ___

WORKSHEET 17e

COST INFORMATION

(continued)

☐ Estimated Decrease (or Increase) in Ancillary Catalysts and Chemicals

Catalyst/Chemical	Unit Cost $ per unit	Decrease (or Increase) in Quantity Unit per time	Total Decrease (or Increase) $ per time

☐ Estimated Decrease (or Increase) in Operating Costs and Maintenance Labor Costs (include cost of supervision, benefits and burden).

_____

_____

_____

☐ Estimated Decrease (or Increase) in Operating and Maintenance Supplies and Costs.

_____

_____

_____

☐ Estimated Decrease (or Increase) in Insurance and Liability Costs (explain). _____

_____

_____

☐ Estimated Decrease (or Increase) in Other Operating Costs (explain).

_____

_____

INCREMENTAL REVENUES

☐ Estimated Incremental Revenues from an Increase (or Decrease) in Production or Marketable By-products (explain).

_____

_____

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 6 of 6 Page ___ of ___

WORKSHEET
17f

COST INFORMATION

(continued)

INCREMENTAL OPERATING COST AND REVENUE SUMMARY (ANNUAL BASIS)

Decreases in Operating Cost or Increases in Revenue are Positive.
Increases in Operating Cost or Decrease in Revenue are Negative.

Operating Cost/Revenue Item	$ per year
Decrease in Disposal Cost	
Decrease in Raw Materials Cost	
Decrease (or Increase) in Utilities Cost	
Decrease (or Increase) in Catalysts and Chemicals	
Decrease (or Increase) in O & M Labor Costs	
Decrease (or Increase) in O & M Supplies Costs	
Decrease (or Increase) in Insurance/Liabilities Costs	
Decrease (or Increase) in Other Operating Costs	
Incremental Revenues from Increased (Decreased) Production	
Incremental Revenues from Marketable By-products	
Net Operating Cost Savings	

Summary of Other Benefits:

- ☐ Reduction in Long-term Liability
- ☐ Reduction in Employee Hazards
- ☐ Improvement in Community Acceptance
- ☐ Reduction in Management Duties
- ☐ Elimination of Uncertainty of Waste Management Trends
- ☐ Other _____

_____

_____

Plant _____	Waste Minimization Assessment	Prepared By _____
		Checked By _____
Date _____	Proj. No. _____	Sheet 1 of 1 Page ___ of ___

WORKSHEET 18

PROFITABILITY WORKSHEET #1
CASH FLOW FOR NPV, IRR

Total Capital Investment ($) (from Worksheet 17c) _____

Annual Net Operating Cost Savings ($ per year) (from Worksheet 17f) _____

$$\text{Payback Period (in years)} = \frac{\text{Total Capital Investment}}{\text{Annual Net Operating Cost Savings}} = \_\_\_\_\_$$

Is the cost of this project worth the benefits it offers your company? (as listed on worksheet 17f)

_____

APPENDIX B:
DEFINITIONS

The following pages provide definitions of waste minimization and other terms used in this *Checklist*. These pages come from the indicated DTSC publications:

Definition of Small Business - Draft Guidance Manual for the Hazardous Waste Source Reduction and Management Review Act of 1989, Appendix B (2 pages).

Glossary (of Metal Finishing Terms) - Waste Minimization Assessment Procedures, Module III, Waste Minimization in the Metal Finishing Industry, May 1991 (15 pages).

SMALL BUSINESS DEFINITION

(Reference : Government Code, Article 2, Section 11342)

Small business means:

(1) A business activity, unless excluded in paragraph (2), that is all of the following:
  (A) Independently owned and operated.
  (B) Not dominant in its field of operation.
  (C) Not exceeding the following annual gross receipts in the categories of:
    (i) Agriculture, one million dollars ($1,000,000).
    (ii) General construction, nine million five hundred thousand dollars ($9,500,000).
    (iii) Special trade construction, five million dollars ($5,000,000).
    (iv) Retail trade, two million dollars ($2,000,000).
    (v) Wholesale trade, nine million five hundred thousand dollars ($9,500,000).
    (vi) Services, two million dollars ($2,000,000).
    (vii) Transportation and warehousing, one million five hundred thousand dollars $1,500,000).
  (D) Not exceeding the following limits in the categories of:
    (i) A manufacturing enterprise, 250 employees.
    (ii) A health care facility, 150 beds or one million five hundred thousand dollars ($1,500,000) in annual gross receipts.
    (iii) Generating and transmitting electric power, 4.5 million kilowatt hours annually.

(2) The following professional and business activities shall not be considered a small business for purposes of this act:
  (A) Financial institutions including banks, trusts, savings and loan association, thrift institutions, consumer and industrial finance companies, credit unions, mortgage and investment bankers, and stock and bond brokers.
  (B) Insurance companies, both stock and mutual.
  (C) Mineral, oil, and gas brokers; subdividers and developers.
  (D) Landscape architects, architects, and building designers.
  (E) Entities organized as nonprofit institutions.
  (F) Entertainment activities and productions including motion pictures, stage performances, television and radio stations, and production companies.
  (G) All utilities, water companies, and power transmission companies, except electrical power generating transmission companies providing less than 4.5 million kilowatt hours annually.
  (H) All petroleum and natural gas producers, refiners and pipelines.

GLOSSARY

Abrasive Blasting

A method used to remove brittle material such as millscale oxide, remains of paint, etc. More generally referred to as grit blasting.

Acid Descaling

An alternative name for "pickling," a process using acid to dissolve oxide and scale.

Activation

Process of removing last trace of oxide on a metal surface and a thin layer of the metal itself to ensure that the metal surface to be plated is electrochemically active. (see "etching")

Alkaline Descaling

A chemical process for removing scale. A typical descaling solution uses caustic soda with additives such as detergents and chelating agents.

Alloying

The addition of one metal to another metal or non-metal or combinations of metals. For instance, steel is an alloy of iron and carbon. Other metals are added to steels to impart specific characteristics like strength or corrosion resistance.

"Alochrom"

A proprietary process applied to aluminum and its alloys to improve corrosion resistance or to prepare surfaces for painting. Treatment produces an adherent aluminum oxide with some absorbed chromate.

Amalgamating

Process in which alloys are formed with mercury such as gold, silver, iron, copper and aluminum. Due to the toxicity of mercury, use of the technique is declining.

Annealing

A heat treatment process which may be applied to all metals to soften them.

Anodic Etching

A form of electrolytic etching where the workpiece being etched is anodic in the electrolytic circuit (in electroplating, the workpiece is the cathode).

Anodizing

A process generally applied to aluminum and its alloys to produce an adherent oxide film to impart corrosion resistance or surface hardness.

Aquablast

A surface cleaning process which can be applied to any material where an abrasive material is suspended in water. The resulting slurry is pressurized and ejected through a nozzle. Since higher pressures can be used in this process than in other types of blasting, surface metal can be quickly removed and leaving a good surface finish.

Blasting

See listing by specific medium (e.g. Abrasive, Dry, Grit, Shot, Aqua).

Borax Treatment

A method of coating steel with a thin film of dry lubricant. After surface cleaning or acid pickling, the material is placed in a hot borax solution, allowed to come to solution temperature and removed and dried. The resulting alkaline coating imparts lubrication for subsequent drawing operations and provides minor corrosion protection.

Boriding

A high temperature process used for surface hardening of mild low carbon steels.

Bright Chrome Plating

Decorative chromium plate deposited directly on a nickel plate substrate.

Bronzing

A chemical process generally applied to steel to impart the appearance of bronze (antimony chloride in hydrochloric acid followed by ammonium chloride in dilute acetic acid). The resulting "bronze" film does not have the corrosion resistance of a true bronze.

Buffing

A specific type of mechanical polishing using a high speed disc made from layers of cloth, leather or plastic impregnated with an abrasive. The workpiece to buffed is pressed against the disc.

Burnishing

A form of metal finishing where the surface is treated mechanically so that no appreciable metal is removed but the surface is smoothed.

Carbonitriding

A surface hardening technique for steel in which a hydrocarbon (e.g. propane, butane) and ammonia are are injected into a furnace (750°-800° C) containing the workpiece. The resulting atomic carbon and nitrogen react with the surface iron to form iron carbides and iron nitrides.

Carburizing

A process used for certain types of ductile steel which increases surface hardness from two to six times. It generally is conducted in a heat resistant box containing an atmosphere of carbon monoxide, carbon dioxide, water vapor, methane, hydrogen, and butane in correct ratios and heated to 900° C.

Case Hardening

A family of surface hardening processes generally applied only to steels. (See specific listings for carbonitriding, carburizing, chromium plating, cyanide hardening, electroless nickel plating, nitriding.)

Casting

A general term covering a production technique where any metal is heated until it is molten and then poured into a mold, allowed to cool and solidify.

Cathodic Etching

A technique applied to steel workpieces where the workpiece is made the cathode in an electrolytic cell with sulfuric acid as the electrolyte. The anode will generally be lead or stainless steel. When a current is applied, hydrogen will be evolved at the cathode and the surface metal oxide will be reduced. The technique is usually applied immediately prior to electroplating.

Cathodic Protection

A technique applied to steel where metals anodic to iron (e.g. zinc, aluminum, magnesium) are applied to the surface on the steel workpiece to provide a corrosion resistant surface. The process relies on the fact that where a cell exists between two metals with an electrolyte, one of the metals will corrode and in the process of corroding protect the other metal.

Chemical Polishing

A process carried out on mild- and low-alloy steel, stainless steel, aluminum. Special solutions are used to attack the surfaces of these metals in such a manner that the peaks or corners are affected in preference to the concave surfaces. The result is a general smoothing of the surface.

Chromate Coating (Chromating)

A corrosion protection technique which has many variations and can be applied to steel, aluminum, magnesium, and zinc. It results in the formation of metal oxides on the surface of the workpiece which reacts to form metallic chromates. Chromating of aluminum and magnesium improves corrosion resistance considerably. With steel it is much less permanent.

Chromium Plating

This electrodeposition of chromium is generally applied to steel in all its forms. It is usually done for decorative purposes (bright chromium) or to provide a hard surface for engineering purposes (hard chromium). Chromium plate is nearly always deposited on top of a nickel deposit. The nickel deposit supplies the necessary corrosion resistance.

Chromium plating solutions contain chromic acid (500 gm/l) and sulfuric acid (5 gm/l). Proprietary additives are sometimes used to improve throwing power, regulate the solution and to help the distribution of current.

Chromizing

A treatment applied to mild- and low-alloy steel only. It is a surface diffusion process in which chromium is alloyed with iron to give a chromium-rich surface layer.

Thoroughly cleaned workpieces are placed in a heat resistant box with a proprietary powder of an unstable chromium compound. When the box is heated to over 1000° C, the chromium decomposes into an active state which reacts with the iron to produce an alloy. The longer the workpiece is retained in the heated box the deeper the penetration the chromium alloy.

Cold Galvanizing

A term sometimes used to differentiate between electroplating zinc on steel from the hot dipping of steel in molten zinc. It can also refer to a form of painting with specialized paints which result in a film of up to 90% powdered zinc. The purpose of all these processes is to provide corrosion resistance.

Color Anodizing

A process used only on aluminum and its alloys using dyes to color the anodic film. The anodic process produces a porous film which when fresh will absorb dyes. The anodizing is carried out using the sulfuric acid process. After completion of the anodizing the workpieces are rinsed in cold water and placed in a dye solution. After dyeing, the workpieces are again rinsed in cold water followed by immersion in nearly boiling water. The heat seals the anodic film and the surface remains permanently colored.

Contact Tin Plating

A form of electroless plating commonly used in the printed circuit board and general electronics industries to improve solderability of workpieces. The workpieces are immersed in a hot chemical solution containing unstable tin compounds. The tin reduces on the surface of the workpieces.

Copper Plating

Copper is electrodeposited for conductivity in the printed circuit and electrical industries, and for decorative purposes. There are four basic types of copper plating solutions; copper sulfate, copper cyanide, copper pyrophosphate, and copper fluoborate.

The oldest technique uses copper sulfate (200 gm/l), sulfuric acid (30 gm/l) and potassium (12 gm/l). Modern solutions use proprietary additives which make it possible to plate at higher temperatures and with a high "leveling" action.

Copper cyanide solutions are often used when steel is to be plated. It produces a thick, dense, non-porous film. A typical copper cyanide solution consists of copper (8 gm/l), and free sodium cyanide (5 gm/l).

Like cyanide, copper pyrophosphate solutions can be used for plating on steel provided an initial "strike" is made before plating. The "strike " solution will usually contain copper (5 gm/l), pyrophosphate (60 gm/l), oxalate (5 gm/l) and chloride (10 gm/l). It may be heated up to 50° C. After the "strike" the workpieces are placed in the standard pyrophosphate plating solution which contains copper (20 gm/l), pyrophosphate (160 gm/l), oxalate (17 gm/l) and ammonia (6 gm/l). The pH of the bath must be maintained at 8.4. Additives are generally present to give good "leveling". Pyrophosphate solutions

require careful control and are more expensive than some alternatives, but give a bright, dense deposit with good throwing power.

Copper fluoborate solutions are used when a rapid build up of thick deposits is necessary. Tight laboratory control is generally required for optimum plating efficiency. A typical solution contains copper (120 gm/l), fluoboric acid (30 gm/l), and is operated at 45° C.

Corrosion

Corrosion occurs in all metals at some time and can be divided into four basic forms. Room temperature oxidation, by far the most common form, is most obvious in mild and low-alloy steels. The process is accelerated dramatically by comparatively small amounts of contaminants like chloride, sulfate, and fluoride.

When exposed to high temperatures, metals will almost invariably result in oxidation of metal surfaces. Chemical corrosion is the result of attack by acids or alkaline compounds which dissolve the metal surface. Electrolytic corrosion occurs when two metals in contact with each other have different electrode potentials. It is a major contributor to most of the corrosion found in steels.

Cromodizing

A name given to the chromating of steel where a film of iron chromate is formed on the surface. The corrosion protection provided by this treatment is of a very low order. "Phosphating" and oiling will probably provide superior corrosion resistance without the use of chromium.

Cyanide Hardening

A surface hardening technique which uses molten cyanide salts to give workpieces a case containing carbon and nitrogen. Temperatures of 650° C to 80° C must be maintained for 20-30 minutes to be effective. The high toxicity of the cyanide used makes it expensive because of treatment requirements.

Degreasing

A form of cleaning which generally uses chlorinated solvents. In the most common form, a liquid solvent is heated in an open topped container. As it boils a hot vapor rises above the liquid. The vapor is held within the container by means of a cooling coil which runs around the inside of the container a short distance below the rim. This cold zone causes the vapor to condense and be returned to the sump for reboiling. It is therefore a form of continuous distillation.

When any cold component is placed in the container, the vapor immediately condenses on the surface. The solvent dissolves any grease on the surface and as further solvent condenses it runs off the workpiece carrying the soluble soils into the sump.

Descaling

This term describes a process that can be applied to all materials to remove scale. Scale is generally produced during manufacture or storage

and it may be obvious such as rust or millscale or it may be very unobtrusive.

The various methods of descaling include blasting, pickling, acid or alkaline sodium hydride treatment, and polishing.

Die-casting

A method of casting in which molten metal is poured, sometimes under pressure, into a mold or die. The die is made of metal and immediately after solidification of the casting the die opens and the casting is ejected.

Dry Blasting

A general name given to any form of blasting where the abrasive agent is not carried in water.

Dry-form Lubrication

A form of painting applied to steel surfaces of workpieces subject to light wear or abrasion. It generally uses colloidal graphite or molybdenum disulfide carried in a phenolic resin.

Electrocleaning

An electrochemical cleaning process by which a workpiece is first made the cathode in an electrolytic cell. When current is applied, the generation of hydrogen gas from the electrolysis of water at the surface of the workpiece results in a highly efficient scrubbing action. Following initial treatment as a cathode the circuit is reversed so that the workpiece is the anode. Oxygen gas, which is generated at the surface produces a final cleaning action.

Electroforming

A specific form of electroplating used where intricate shapes and relatively thin metal deposits are required. Molds of plastic, wax, or sometimes metals are made conductive by application of carbon or metallic powder and are plated by conventional methods. Nickel, copper or precious metals are generally selected for plating. The mold is generally removed at the completion of the plating process by one of a number of methods depending on the material from which the mold is constructed.

Electrogalvanizing

See "Zinc Plating"

Electroless Plating

When a metal is immersed in a solution of another metal with a higher electrode potential, that dissolved metal will displace the lower potential metal on the surface of a workpiece. The best known electroless plating process occurs when steel is placed in a copper sulfate solution. Copper is plated without the application an external electric current.

In another common electroless process, aluminum, which rapidly forms aluminum oxide in conventional electrolysis, is plated with zinc. The zinc deposit can then be subsequently electroplated using conventional techniques.

Electroless Nickel Plating

In this process an alloy of nickel and phosphorous can be applied to almost any metal, and to many plastic materials including glass. Prior to nickel deposition, the workpieces must be cleaned to a very high standard and then "etched" or "sensitized" before they are immersed in the electroless nickel plating solution. The solutions must be heated above 80 C for good adhesion to be achieved.

Electroless nickel plating has found considerable use in two major applications. First it is employed where good corrosion resistance is required on intricate shapes, crevices, blind holes and deep cavities where conventional electroplating is not possible. Electroless nickel deposits occur in homogeneous, uniform manner on all surfaces as opposed to in electrolytic plating where there will always be areas of high current density, such as edges and points where deposits are thicker, and areas of low current density, such as recesses, where deposits are thinner.

The second major area of use is where, after electroless plating, heat treatment is employed to obtain a high surface hardness.

Electrolytic Etch

A technique generally applied to steels which attacks the surface to produce a clean, oxide free material. It is often used prior to electroplating, especially chromium plating. Since it preferentially attacks edges it will open up minute cracks in the metal surface allowing electrolytic etching to be used as an inspection technique.

Electrolytic Polishing

An electrochemical process usually applied to steels and aluminum and its alloys which produces a bright surface with a highly reflective finish. In most instances this is used for decorative purposes and it often associated with some other form of metal finishing such as anodizing, plating, or lacquering.

In electropolishing the workpiece is made the anode in an electrolytic cell. When current is applied metal is removed from the anode surface. Corners and peaks are preferentially dissolved because of the higher current density surrounding them. The result is the surface of the workpiece is smoothed.

The electrolytes employed generally are sulfuric acid, phosphoric acid or chromic acid. Alternatives methods of polishing include "barreling" or other forms of mechanical polishing, and vapor blasting.

Electro-osmosis

See "Reverse Osmosis"

Electrostatic Painting

A form of spray painting using specially formulated paints with pigment particles which will accept a static electric charge and be carried in a non-polar solvent. Paint guns eject the paint at a slight velocity. The particles

leaving the gun are given an electrostatic charge of anything up to 30,000 volts. Very small currents are employed so the safety hazard is negligible. The workpiece to be painted is at earth ground and thus there is considerable attraction between the paint and the workpiece. As the paint particles arrive at the workpiece, they are attracted and adhere to the surface. This results in the neutralization of the static charge, and added attraction of the paint particles to areas which have not been painted.

Emulsion Cleaning

A cleaning technique which acts by emulsifying contaminants. Emulsions are mixtures of two liquids, with one liquid holding the other one in a suspension similar to a colloidal suspension. The liquids will typically have different polarities and will dissolve different types of materials. One of the liquids is usually water and the other will have non-polar properties. They can therefore be used to dissolve non-polar contaminants like oil and grease from metal surfaces.

With proper use emulsion cleaners can have a long useful life and produce very clean surfaces. They may have to be formulated specifically to clean certain soils.

Etching

Etching may be used as a surface preparation technique prior to electroplating (see "Activation") or for removal of metal such as in the printed circuit industry where material not required on the finished product on the final printed circuit is removed by a chemical solution.

It can also be used as an inspection technique due to its ability to accentuate surface cracks and defects. Even minute surface defects will be highlighted since the edges are preferentially dissolved.

Evaporation Process

See "Vacuum Deposition"

"Ferrostan" Process

A method of continuous electrolytic tin plating of steel strip in which cold reduced strip is continuously fed through the cleaning, etching, plating and rinsing processes. The solution is generally an acid sulfate which produces a matt finish.

Fire Gilt Process

A process confined to the jewelry trade in which gold dissolved in mercury (gold amalgam) is wiped on surfaces to be plated. When the article is heated the mercury is driven off leaving a gold film. The process represents a considerable health hazard due to the emission of the mercury vapor.

Fluxing

A process used in the heating of metals which may be intended to reduce or eliminate oxidation, confine the products of oxidation, reduce their melting point, and improve fluidity of surface metal layers. Fluxing is generally used in casting, welding and soldering.

Frosting

A type of metal finishing where a fine matt finish is produced by using techniques such as acid-etching, blasting, scratch brushing or barreling.

Galvanic Protection

A general term used in the corrosion protection of steel. Technically, it refers to a metal used to protect a metal higher than itself in electrode potential. In practice, it refers to the use of zinc to protect steel.

Galvanizing

A corrosion protection technique applied only to mild steel, cast iron, and steel alloys in which workpieces are immersed in liquid zinc at 500° C. A zinc/iron alloy is formed at the surface of the workpiece giving it an adherent coating of zinc.

Prior to galvanizing, the metal surface must be in a moderate state of cleanliness. This is generally accomplished by light acid pickling or blasting.

Galvanized coatings are generally about 0.005 inches thick and can give a protection for 10 to 20 years.

Gilding

A process in which gold is coated on the surface of another base metal. Gold leaf, a layer beaten or rolled so thin it is porous to light, is glued or beaten onto the article to be gilded. A similar method applies a fine gold powder mixed with a flammable liquid solvent applied to the article like a paint. The solvent is allowed to evaporate or in some cases may be ignited.

Gold Electroplating

Gold has two specific properties which make it valuable in industrial and commercial uses, it resists oxidation and corrosion to a very high degree and it retains its attractive color.

In industry, gold is now finding considerable use in the electronics field. While gold has a conductivity of only 60% that of copper, it has the advantage that it will retain that conductivity over a wide variety of conditions.

Traditionally, gold has been plated from high concentration cyanide solutions which are often produced by immersing the gold in the cyanide dissolving the metal as gold cyanide. The solution may then be used as the electrolyte with an inert anode.

The main advantage of gold plating over other methods of applying gold to surfaces, is that electroplated coatings do not have pores as gilded coatings do. This provides significantly greater life and corrosion resistance.

Grit Blasting

A technique of abrasive cleaning or surface preparation using sharp particles (e.g. cast iron shot, aluminum oxide). It covers such processes

as removal of scale, corrosion, paint and other surface films. Use of free silica presents a health threat and should be avoided.

Hard Chrome Plating

See "Chromium Plating"

Hard Facing

A term referring to processes used to harden metal surfaces and impart wear resistance by a variety of heat treatments. Also see "Metal Spraying"

Hot-dip Coating

See "Galvanizing"

Hydrogen Embrittlement

A defect which occurs during the electroplating process. Atomic hydrogen is produced at the cathode of the workpiece being plated. This atomic hydrogen is extremely reactive and has the capability of entering the interstices of the metal. Being unstable in the atomic state, the hydrogen will combine as rapidly as possible with other atoms to form molecular hydrogen. This molecular hydrogen, having a higher unit volume than atomic hydrogen, results in internal pressure in the plated metal.

Immersion Plating

A plating technique similar to electroless plating where a more electropositive metal dissolved in an electrolyte is plated onto the surface of a less electronegative metal workpiece. The term immersion plating is used where a deposit is obtained and the plating process then stops. This is distinguished from electroless plating where the deposition of the metal being plated continues to be deposited as long as the workpiece remains in the solution.

Inchrom Process

See "Chromizing"

Indium Plating

Indium is a metal not unlike lead but with friction and corrosion resistant properties which are unique. In fact, the sole purpose of indium plating is improving the friction characteristics of very high-rated bearing.

"Kanigen Plating"

First proprietary process for electroless nickel plating. For more information see "Electroless Nickel Plating"

Lacquering

A term which refers to applying a clear non-porous varnish to protect an existing finish. Most lacquers are cellulose-based materials in which cellulose is dissolved in a solvent. They are generally applied by spray or brush. The solvent is allowed to evaporate leaving a thin film of cellulose remains on the metal surface.

Lead Plating

Lead plating does not have many common uses except in the production of electrodes for lead acid batteries. Steel which has been plated with lead is much stronger mechanically and lighter than the same thickness of pure lead. It is also used as a base layer for indium plating. Lead plating solutions contain approximately 100 gm/l lead and 40 gm/l fluoboric acid.

Leveling

Electrodeposited metals tend to be concentrated at sharp corners, peaks and ridges, due to the fact that current distributed on a surface will tend to concentrate at these irregularities much more than in concave surfaces such as recesses. Therefore, when a workpiece with a rough surface is electroplated, the rate of deposition will be faster on these the convex irregularities. The result will be accentuation of the item's original roughness.

To counteract this effect, additives are added to the electrolyte solution which produce a polarization effect which is concentrated at the peaks and ridges. This polarization effect **lowers** the current density at the peaks and thereby reduces the rate of deposition. The net result is to smooth or "level" the metal surface.

Metal Coloring

Dyes applied after anodizing or plating to color-code (ie. identify) parts.

Metal Spraying

The general term is applied to the spraying of one of several metals onto a metal substrate. In general, it is intended to produce three effects. The first, corrosion protection, usually involves spraying zinc or aluminum on structural steel components. It is also used on high tensile workpieces such as those used in aircraft, which cannot be electroplated due to hydrogen embrittlement.

The second purpose for metal spraying is "hard facing". Materials used in hard facing are tungsten bearing or tungsten carbide materials, cobalt and nickel with small amounts of chromium, and high manganese chrome materials. These materials provide significant resistance to wear.

The third application for metal spraying is for salvage purposes. When engineering components are found to exhibit wear while in service, technical and economic considerations may make metal spraying to replace the wear a better alternative to replacement.

The most common method of metal spraying is "flame impingement". The technique uses powdered metal continuously fed into a high velocity flame. The flame atomizes the metal powder into a molten state and the particles are then projected by the energy of the flame onto a prepared metal surface.

Plasma coating is a similar method which employees radio frequency-induced plasmas at temperatures up to 30,000° C. This method is limited to high integrity components where excellent adhesion or sophisticated materials are required.

"Micro-Chem"

A proprietary electrocleaning process used for "brightening" and "passivating" stainless steel. It is a form of electropolishing which gives a considerably smoother and shinier finish.

Nickel Plating

A very common form of electrolytic deposition which is generally used as an undercoating for subsequent deposits. There are three common solutions used in nickel electroplating; Watt's solution, sulfamic acid, and electroless plating. For a complete discussion of the latter, see "Electroless Nickel Plating".

Watt's solution typically contains nickel sulfate (300 gm/l), nickel chloride (50 gm/l) and boric acid (35 gm/l). The mixture of constituents is necessary to properly balance the solution. Nickel chloride is required to counteract nickel sulfate's low conductivity. Without boric acid to act as a buffer, the plating process would make the solution increasingly more acidic. Baths are usually maintained at 40° C or above to achieve the best results.

Nickel sulfamate plating is a more recent development. It uses a solution containing nickel sulfamate (500 gm/l), boric acid (30 gm/l) and nickel chloride (5 gm/l).

Nickel plating is most often used to prior to deposition of bright chromium deposits for decorative purposes or where a very hard surface is required. For this reason nickel plating is usually applied in a "bright" condition. Because of the high cost of nickel it is often applied over a bright copper deposit. The bright copper deposit does the initial leveling of the surface of the workpiece so only a relatively thin layer of nickel is required.

Nitriding

A surface hardening process which is applied only to certain types of steel which results in the hardest surface attainable by heat treatment. The process consists of maintaining workpieces in a 500° C ammonia atmosphere for up to 100 hours. Under these conditions atomic nitrogen combines with surface iron to form iron nitride. The nitrogen slowly diffuses away from the surface as long as the proper temperature is maintained. The resulting case thickness is therefore dependent on length of the heat treatment.

Passivation

The cleaning of stainless steel with nitric acid to remove carbon and other impurities.

Phosphating

A process by which the surface of a steel workpiece is converted to iron phosphate usually as preparation for painting. Before phosphating, surface must be free from rust and scale. This is usually accomplished by acid pickling or mechanically by wire brushing or blasting.

Phosphating takes a relatively short time, usually five to twenty minutes. Solutions are usually maintained between 60° C and 90° C. Workpieces are generally either painted or chromated within 24 hours after treatment since the corrosion resistance imparted by phosphating is poor.

Pickling

A chemical treatment which removes oxide or scale from the surface of a metal. It most often refers to the use of sulfuric or hydrochloric acid to remove scale formed on mild and low-alloy steel during hot forming operations. Treatment of stainless steel or high nickel alloys is done with hydrofluoric acid, a particularly hazardous material which must be handled with extreme care.

Reflowing

A technique used in the printed circuit board industry in which a component is heated in order to melt solder deposits and cause them flow. It produces a bright attractive looking material, but its main purpose is for quality control. With reflowing, any defect on the substrate will not wet, clearly indicating areas where solder is missing.

Rustproofing

A general term which refers to processes applied to steel. It may include painting or galvanizing, but most often refers to phosphating and similar low duty rust preventatives.

Sacrificial Protection

A corrosion protection technique which uses a metal of lower electrode potential to protect a metal of higher electrode potential. This is possible because in the presence of an electrolyte an electrochemical cell is established in which the lower potential metal acts as a anode and the metal to be protected acts as a cathode. The anode corrodes and deposits on the surface of the cathode. In practice, zinc and aluminum are the two metals most commonly for sacrificial protection

Sealing

A term commonly applied to any metal process having a subsequent treatment capable of affecting this previous process in order to give increased corrosion protection (i.e. anodizing, phosphating).

Sensitizing

A relatively non-specific term used to cover a range of metal finishing processes which improve the treatability of a metal surface for a subsequent process. It often refers specifically to a part of the electroless plating procedure on plastics or non-metal surfaces. After the surface has been etched it is reacted with solution which deposits a very thin film of a metal or metallic compound. The surface is then referred to as sensitized.

Silver Plating

Silver, the easiest metal (for use in plating), is deposited for decorative purposes on household and jewelry items. It is sometimes used by the electrical industry where it is plated over copper to improve corrosion resistance.

A typical silver plating solution contains silver cyanide (19 gm/l), potassium cyanide (15 gm/l) and potassium carbonate (25 gm/l).

Solder Plating

The term covers the deposition of an alloy of 60% tin and 40% lead which is widely used in the electrical and electronics industries. It provides two valuable features, corrosion resistance and "solderability".

A typical plating solution contains tin (stannous chloride, 55 gm/l), lead (25 gm/l) and free fluoboric acid (40-100 gm/l). Organic additives like glue are often added to the solution to reduce the amount of granular deposits.

Solvent Cleaning

Solvent cleaning normally uses chlorinated hydrocarbons, methylated spirits, or methyl alcohol. Cleaning with carbon tetrachloride, benzene, toluene, xylene and ether should not be permitted because of health hazards posed by these substances.

Workpieces are either wiped with a solvent soaked cloth or dipped in liquid solvent to remove soluble soils. The soil becomes dissolved evenly throughout the solvent and on the surface of the workpiece when it is removed and evaporated.

Solvent Degreasing

See "Vapor Degreasing"

Stop-off

Method of protecting portions of workpiece surface from chemical processes. Waxes, lacquers or special tapes are applied to areas to prevent chemical attack or deposition.

Surface Hardening

A general term referring to methods for making the surface of steel workpieces mechanically harder than their inner portions. Also see: "Nitriding", "Carburizing", "Cyanide Hardening", "Carbonitriding".

Ultrasonic Cleaning

A sophisticated method of cleaning in which adherent soils are removed by ultrasonic energy applied through liquid. The energy takes the form of cycles of positive and negative pressure in the surface of the workpiece. With a liquid acting as a working fluid, the high frequency (up to 10 KHz) pushing and pulling loosens even tightly adherent soils. It is particularly effective on surfaces placed directly in the line beam of energy. It has limited application where intricate shapes with many recesses require cleaning.

Vacuum Deposition

A process in which certain pure metals are deposited on a substrate. The technique relies on the fact that, in a vacuum, pure metals can be vaporized at a low temperature in a closed container. The metal vapor will condense evenly on all surfaces to give a metallic coating. Aluminum is the most successfully deposited material, producing a highly reflective finish.

Vapor Degreasing

A form of cleaning which generally uses chlorinated solvents, which have excellent degreasing properties in their own right but also produce vapors which are heavier than air. In a typical vapor degreaser, a solvent is heated in an open-topped container and as it boils it produces a hot vapor which rises above the boiling liquid. The vapor is held within the container by means of cooling coil which runs around the inside of the container a short distance below the rim.

When a cold workpiece is placed in the vapor zone, the vapor immediately condenses on the surface, producing a hot clean solvent. The solvent dissolves any grease on the surface and as more vapor condenses and runs off, carrying the grease with it into the sump at the bottom of the sump for re-boiling.

Wetting Agents

Chemicals which reduce the surface tension of water, allowing it to flow from work pieces without beading up.

Zinc Coating

See "Galvanizing"

Zinc Phosphating

A process applied to freshly zinc plated workpieces which are immersed in a zinc phosphate solution acidified with phosphoric acid. The zinc surface deposit is converted to zinc phosphate. The workpieces are then immersed in a dilute chromic acid solution to seal the zinc phosphate deposits and prevent formation of unsightly zinc oxide.

Zinc Plating

This very common form of plating is used to provide corrosion resistance for steels. There are three widely used types of plating solutions, two of which employ cyanide. In the first, a high cyanide solution, typically contains zinc (30 gm/l), sodium cyanide (85 gm/l) and caustic soda (25 gm/l).

The second solution is a low cyanide solution. It typically contains zinc (8 gm/l), sodium cyanide (8 gm/l), and caustic soda (65 gm/l). The third is an acid zinc solution which typically contains zinc (30 gm/l), sodium chloride (25 gm/l), and boric acid (15 gm/l).

Zincate Treatment

A pretreatment necessary for aluminum and its alloys before electroplating. After cleaning, etching in chromic or phosphoric acid to remove oxide and dipping in nitric acid to activate the surface, workpieces are immersed in a sodium zincate solution. Metallic zinc is deposited on the surface of the workpiece. It is then rinsed and immediately brought to the final plating operation.

APPENDIX C:
CALIFORNIA WASTE CODES (CWC)

The following pages provide definitions of the standard codes used to identify various types of hazardous wastes. These codes are used in Section 1 of this *Checklist*. For additional information on these codes, refer to the DTSC publication from which they were obtained:

California Waste Codes - Draft Guidance Manual for the Hazardous Waste Source Reduction and Management Review Act of 1989, Appendix B-1 (2 pages).

CALIFORNIA WASTE CODES

California Nonrestricted Wastes

Inorganics

121. Alkaline solution (pH> or = 12.5) with metals (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, or zinc)
122. Alkaline solution without metals (pH > or = 12.5)
123. Unspecified alkaline solution
131. Aqueous solution (2 < pH < 12.5) containing reactive anions (azide, bromate, chlorate, cyanide, fluoride, hypochlorite, nitrite, perchlorate, and sulfide anions)
132. Aqueous solution with metals (< restricted levels and see 121)
133. Aqueous solution with total organic residues 10 percent or more
134. Aqueous solution with total organic residues less than 10 percent
135. Unspecified aqueous solution
141. Off-specification, aged, or surplus inorganics
151. Asbestos-containing waste
161. FCC waste
162. Other spent catalyst
171. Metal sludge (see 121)
172. Metal dust (see 121) and machining waste
181. Other inorganic solid waste

Organics

211. Halogenated solvents (chloroform, methyl chloride, perchloroethylene, etc.)
212. Oxygenated solvents (acetone, butanol, ethyl acetate, etc.)
213. Hydrocarbon solvents (benzene, hexane, Stoddard, etc.)
214. Unspecified solvent mixture
221. Waste oil and mixed oil
222. Oil/water separation sludge
223. Unspecified oil-containing waste
231. Pesticide rinse water
232. Pesticides and other waste associated with pesticide production
241. Tank bottom waste

251. Still bottoms with halogenated organics
252. Other still bottom waste
261. Polychlorinated biphenyls and material containing PCBs
271. Organic monomer waste (includes unreacted resins)
272. Polymeric resin waste
281. Adhesives
291. Latex waste
311. Pharmaceutical waste
321. Sewage sludge
322. Biological waste other than sewage sludge
331. Off-specification, aged, or surplus organics
341. Organic liquids (nonsolvents with halogens)
342. Organic liquids with metals (see 121)
343. Unspecified organic liquid mixture
351. Organic solids with halogens
352. Other organic solids

Solids

411. Alum and gypsum sludge
421. Lime sludge
431. Phosphate sludge
441. Sulfur sludge
451. Degreasing sludge
461. Paint sludge
471. Paper sludge/pulp
481. Tetraethyl lead sludge
491. Unspecified sludge waste

Miscellaneous

511. Empty pesticide containers 30 gallons or more
512. Other empty containers 30 gallons or more
513. Empty containers less than 30 gallons
521. Drilling mud
531. Chemical toilet waste
541. Photochemicals/photoprocessing waste
551. Laboratory waste chemicals
561. Detergent and soap
571. Fly ash, bottom ash, and retort ash
581. Gas scrubber waste
591. Baghouse waste
611. Contaminated soil from site clean-ups
612. Household wastes
613. Auto-shredder waste

California Restricted Wastes

711. Liquids with cyanides > or = 1000 Mg/L
721. Liquids with arsenic > or = 500 Mg/L
722. Liquids with cadmium > or = 100 Mg/L
723. Liquids with chromium(VI) > or = 500 Mg/L
724. Liquids with lead > or = 500 Mg/L
725. Liquids with mercury > or = 20 Mg/L
726. Liquids with nickel > or = 134 Mg/L
727. Liquids with selenium > or = 100 Mg/L
728. Liquids with thallium > or = 130 Mg/L
731. Liquids with polychlorinated biphenyls > or = 50 Mg/L
741. Liquids with halogenated organic compounds > or = 1000 Mg/L
751. Solids or sludges with halogenated organic compounds > or = 1000 mg/Kg
791. Liquids with pH < or = 2
792. Liquids with pH < or = 2 with metals
801. Waste potentially containing dioxins

APPENDIX D:
ADDITIONAL PUBLICATIONS

The following free DTSC waste minimization publications have information to supplement this *Checklist*. Refer to the enclosed publications order form for information on how to obtain copies for yourself.

Waste Audit Study:
- *Metal Finishing Industry*
- *Fabricated Metal Products Industry*
- *Printed Circuit Board Industry*

Checklist:
- *Printed Circuit Board Industry*

The California Waste Exchange

Technical Reports:
Reducing California's Metal-Bearing Waste Streams
Metal Waste Management Alternatives (Proceedings)

Additional References: *Hazardous Waste Minimization Bibliography*

WASTE AUDIT STUDIES (continued)

305 **Fabricated Metal Products Industry** (1989, 188 pp.)

306 **Fiberglass-Reinforced and Composite Plastic Products** (1989, 164 pp.)

307 **General Medical and Surgical Hospitals** (1988, 182 pp.)

308 **Gold, Silver, Platinum, and Other Precious Metals Product and Reclamation** (1990, 198 pp.)

309 **Marineyards for Maintenance and Repair** (1989, 156 pp.)

310 **Mechanical Equipment Repair Shops (Includes Addendum)** (1990, 87 pp.)

311 **Metal Finishing Industry (Includes Addendum)** (1988, 236 pp.)

312 **Nonagricultural Pesticide Application Industry** (1991, 116 pp.)

313 **Paint Manufacturing Industry** (1989, 130 pp.)

314 **Pesticide Formulating Industry** (1987, 160 pp.)

316 **Printed Circuit Board Manufacturers** (1989, 234 pp.)

317 **Research and Educational Institutions** (1988, 144 pp.)

318 **Stone, Clay, Glass, and Concrete Products Industries** (1991, 120 pp.)

319 **Thermal Metal Working Industry** (1990, 195 pp.)

HAZARDOUS WASTE MINIMIZATION CHECKLIST AND ASSESSMENT MANUALS—*Assessment manuals developed to aid manufacturers in evaluating their shops for waste minimization opportunities.*

Order #	Title
Update 400	**Automotive Repair Shops** (1988, 47 pp.)
Update 402	**Metal Finishing Industry** (1993, 143 pp.)
403	**Paint Formulators** (1991, 40 pp.)
404	**Pesticide Formulators** (1990, 20 pp.)
405	**Printed Circuit Board Manufacturers** (1991, 31 pp.)
406	**Auto Paint Shops** (1992, 12 pp.)
New 407	**Building Construction** (1992, 28 pp.)
New 408	**Ceramic Products** (1993, 27 pp.)
New 409	**Marine Ship and Pleasure Vessel Boat Yards** (1993, 30 pp.)

WASTE MINIMIZATION ASSESSMENTS OF SPECIFIC FACILITIES

Order #	Title
500	**Aerospace Waste Minimization Project—Final Report** (1987, 133 pp.) A feasibility study was conducted to identify and evaluate waste minimization technologies applicable to the aerospace and electronics industries. Eight waste stream categories were targeted for the application of waste minimization technologies and alternative management strategies.
504	**Pollution Prevention Technologies at General Dynamics—Pomona, California** (1991, 9 pp.) A variety of waste minimization technologies were technically and economically evaluated at an aerospace facility. Technologies range from computerized printed circuit board plating to solvent distillation.
522	**Waste Reduction Strategies for the Printed Circuit Board Industry** (1987, 115 pp.) An assessment of the feasibility of achieving significant reductions of hazardous waste generated by the printed circuit board industry.
516	**Reduction of Solvent Wastes in the Electronics Industry** (1988, 85 pp.) Hewlett Packard's San Jose facility was used as a model to study the techniques required to reduce the volume and type of organic solvent wastes in the electronics industry. Up to a 70% reduction in organic solvent waste volume at the facility could be realized, thus saving the company up to $414,000 per year in disposal and chemical purchase costs.
502	**Disposal of Heavy Metal Waste Sludges in Ceramic Products** (1990, 103 pp.) A laboratory-scale test to determine the feasibility of incorporating heavy metal sludges into manufacturing ceramic products. The process can be economical and is technically sound.
519	**Pollution Prevention Assessment of the Office of the State Printer** (1991, 42 pp.) Provides the findings of a pollution prevention assessment of the State Printing Plant and can serve as a waste minimization guideline for printers in California.
521	**Waste Minimization: Small Quantity Generators at Los Angeles International Airport** (1990, 49 pp.) Summarizes the results of a study that involved visits to five representative small-quantity generators and targeted waste minimization of used oil and jet fuel, cleaning operations, and paint stripping.

WASTE STREAM SPECIFIC INFORMATION

Order #	Title
511	**Metal Waste Management Alternatives—1989 Symposium Proceedings** (1989, 252 pp.) Contains papers delivered at two symposia in September 1989. The papers discuss metal waste disposal restrictions and alternatives to disposal such as waste prevention and current recycling technologies.
513	**Reducing California's Metal-Bearing Waste Streams** (1989, 174 pp.) Analyzes alternatives to land disposal of California's hazardous metal waste streams and focuses on methods that prevent waste generation. Source reduction, recycling, and treatment strategies are examined.
604	**Guide to Oil Waste Management Alternatives for Used Oil, Oily Wastewater, Oily Sludge, and Other Wastes Resulting from the Use of Oil Products—Final Report** (1988, 220 pp.) Presents the results of a study of oil waste management alternatives. Includes regulations, established and emerging technologies, current practices, economics and environmental impacts of oil waste management.
606	**Guide to Solvent Waste Reduction Alternatives—Final Report** (1986, 222 pp.) Practical waste management alternatives to land disposal that have potential for reducing the amount and/or toxicity of solvent waste generated.

LOCAL GOVERNMENT

Order #	Title

507 **Hazardous Waste Reduction: A Step-by-Step Guidebook for California Cities** (1992, 180 pp.)
Outlines the essential elements of a successful city run, multimedia waste minimization program. It is designed to walk the user through the steps the city can take to implement and reduce hazardous materials use and hazardous waste typically generated by city operations.

520 **Waste Minimization Opportunities for Selected City of Los Angeles Hazardous Waste Generating Operations** (1990, 143 pp.)
Summarizes a joint effort between the City of Los Angeles and the DTSC to identify and evaluate waste minimization opportunities for selected city operations.

509 **Low Cost Ways to Promote Hazardous Waste Minimization: A Resource Guide for Local Governments (Includes Resource Appendix B)** (1988, 102 pp.)
Explains why and how to set up an educational outreach program. Provides complete resource listings for 28 low-cost activites. Model resolution, useful tables, and informative appendices are included.

512 **Minimizing Hazardous Wastes: Regulatory Options for Local Governments** (1989, 94 pp.)
Describes regulatory framework that can be used to promote hazardous waste minimization at the local level in California. Explores the role of direct requirements, indirect regulatory inducements, and positive incentives. Model resolution and useful appendices included.

514 **Reducing Industrial and Commercial Toxic Air Emissions by Minimizing Waste—The Role of Air Districts** (1990, 120 pp.)
Designed to assist Air Pollution Control Districts in reducing toxic air emissions and explains how waste minimization results in lower toxic air emissions.

515 **Reducing Industrial Toxic Wastes and Discharges: The Role of POTWs** (1988, 101 pp.)
Explains importance of POTW (Publicly Owned Treatment Works) involvement in hazardous waste minimization. Provides educational and technical assistance and regulatory options for reducing hazardous pollutants. Model resolution and useful appendices are included.

523 **Final Report—Source Reduction and Technical Assistance Program** (1992, 40 pp.)
Describes the effort to develop a program to train a city's planning and building inspection staff to recognize industries that will generate hazardous waste so they can refer businesses to a technical assistance program. The project had mixed success and contains valuable recommendations for other agencies considering similar programs.

FURTHER WASTE MINIMIZATION INFORMATION

Order #	Title

505 **Hazardous Waste Minimization Bibliography** (1991, 76 pp.)
References are organized in four sections: (1) general hazardous waste minimization topics, (2) industry-specific, (3) material-specific, and (4) available abstracts from the previous three sections. All references are listed in alphabetical order by title.

506 **Incinerable Hazardous Waste Minimization Project Fact Sheet** (1992, 8 pp.)
Provides an interim update for the project using 1990 data taken from the manifest system.

508 **Incinerable Waste Minimization Workshops Proceedings** (1991, 251 pp.)
A compilation of the papers presented at two workshops held in January 1991. Areas covered include: regulations, source reduction, recycling strategies and opportunities, alternative technologies for petroleum refineries, electronics industry, aerospace industry, and chemical and paint manufacturers.

510 **No-Waste Lab Manual for Educational Institutions** (1991, 115 pp.)
A laboratory manual for introductory chemistry courses incorporating procedures that produce little or no toxic waste. This is accomplished by the use of consecutive chemical reactions so that the production of one reaction is used as the starting material for the next.

517 **Waste Minimization for Hazardous Materials Inspectors: Introductory Text with Self-Testing Exercises (Module 1), Assessment Procedures (Module II, Unit 1), and Metal Finishing Industry (Module III)** (1991, 182 pp.)
Module 1 is written for use by both experienced and novice hazardous materials inspectors who wish to learn more about hazardous waste minimization. Module II provides basic information in conducting a self-assessment, and Module III focuses on some of the viable waste minimization alternatives for certain metal finishing operations.
(Videotape also available—See Order #1500)

518 **Waste Minimization Assessment Procedures: For the Generator (Module II, Unit 2)** (1991, 81 pp.)
Provides the hazardous waste generator with procedures for conducting a self-assessment and introduces the provisions of Senate Bill 14, the Hazardous Waste Source Reduction and Management Review Act of 1989.

New **525** **Working With Small Businesses—A Case Study in Developing a Small Business Pollution Prevention Program** (1993, 73 pp.)
Developed by the City of Anaheim Public Utilities and Fire Departments and DTSC to assist small business owners and operators in dealing with a variety of environmental issues.

RESOURCE RECOVERY—*Information on the use, reuse, or reclamation of hazardous constituents.*

Order #	Title

Updated **600** **California Waste Exchange Directory** (1993, 50 pp.)
Listing of commercial recyclers.

602 **California's Compilation of Hazardous Waste Recycling Laws** (1992, 17 pp.)
Lists excerpts from the California Hazardous Waste Control Law specific to recycling in California. Laws specific to the recycling of used oil are not included.

WASTE EVALUATION—*Evaluations of waste to determine whether they are hazardous based on interpretive guidance of Federal and California criteria.*

Order #	Title

700 **Regulation of Ethylene Glycol Wastes in California: A Regulatory Interpretation** (1991, 27 pp.)
Provides the DTSC interpretation of existing statutory and regulatory authority as it pertains to ethylene glycol.

LAND DISPOSAL INFORMATION

Order #	Title
Updated 850	**Land Disposal Restrictions Bulletins** (April 1990, September 1990, March 1991, and December 1992, 14 pp.) An update on California's Treatment Standards and Land Disposal Restrictions.
851	**Cleanup Wastes Under RCRA/Non-RCRA** (1991, 174 pp.) A guidance document on Federal and State land disposal restrictions for wastes generated from site remediation, corrective action, or other types of cleanup activities.
852	**Land Disposal Restrictions Handbook** (1992, 101 pp.) Provides an overview of the Land Disposal Restrictions (LDRs) for hazardous waste. It serves as a guide to the requirements and treatment standards associated with these restrictions and contains general information about the variances and exemptions available under this program.
853	**Guidance Manual: Petitioning for Treatability Variance from Hazardous Waste Treatment Standards** (1991, 173 pp.) A treatability variance can be issued if the hazardous waste cannot be treated to meet treatment standards due to technical reasons. This document outlines essential information that must be included in the variance application.

HAZARDOUS WASTE DATA AND INFORMATION ANALYSIS

Order #	Title
900	**California's Exports and Imports of Hazardous Waste—1986 to 1988** (1990, 162 pp.) Looks at California's interstate and international shipments of hazardous waste from 1986-1988. International shipments are focused mainly on maquiladora waste (waste from American companies operating in Mexico).
901	**California's Nonrecurrent Hazardous Waste Reports** (1990, 148 pp.) One hundred seventy-six sites for nonrecurrent hazardous waste are described through a variety of narration, data tables, and graphs to illustrate methods used by the DTSC to manage this source of hazardous waste. The historical and current status data were utilized to project future quantities of nonrecurrent hazardous waste generated and treated over the next 20 years.
Updated 902	**Commercial Hazardous Waste Facilities for Recycling, Treatment, and Disposal** (1993, 120 pp.) Directory to assist California hazardous waste generators, industry, and the general public in assessing the current recycling, treatment, and land disposal options available in California and other states. The directory offers suggestions for locating commercial recycling/treatment/disposal facilities.

PLANNING—*Evaluations of waste generators, facilities, and future needs.*

Order #	Title
1000	**Capacity Assurance Plan for Hazardous Waste Management** (1989, 126 pp.) Outlines the program that California will follow to meet its integrated hazardous waste management needs in accordance with the Federal government's requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
1001	**Status Report on Hazardous Waste Management in California — A Draft Report** (1989, 143 pp.) Summarizes the quantities of hazardous waste generated in California industry, government, and households for the year 1987. A large fraction of this waste was recycled. Future projections for the year 1995 show that adequate capacity is expected to exist in each hazardous waste management category except incineration.

GRANTS—*Findings of DTSC Grant Projects.*

Order #	Title
Updated 1101	**California Hazardous Waste Reduction Grant Program—Grant Application Manual (Updated Annually)** (1994, 56 pp.) Provides information on how to submit a properly prepared application to the California Hazardous Waste Reduction Grant Program that is managed by the Office of Pollution Prevention and Technology Development.
Updated 1102	**Hazardous Waste Reduction Technology Research, Development, and Demonstration Grant Program** (1993, 1 p.) Brief description of the Grant Program. Fifteen to twenty grants are usually awarded each year.
1155	**Hazardous Waste Reduction Program Abstracts (1985-1991)** (94 pp.) A compilation of the abstracts from the Hazardous Waste Reduction Grant projects completed since 1985. Over 125 projects have received funding totaling over $7 million. The compiled abstracts serve to transfer technology awareness to industry, consultants, regulators, and the public.

BIENNIAL REPORTS TO THE CALIFORNIA STATE LEGISLATURE

Order #	Title
1206	**Alternative Technologies for Recycling and Treatment of Hazardous Wastes (Third Biennial)** (1986, 186 pp.) It is a guide for hazardous waste generators seeking alternative waste management techniques and serves as a resource for the public and policy makers in government and industry. The technologies and economics described are critical considerations for the formulation of California's hazardous waste management policy.
1203	**Economic Implications of Waste Reduction, Recycling, Treatment and Disposal of Hazardous Wastes (Fourth Biennial)** (July 1988, 126 pp.) Reports on the cost/benefit of reducing hazardous waste in industry. Cost comparisons of site mitigation activities, industry waste minimization, and future liabilities of hazardous waste disposal are discussed.
1202	**Alternative Technologies for the Minimization of Hazardous Waste (Fifth Biennial)** (1990, 140 pp.) Reports on activities relating to innovative hazardous waste minimization, recycling, and treatment technologies.
501	**Pollution Prevention in California—An Overview of California's Pollution Prevention Programs (Sixth Biennial)** (1992, 110 pp.) An overview of California's multimedia pollution prevention programs at the State and local government levels. Industry pollution prevention case studies show how business responds to the pressure to reduce wastes.

ALTERNATIVE TECHNOLOGY—*New and innovative alternative technologies.*

Order #	Title
1200	**Application of the Polysilicate Technology to Heavy Metal Wastestreams** (1987, 33 pp.) The polysilicate treatment technology has been applied to a variety of waste streams containing heavy metals. It differs from conventional forms of solidification/fixation/stabilization by forming a metal metasilicate as a by-product. It is still semi-empirical in nature and requires further research.

ALTERNATIVE TECHNOLOGY
(continued)

1201 **Final Report on CCBA (Coordinate Chemical Bonding Project) Phase III** (1988, 24 pp.)
The goal of this successful project was to demonstrate that when mixing industrial sludges containing metal ions with highly absorptive clay, in proper proportions and at elevated temperatures, the metal ions will fuse into the clay's silica structure and render the resulting material nonhazardous.

1204 **Laboratory Scale Tests of the Circulating Bed Combustion of Spent Potliners—Final Report (Includes Project Summary)** (1988, 76 pp.)
Spent potliner (SPL) is a solid waste by-product of aluminum smelters that contains soluble species of cyanides and fluorides. The circulating bed combustor process treats SPL reducing both cyanide and leachable fluoride levels by specialized thermal treatment processes.

1207 **UV/Hydrogen Peroxide Treatment for Destruction of Pesticide Laden Waste—Final Report (Includes Project Summary)** (1987, 30 pp.)
This system has been reported to be effective in degrading organic contaminants in water by a chemical oxidation process. The study focuses on the destruction of low level, aqueous pesticide wastes.

1208 **UV/Ozone Treatment of Pesticides and Groundwaters** (1988, 36 pp.)
A discussion of a demonstration project using the Ultrox Ultraviolet light enhanced oxidation technique for a variety of organic contaminants including pesticides, halogenated compounds, phenols, benzene, and other aromatics.

1209 **Composting for Treatment of Pesticide Rinseates—Final Report (Includes Project Summary)** (1988, 63 pp.)
This study tests the viability of aerobic composting as a treatment option for low level pesticide wastes previously stored in evaporation ponds or in a landfill.

New **1215** **The Construction and Assessment of a Biological System for Biodegradation and Recycling of Pesticide Waste** (1993, 57 pp.)
Experimental results and data of a biologically based, electromechanical system that uses horse manure as a source of microbes to biodegrade pesticide waste.

New **1216** **Pesticide Rinsates: Biodegradation Technology (Technology Brief)** (1993, 4 pp.)
Describes a biologically based, electromechanical system that uses horse manure as a source of microbes to biodegrade pesticide rinsates.

1210 **Chlorinated Solvent Recovery from Groundwater Using Contaminated Ambersorb XE-340 Carbonaceous Resin Adsorbent—Final Report (Includes Project Summary)** (1991, 7 pp.)
Presents findings and conclusions of using Ambersorb XE-340 carbonaceous resin adsorbent to remove 1,1,1-trichloroethane (TCA) and trichloroethylene (TCE) from groundwater.

1211 **Reclamation of Waste Foundry Sands: Fresno Valves and Castings, Inc. Waste San Reclamation Project** (1992, 4 pp.)
Describes a project involving the reconditioning and reuse of most of the waste sand.

1212 **Alternative Technology Demonstration Project Report—Use of Kerr McGhee Chemical Corporation Boiler Fly Ash as a Feedstock in the Manufacturing of Southwestern Portland Cement**
This project determined that the use of Kerr McGhee fly ash as an ingredient in the manufacture of Portland Cement resulted in a cement product that effectively stabilized hazardous levels of nickel and vanadium present in the ash ingredient.

New **1213** **Alternative Technology Demonstration Project Report—Separation of Phosphor Powder, Glass and Endcaps to Enable Recycling of Spent Fluorescent Lamp Tubes** (1993, 12 pp.)
A full-scale demonstration of this effective system was conducted with Mercury Technologies, Incorporated.

New **1214** **Water Based Ink Wastes: Biodegradation Technology (Technology Brief)** (1993, 4 pp.)
Describes a biologically based electromechanical system that uses horse manure as a source of microbes to biodegrade water based ink wastes.

New **1217** **California Environmental Technologies and Services Directory** (updated annually) (1993, 272 pp.)
The Directory consists of an alphabetical listing of over 1,100 California environmental companies and a series of technology matrices giving detailed information about the company's involvement in the environmental industry.

TREATMENT STANDARDS—*Treatment standards established by the U.S. EPA pursuant to the Resource Conservation and Recovery Act (RCRA) will be adopted by the DTSC for RCRA wastes. The DTSC is developing treatment standards for non-RCRA wastes. The following treatment standards reports are available:*

Order #	Title
800	**Proposed Treatment Standards for Metal-Containing Aqueous Wastes** (1988, 312 pp.)
801	**A Proposed Treatment Standard for Non-RCRA Aqueous and Liquid Organic Waste Vol. I & II** (1990, 73 pp.)
802	**Treatment Standards for Asbestos-Containing Wastes** (1990, 62 pp.)
803	**Treatment Levels for Auto Shredder Wastes** (1989, 88 pp.)
804	**Treatment Standards for Foundry Sand** (1989, 101 pp.)
805	**Treatment Standards for Non-RCRA Fly Ash, Bottom Ash, Retort Ash, Baghouse Waste, and Gas Scrubber Waste** (1990, 131 pp.)
806	**Landfill Criteria for Nonliquid Hazardous Waste** (1988, 109 pp.)
808	**Treatment Standards for Non-RCRA Organic Containing Petroleum Hazardous Wastes** (1992, 220 pp.)
809	**Development of Treatment Standards for Non-RCRA Solvent Waste** (1989, 99 pp.)
810	**Treatment Standards for PCB Wastes** (1988, 142 pp.)
812	**Implementation of SB 2093, Chapter 1417, Statutes of 1988, Health and Safety Residuals Repository** (1990, 82 pp.)
813	**Proposed Treatment Standards for Solid Wastes with Metals** (1989, 195 pp.)
814	**Treatment Standards for Solids with Organics** (1991, 63 pp.)
815	**Treatment Standards for Liquid Redox Waste** (1990, 98 pp.)

REMEDIAL TECHNOLOGY DEMONSTRATION REPORTS—***Independent technical evaluations of new, innovative, hazardous waste remedial technologies. Reports include details of bench-, plot-, or full-scale demonstration projects. The findings result in a Department conclusion regarding the project feasibility and provide the technical basis for any future permits for commercial operation. Reports are grouped by type of treatment.***

Order #	Title

BIOLOGICAL

1300 Above-Ground Bioremediation of Biphenyl and Diphenyl Oxide Contaminated Soil (1991, 8 pp.)
Two pilot-scale demonstrations were conducted to evaluate the effectiveness of above-ground bioremediation of soil contaminated with a mixture of biphenyl and diphenyl oxide. The tests demonstrated that the addition of water and nutrients, and the tilling of the soil reduced the concentrations of the contaminants by about 50-60 percent with or without the addition of exogenous bacteria.

1303 Biological Remediation of a Fuel Contaminated Soil Site in Carson, California—Protek Environmental, Inc. (1990, 7 pp.)
Diesel fuel-contaminated soil was biologically treated above ground in treatment cells. Total petroleum hydrocarbons were reduced from 1,084 mg/kg to 2 mg/kg in 90 days in the treatment cells. Similar removal occurred in the control cell.

1304 Bioremediation of Used Oil-Contaminated Soil at Two Caltrans Maintenance Yards—Groundwater Technology Corporation (1990, 10 pp.)
Provides results for full-scale bioremediation at two sites. At one site, a single pile was treated with an aqueous nutrient solution and passive aeration. At the second site, one pile was treated with an aqueous nutrient solution and active aeration while a second pile was used as a control. All piles showed some removal of hydrocarbons.

CHEMICAL

1305 Chemical Reduction of Hexavalent Chromium Contaminated Soils for a Site in Bakersfield, California (1991, 6 pp.)
Full-scale tests were conducted to determine the effectiveness of a chemical reduction process to treat hexavalent chromium-contaminated soils. The process was successful at reducing the concentration levels of hexavalent chromium by an average of 95.8 %.

1306 Hydrogen Peroxide/Catalyst Oxidation Process from a Gasoline Contaminated Site in Fullerton, California—Ensotech, Inc. (1990, 20 pp.)
Full-scale field tests were conducted to evaluate the effectiveness of Ensotech, Inc.'s hydrogen peroxide/catalyst process to treat soil contaminated with gasoline from a leaking underground fuel tank. Test results show significant reductions in gasoline concentrations in soil but no significant difference between the Ensotech process and the control.

PHYSICAL

1301 AquaDetox/SVE Integrated System for Groundwater and Soil Contaminated with Volatile Organic Compounds in Burbank, California (1991, 22 pp.)
An evaluation of the AquaDetox/Soil Vapor Extraction (SVE) Integrated System developed by AWD Technologies, Inc. The evaluation included calculating the contaminant removal efficiencies of the AquaDetox and SVE systems separately. The AquaDetox system removed 99.87 percent of the volatile organic compounds from the contaminated groundwater. The SVE system removed 99.65 percent of the volatile organic compounds from the air that was vacuum extracted from the contaminated soil.

1313 Soil Washing Technology for Low Volatility Petroleum Hydrocarbons—Verl's Construction Company (1990, 6 pp.)
A full-scale field demonstration of a portable soil washing system owned and operated by Verl's Construction Company was conducted at the Peterson Tractor site in San Leandro, California. Removal efficiencies of oil and grease as high as 71% were measured during a single pass through the washer.

STABILIZATION

1302 Bench-Scale Demonstration of a Metal Stabilization Process for a Site in Commerce, California—Silicate Technology Corporation (1990, 8 pp.)
Bench-scale tests were conducted to evaluate the effectiveness of Silicate Technology Corporation's process to stabilize soluble metals in lead contaminated soil from a hazardous waste site. The treated soils showed significant reductions in soluble lead concentrations.

1307 Metal Stabilization Process for Municipal Waste-To-Energy Ash—Lassen College (1990, 15 pp.)
A three-part demonstration was conducted to evaluate the effectivness of a sodium silicate/cement-based process used to stabilize heavy metal contaminated fly and bottom ash generated by a municipal solid waste-to-energy cogeneration facility. Results show the process has the potential to reduce soluble heavy metal concentration to below the California regulatory limits.

1308 Portland Cement Stabilization Process for Lead-Contaminated Soil (1991, 7 pp.)
Six cubic-foot batches of lead-contaminated soil were treated with differing ratios of Portland Cement. Average soluble lead concentrations were significantly reduced.

1310 Silicate Stabilization Process for Heavy Metal Contaminated Soil at the Tamco Steel Site—Solids Treatment Systems, Inc. (1990, 7 pp.)
A full-scale demonstration of a silicate stabilization process was conducted. Soil contaminated with lead, zinc, and cadmium were treated by the Trezek or Lopat process. All leachable metal concentrations were reduced to below their respective hazardous waste thresholds.

1314 A Stabilization Process for Soils Contaminated with Metals and Petroleum Hydrocarbons—Benz/Gabbita Consulting Services (1990, 10 pp.)
Bench-scale demonstration tests evaluated the effectiveness of a stabilization process to treat lead and petroleum hydrocarbons in a soil matrix. The ability of the process to stabilize total petroleum hydrocarbons could not be confirmed.

1315 Sulfide Stabilization Technology for Copper-Contaminated Soil—Toxco Incorporated (1990, 7 pp.)
Copper-contaminated soil was treated with a sulfide precipitation process that created reactive sulfides at levels that classified the treated soil as a RCRA waste. The pH was above the hazardous waste threshold of 12.5.

THERMAL

1311 Soil Cleanup System for a Diesel Contaminated Site in Kingvale, California—Earth Purification Engineering, Inc. (1990, 15 pp.)
Full-scale field tests were conducted to determine the effectiveness of Earth Purification Engineering Inc.'s Soil Cleanup System to treat diesel fuel contaminated soil and to estimate the level of stack air emissions from the treatment. The system was successful at removing the diesel contamination from the soil, but did not achieve good destruction of the diesel in the stack gases.

1312 Soil Detoxification Utilizing an Existing Aggregate Drier—South Coast Asphalt Products Company (1990, 3 pp.)
Simple feasibility tests using an existing rotary drier at an asphalt batch plant were coordinated in 1986. Results of the demonstration indicated high gasoline removal but poor combustion of the gasoline vaporized from the soil.

REMEDIAL TECHNOLOGY DEMONSTRATION REPORTS—THERMAL (continued)

1316 Thermal Treatment of Hydraulic Fluid Contaminated Soil (1991, 12 pp.)
Tests were conducted to determine the effectiveness of U.S. Waste Thermal Processing's Mobile Thermal Processor, Model 100, to treat hydraulic fluid-contaminated soil and to measure the level of stack air emissions from the treatment. The Model 100 successfully removed hydraulic fluid from the soil and achieved good destruction and removal of the contaminants from the stack gases.

1317 Thermal Treatment of Petroleum Hydrocarbon-Contaminated Soil (1991, 42 pp.)
A demonstration of Ogden Environmental Services' Circulating Bed Combustor for the remediation of soil contaminated with fuel oil #6 was conducted. Total petroleum hydrocarbons in the treated soil (bed and fly ash) were below or slightly above the U.S. EPA Method 418.1 detection limit of 5 parts per million.

1318 Thermal Treatment Process for a Diesel-Contaminated Site in San Diego, California (1991, 14 pp.)
A full-scale field test was conducted to determine the effectiveness of Earth Purification Engineering, Inc.'s Soil Cleanup System to treat diesel fuel-contaminated soil. The system successfully removed the diesel contamination from the soil to below the established cleanup level of 1,000 mg/kg.

1319 Thermal Treatment Process for Fuel Contaminated Soil—U.S. Waste Thermal Processing (1990, 30 pp.)
Tests were conducted to determine the effectiveness of a mobile thermal processing unit to treat petroleum fuel contaminated soil. The tests were successfully performed on synthetically prepared gasoline and diesel contaminated soil.

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OTHER REMEDIAL TECHNOLOGY INFORMATION

Order #	Title
1350	**Remedial Technology Applications Matrix for Soils and Sludges** (1991, 16 pp.) The Remedial Technology Applications Matrix was developed to identify treatment technologies applicable to treating contaminated soils and sludges that should be considered for hazardous waste site cleanup.
1351	**Site Cleanup Treatment Technologies** (1992, 82 pp.) Designed to provide "Superfund" site managers, engineers, and planners with current information on the capability and availability of treatment systems to remediate hazardous waste sites. The summary information was obtained from the responses to the 1991 Solicitation of Interest (SOI) as part of the Remedial Technology Assessment Program (RTAP). The responses are from treatment technology developers and vendors who have, or are in the process of, developing treatment systems applicable to site remediation.

VIDEOS

SOURCE REDUCTION

Order #	Title	Price
1400	**Hazardous Waste Minimization: Planning for Success** (1991, 3 hours, 2 tapes) An interactive videoconference on SB 14: The Hazardous Waste Source Reduction and Management Act of 1989.	**25.00**

WASTE MINIMIZATION

Order #	Title	Price
1500	**Waste Minimization for Inspectors (Videotape of a slide show)** (1991, 44 minutes) A three-section videotape of a slide show that provides a basic introduction to waste minimization and assessment procedures, and an excellent overview of waste minimization processes involved in metal cleaning, metal finishing, and printed circuit board manufacturing.	**15.00**
New 1501	**Why Waste?: Waste Minimization for Today's Businesses** (1990, 28 minutes) Defines waste minimization and illustrates waste minimization successes in several different types of businesses. Source reduction and recycling case studies illustrate the environmental and economic benefits of implementing waste minimization programs. Is useful for training sessions and seminars focusing on innovative ways for reducing hazardous waste.	**15.00**

APPENDIX E:

FURTHER INFORMATION

For more information, contact the Technology Clearinghouse in the Office of Pollution Prevention and Technology Development at:

Department of Toxic Substances Control
Office of Pollution Prevention and Technology Development
P.O. Box 806
Sacramento, CA 95812-0806
(916) 322-3607

For information about your regulatory requirements, contact the DTSC regional office nearest you:

Region 1	- Sacramento	(916) 255-3545
	Fresno	(209) 297-3901
Region 2	- Emeryville	(510) 540-2122
Region 3	- Burbank	(818) 551-2800
Region 4	- Long Beach	(213) 590-4868

To get an EPA ID number, call:

DTSC,
Program and Administrative Support Division
(916) 324-1781 or (800) 618-6942

Metal Finishing shop owners and operators may be able to get additional information from:

- registered hazardous waste haulers
- trade associations
- recycling or treatment equipment vendors or services
- informational workshops
- consultants

To purchase a copy of the Califonia Code of Regulations, call (415) 244-6611, or write:

Barclays Law Publishers
P.O. Box 3066
South San Francisco, CA 94083-3066
(There is a charge for the regulations)

California Highway Patrol
Motor Carrier Safety Unit
1551 Benica Rd.
Vallejo, CA 94591
(707) 648-4180

California Highway Patrol
Motor Carrier Safety Unit
437 N. Vermont Ave.
Los Angeles, CA 90004
(213) 664-1108

California Highway Patrol
Motor Carrier Safety Unit
11336 Trade Center Dr.
P.O. Box 640
Rancho Cordova, CA
95741-0640
(916) 464-2090

For general questions about small quantity generators or federal regulations, call:

U.S. EPA, Small Business Ombudsman Clearinghouse Hotline	(800) 368-5888
U.S. EPA, RCRA (Resource Conservation and Recovery Act) Hotline	(800) 424-9346
U.S. EPA, Community Relations, Region IX, San Francisco, CA	(800) 231-3075
U.S. EPA, RCRA Information Line, Region IX, San Francisco, CA	(415) 744-2074

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Hazardous Waste Minimization Manual for Small Quantity Generators. University of Pittsburgh, Center for Hazardous Materials Research, 1989.

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Pollution Prevention Tips: Counter-Current Rinsing. North Carolina Department of Natural Resources & Community Development, 1985.

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Thibault, James. "The Costs and Benefits of Source Reduction in Metal Finishing" in Meeting Hazardous Waste Requirements for Metal Finishers (Seminar Publication). U. S. Environmental Protection Agency (EPA/625/4-87/018), September, 1987.

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