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·lazardous Waste Minimization Assessment: Fort Ord, CA

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FOREWORD

This work was performed for Headquarters, U.S. Army Forces Command (HQFORSCOM), under an Interagency Reimbursable Order (IAO) 3788, dated 25 July 1988. The FORSCOM Technical Monitor was Mr. Rudy Stine.

The work was done by the Environmental Engineering Team of the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (USACERL). Dr. Edward W. Novak is the Acting Chief of EN. The technical editor was Gloria J. Wienke, USACERL Information Management Office.

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COL Everett R. Thomas is Commander and Director of USACERL, and Dr. L.R. Shaffer is the Technical Director.

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HAZARDOUS WASTE MINIMIZATION ASSESSMENT: FORT ORD, CA

1 INTRODUCTION

Background

Waste minimization is the process of reducing the net outflow of hazardous solid, liquid, and gaseous effluents from a given source or generating process. It involves reducing air emissions, contamination of surface and ground water, and land disposal by means of source reduction, recycling processes, and treatment leading to complete destruction. Transferring pollutants from one medium to another (e.g., from water to air) by treatment processes is not waste minimization.

On November 8, 1984, the U.S. Congress signed into public law[1] the Hazardous and Solid Waste Amendments (HSWA) act establishing a national policy on waste minimization. HSWA required the U.S. Environmental Protection Agency (USEPA) to issue regulations that began the process of implementing the 1984 amendments to the Resource Conservation and Recovery Act (RCRA).[2] Among the Federal regulations is a requirement that every generator of hazardous wastes (HW) producing in excess of 2205 pounds (lb)[*] per month certify, when hazardous wastes are manifested (listed on a tracking document), that a hazardous waste minimization program is in operation.[3] Generators are required to submit biennial reports to the USEPA that describe efforts taken to reduce the volume and toxicity of waste generated during the year. Federal regulations issued in October 1986 clarify the status of small quantity (220 to 2205 lb/month) generators (SQG) of hazardous waste.[4] SQGs are required to make a "good faith" effort to minimize hazardous waste generation and implement the best available treatment, storage, or disposal alternative economically feasible.

The more restrictive regulations, high treatment/disposal expenses, and increased liability costs prompted private industry and several government agencies to critically examine means that will lead to prevention of pollution as opposed to end-of-pipe treatment methods. Waste minimization is economically beneficial to Army installations. Some of the cost savings realized by minimizing wastes result from: reduced transportation and disposal costs for offsite disposal; reduced compliance costs for permits, monitoring, and enforcement; reduced onsite treatment costs; reduced onsite storage and handling costs; lower risk of spills, accidents, and emergencies; lower long term liability and insurance costs; reduced raw materials costs; reduced waste generation fees; reduced effluent costs and assessments from local sewage treatment plants; reduced production costs through better management and efficiency; and, reduced operation and maintenance costs.

In fiscal year (FY) 1987, the Army directly paid (through a centrally funded process) the Defense Logistics Agency (DLA) $17.5 million for disposal of only 15 percent of the total wastes generated by Army installations.[5] The DLA, through its Defense Reutilization and Marketing Offices (DRMOs) located in several regions, was responsible for disposal of most categories of hazardous waste generated by the installations. The installations do not have a separate funding account for waste disposal and

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[1]Public Law 98-616, *Hazardous and Solid Waste Amendments* (1984).
[2]Public Law 94-480, *Resource Conservation and Recovery Act* (1976).
[*]Regardless of the units of measure used in source documents, all measurements have been converted to English units. Metric conversions are on p 185.
[3]40 CFR 261, *Identification and Listing of Hazardous Waste*, and 40 CFR 262, *Standards Applicable to Generators of Hazardous Wastes* (1985).
[4]Federal Register, Vol 51, No. 190 (October 1986), pp 35190-35194.
[5]V.J. Ciccone and Associates, Inc., *Program Status Report: Department of the Army Hazardous Waste Minimization* (U.S. Army Environmental Office, August 1988), p 43.

therefore do not realize the responsibility for waste generation and the cost of disposal. Beginning in FY 1990, the accounting process for waste disposal will be decentralized to provide a strong economic incentive to reduce waste generation.[6] The installations will have to pay the waste disposal costs from their operation and maintenance budget.

In December 1985, the Joint Logistics Commanders (JLC) established the following Department of Defense (DOD) policy:[7]

> The generation of hazardous waste (HW) at Department of Defense activities is a short- and long-term liability in terms of cost, environmental damage, and mission performance. A HW minimization program shall be developed by each service and shall contain the basic concepts in this directive.

Recognizing the liabilities of improper disposal and the advantages of waste minimization, JLC set a DOD-wide goal of 50 percent reduction in hazardous waste generation by 1992, based on the baseline generation in 1985. The Department of the Army is following this DOD goal and has established a policy[8] applicable to all Active Army, Reserve, and National Guard installations.

Army installations are like small cities with a variety of activities that generate pollution within their boundaries. Unlike civilian cities, where there are many SQGs, each installation as a whole (and its Commander) is a generator held responsible for complying with regulations and reducing pollution from all the activities within its boundaries. Environmental protection must be made a primary concern of every employee on an installation. Everyone must make an effort to protect air, water, and land from industrial and chemical contaminants. Pollution prevention pays not only in terms of complying with regulations, saving in disposal/treatment costs, reducing liability and improving public image, but also in maintaining the good health and welfare of all people.

Each installation is responsible for implementing a hazardous waste minimization (HAZMIN) plan and each employee, military and civilian, is responsible for following the plan. To comply with both the letter and the spirit of the law, the U.S. Army Forces Command (FORSCOM) contracted the U.S. Army Construction Engineering Research Laboratory (USACERL) to prepare HAZMIN plans for five FORSCOM installations.

Objective

The objective of this research was to develop a hazardous waste minimization plan for Fort Ord, CA, to include the actions necessary to accomplish reduction in volume and toxicity of hazardous wastes generated.

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[6] Office of the Assistant Chief of Engineers, "Hazardous Waste Disposal Funding," DAEN-ZCP-B Memorandum (Department of the Army, 28 October 1988).
[7] Joint Logistics Commanders, "Hazardous Waste Minimization Program," Memorandum to the Deputy Secretary of Defense (12 December 1985).
[8] *Hazardous Waste Minimization (HAZMIN) Policy* (Department of the Army, 1989).

Approach

The following approach was used to develop the plan:

1. Prepare a study strategy that included development of a protocol for conducting a HW inspection/survey. The inspection/survey protocol was developed from literature reviews and previous HW surveys performed by the U.S. Army Environmental Hygiene Agency (USAEHA), and USACERL.

2. Conduct a survey of all possible waste generated at Fort Ord from 26 through 28 April 1989 and 19 through 30 June 1989.

3. Compile data on hazardous materials procurement by different users on the installation.

4. Compile data on hazardous waste generation for each possible generator on the installation.

5. Compile information on each waste stream including: waste characterization; waste source; baseline generation; current method of treatment, storage, and disposal and the associated costs; and past/present minimization efforts and associated costs.

6. Prioritize waste streams by criteria such as: composition, quantity, degree of hazard, method and cost of disposal, compliance status, liability, and potential to minimize.

7. Identify and prioritize minimization options for major waste streams.

8. Conduct feasibility and economic analyses of minimization options.

9. Prepare the final plan.

Scope

This technical report presents the results of the HAZMIN assessment of Fort Ord and minimization techniques that must be implemented. Although an attempt was made to quantify all the hazardous materials procured by and hazardous wastes generated at Fort Ord, a study of the mass balance of chemicals entering and wastes leaving the installation (which allows development of strategies for waste minimization) could not be completed because of lack of data.

Some of the tables prepared for this report contain blanks. The blanks do not represent zero waste generation, but rather that the data was not available. Fort Ord should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use.

Mode of Technology Transfer

The HAZMIN plan (Appendix A) will be presented to Fort Ord for implementation. The recommendations that have been made should be incorporated in the installation policies and regulations.

2 HAZARDOUS WASTE MINIMIZATION

The HSWA requires generators of hazardous wastes to certify that they have a waste minimization program. Every waste shipment manifest (or tracking document) is accompanied by the following declaration, in compliance with Section 3002(b) of HSWA:

> The generator of the hazardous waste has a program in place to reduce the volume and toxicity of such waste to the degree determined by the generator to be economically practicable; . . .

HSWA Section 3002(a) requires the generators of hazardous wastes to submit a biennial report, including their efforts to reduce the volume and toxicity of wastes generated. HSWA Section 3005(h) requires facilities that treat, store, or dispose of hazardous wastes to submit annual reports accompanied by similar declarations on waste minimization.

The HSWA also established a national land disposal restriction program by developing a schedule for banning all hazardous wastes from land disposal by May 1990. In November 1986, USEPA issued the first set of restrictions regarding land disposal of hazardous wastes.[9] These restrictions prohibited land disposal of untreated and concentrated spent solvents. Deadlines for banning land disposal were extended for other solvent wastes because it was felt that sufficient nationwide capacity for treatment did not then exist. It may well be that in a few years commercial land disposal will be available only to hazardous waste residues from treatment processes. In addition, generators must realize that they may be held liable for environmental contamination. Therefore, alternatives to land disposal are necessary.

Minimization includes any reduction in hazardous waste generation and any activities that result in either a reduction in the total volume or quantity of hazardous wastes, or a reduction in the toxicity of hazardous wastes produced, or both, as long as the activities are consistent with the national goal minimizing present and future threats to the environment.[10] By this definition, treatment options such as incineration are considered HAZMIN techniques. HAZMIN, therefore, can be achieved by:

1. Source Reduction: reducing or eliminating waste generation at the source, usually within a process or by an action taken to reduce the amount of waste leaving a process,

2. Recycling Onsite/Offsite: using a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in a process. Recycling also implies reclaiming useful constituent fractions from a waste or removing contaminants, allowing the waste to be reused, or

3. Treatment: eliminating the hazardous characteristics of a waste to make it nonhazardous to human health and the environment.

The hierarchy that should be used in a waste minimization process is shown in Figure 1.* The small amount of residue (e.g., ash) from the process will require "ultimate" disposal (e.g., landfill burial). Various waste minimization techniques, discussed in detail below, are shown in Figure 2. These techniques can be divided into three HAZMIN categories. Maximum waste reduction is usually achieved by using the best combination of suitable techniques from all three categories.

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[9] Federal Register, Vol 51, No. 190.

[10] *Minimization of Hazardous Waste. Executive Summary and Fact Sheet*, EPA/530/SW-86/033A (U.S. Environmental Protection Agency [EPA], Office of Solid Waste, 1986).

*Figures and tables are located at the end of each chapter.

Source Reduction

Source reduction is at the top of the hierarchy and is the "ideal" solution to the problem of hazardous wastes. All wastes have some potential to be minimized by using better operating practices, product/material substitution, and process changes. Source reduction eliminates the need for storage, transportation, treatment, and residue disposal, and the associated liabilities.

Better Operating Practices

Better operating practices include the simplest source reduction measures such as reducing spillage and leaks, inventory control, employee education/training and control, and better materials/wastes handling practices (e.g., segregation). Experience has shown that education and training programs in safety and hazardous materials/wastes management can be very effective. One approach to good housekeeping is to automate or computerize continuous processes, thereby decreasing human involvement and errors. Waste segregation is an extremely important housekeeping practice that should be incorporated into the work standard. For example, mixing a minute quantity of hazardous waste with a large quantity of nonhazardous waste generates a large quantity of hazardous waste that has to be reported and properly disposed of. Therefore, wastes should never be mixed (e.g., solvents and oils, trash and solvents/oils, gasoline and solvents, etc.). Also, the purity of the waste determines its recyclability (discussed below). Combining dissimilar wastes reduces the chance of recovering either one of them. By using waste segregation and improved handling, most generators could considerably reduce the quantities of wastes generated.

Inventory control is perhaps the most critical and effective better operating practice for HAZMIN. It is a low-cost and easily implementable method that is popularly used in many industries.[11] The quantities of wastes generated can be minimized by reducing the amount of excess material in stock and the amount used in any process or operation. Controlling the purchase of raw materials is the first step in inventory control. Standard operating procedures that allow local or Federal supply system purchase of only approved materials should be established. New materials must be approved before purchase. A tracking system should be established to ensure that all the materials purchased are used properly. Such a materials "manifest" system is a tool that is useful not only in minimizing waste generation but also in complying with the Community "Right-To-Know" law.[12]

Product/Material Substitution

Product/material substitution is a major category of source reduction. Most hazardous wastes are so categorized because they result from processes that use hazardous materials as input or in an intermediate step. Product substitutions are necessary to minimize the environmental impacts of some products (e.g., pesticides such as DDT, 2,4,5-T, etc.) and associated wastes. Use of nonhazardous or less hazardous products as substitutes is therefore recommended. An example of product substitution is replacing cadmium plated products with zinc or aluminum plated products in metal finishing operations.

Material substitution can also be viewed as a change in a process that involves using nonhazardous or less hazardous input or raw material, or a material with few impurities. Less hazardous materials with fewer impurities can reduce the likelihood of generating high volumes of hazardous

[11] G.E. Hunt and R.N. Schecter, "Minimization of Hazardous-Waste Generation," in *Standard Handbook of Hazardous Waste Treatment and Disposal*, H.M. Freeman Ed. (McGraw Hill, New York, NY, 1989), pp 5.3-5.27; D. Huisingh, *Profits of Pollution Prevention: A Compendium of North Carolina Case Studies* (North Carolina Board of Science and Technology, Raleigh, NC, 1985).

[12] Public Law 99-499 Title III, *Superfund Amendments and Reauthorization Act* (1986).

wastes. Some examples of material substitution are:[13] replacing chlorinated solvents (e.g., trichloroethylene [TCE], 1,1,1-trichloroethane, etc.) with hot caustic solutions or detergents in degreasing operations; using noncadmium pigments in ink manufacture; and replacing cyanide formulations with noncyanide formulations in cadmium electroplating baths.

One major form of product/material substitution is "aqueous" substitution; the use of water-based materials as inputs or products in a process. Many aqueous alternatives have been developed by the chemical industries. Some examples of aqueous substitution are:[14] replacing organic liquids (e.g., TCE, Stoddard solvent, xylene, toluene, etc.) with water-based products (e.g., Citrikleen, Histoclear, etc.) in metal cleaning and degreasing operations; replacing petroleum-based fluids with water-based fluids in metalworking and machining operations; substituting solvent-based ink with water-based ink in the printing processes; and using a water-based developing system instead of a solvent-based system in the manufacture of printed circuit boards.

Process Changes

Some generators will have to consider either improvements in the manufacturing process or even major changes in the technological processes to achieve waste reduction. Process change is a category of source reduction and includes source control. Source control implies examination and reevaluation of the processes that generate hazardous waste. Process optimization and increased efficiency were terms commonly used in source control projects to obtain the best quality product. Not much attention was paid to the waste. The concept of source control, therefore, is not new. Optimizing a process or increasing its efficiency also reduces the quantities of wastes generated. Process change or source control can further be divided into: process/equipment modifications, improved controls, and energy/water conservation.

Process/equipment modifications will require that operating/manufacturing processes and equipment used for waste minimization be redesigned. Some examples of process modifications are:[15] using dry plastic media blasting instead of wet chemical stripping (with methylene chloride, hot caustics, etc.) to remove paint from metallic substrates, replacing cocurrent rinsing with countercurrent rinsing in metal plating and surface finishing operations, and retrofitting the existing chrome-plating processes with equipment that reduces the discharge of rinsewater to almost zero.

Improved controls could also be included under "better operating practices." It implies proper control of processes or equipment to reduce emissions and waste generation. Conserving energy/water by controlling the heat input and reducing the amount of rinse/process water used can reduce emissions, solid wastes, and wastewater.

Recycling Onsite/Offsite

After all source reduction techniques have been examined for a particular waste stream, recycling options, both onsite and offsite, should be considered. Three types of onsite recycling operations are available:[16] (1) reuse of waste in the same process (e.g., continuous recycling of rinsewaters in plating/finishing operations, recycling of tetrachloroethylene in dry cleaning operations), (2) use of the waste in a different process (e.g., using waste battery acid as a neutralizing agent in an industrial wastewater treatment plant), and (3) processing the waste to produce a reusable product (e.g., distilling

[13] *Alternative Technology for Recycling and Treatment of Hazardous Wastes*, Third Biennial Report (California Department of Health Services, Alternative Technology and Policy Development Section, 1986).
[14] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[15] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[16] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*

solvents, burning used oil for heat content, etc.). Offsite recycling includes methods used to process the waste to produce a usable product (e.g., re-refining waste oil, reclaiming lead from lead-acid batteries, recovering silver from fixing bath solutions, incinerating hazardous wastes for heat content, etc.).

Recycling of hazardous wastes is encouraged by the Federal and State governments. Hazardous waste generators must explore all recycling opportunities for wastes whether or not the generation is reduced. Industrial recyclers are available for a number of wastes. Recyclable wastes include:[17] unused commercial chemical products, halogenated solvents, oxygenated solvents, hydrocarbon solvents, petroleum products (including oils and hydraulic fluids), pickling liquor, unspent acids and alkalis, and selected empty containers. Some offsite programs recycle batteries, mercury, and drums. Offsite recycling is also a major part of the program called "solvent leasing." In this program, a generator will lease process equipment. The equipment owner provides clean solvent and is responsible for removing and recycling used solvent.

An offsite recycling method that needs to be evaluated by DLA and DRMOs is the use of waste exchanges to recycle wastes. Waste exchanges are operations that engage or assist in transferring wastes and information concerning wastes. They help generators develop effective waste minimization programs and comply with legislative and regulatory requirements. A list of waste exchanges operating in North America is provided in Table 1. Some of these organizations are waste information "clearinghouses" and others are waste material exchanges. The information exchanges are usually nonprofit organizations that provide information about the availability and demand of waste materials. Material exchanges act as agents or brokers, and usually take the waste materials, process them, and market them for profit.

Treatment

Treatment of hazardous wastes should be the last minimization choice; after source reduction and recycling, but before "ultimate" disposal. Treatment alternatives must be considered only if source reduction and recycling are not feasible or economically practical. A treatment process: (1) destroys or detoxifies a hazardous waste to a material safe for disposal, (2) concentrates or reduces the volume of wastes for safer handling and disposal, or (3) immobilizes the hazardous components to keep them from the environment. Generators of large amounts of hazardous wastes usually treat the wastes onsite; generators of small amounts of hazardous wastes use offsite treatment facilities. With the increased availability of commercially packaged treatment units, generators may opt to treat wastes onsite. A hazardous residue requiring "ultimate" disposal may still be generated. Treatment processes include neutralization, filtration, evaporation, incineration, and precipitation. Acids, bases, and plating wastes are some of the waste streams that can be treated readily.

Four broad categories of treatment technologies (physical, chemical, biological, and thermal) are applicable to all waste streams. Physical treatment techniques, generally involving phase separation (e.g., solids from liquids), include:[18] separation techniques such as centrifugation, clarification, coagulation, decantation, encapsulation, filtration, flocculation, flotation, foaming, sedimentation, thickening, and ultrafiltration; and specific component removal techniques such as adsorption, blending, catalysis, crystallization, dialysis, distillation, electrodialysis, evaporation, magnetic separation, leaching, ion exchange, liquid-liquid extraction, reverse osmosis, stripping, and sand filtration. Some of the physical treatment techniques can be readily used as pretreatment steps (e.g., filtration, sedimentation, etc.) before onsite recycling of wastes and also as a part of better housekeeping practices.

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[17] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[18] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*

Chemical treatment techniques that use the differences in chemical properties of substances, include:[19] mound adsorption, fixation, oxidation, precipitation, reduction, chlorination, chlorinolysis, cyanide destruction, degradation, detoxification, ion exchange, neutralization, ozonation, and photolysis. Biological treatment techniques include:[20] activated sludge digestion, aerobic processes, composting, trickling filtration, and waste stabilization. Biological treatment processes rely on microorganisms (bacteria, fungi, etc.) to decompose and/or bioaccumulate the contaminants in wastes.

As a HAZMIN technique, treatment, unlike source reduction or recycling, has legal (or RCRA) implications. A permit has to be obtained for treatment of hazardous wastes. Only elementary neutralization (e.g., laboratory acids/bases neutralization) and "enclosed" wastewater and other treatment units are exempt from permitting requirements.[21]

HAZMIN Assessment

The HAZMIN assessment procedure and development of the plan (Appendix A) was based on the methods described in *EPA (Environmental Protection Agency) Manual for Waste Minimization Opportunity Assessments*[22], and other references.[23] The assessment protocol and survey forms are attached in Appendix B.

Development of a successful HAZMIN program contains four critical phases: planning and organization, assessment, feasibility analysis, and implementation (see Figure 3). Figure 4 indicates the two phases that USACERL was involved in. The U.S. Army Forces Command (FORSCOM) did the initial planning and organization for Fort Ord.

The first task in the assessment phase is to gather all the available information pertaining to hazardous materials procurement, waste generation, and operating procedures. Second, the waste streams are prioritized and selected for assessment. Team members are selected and a survey agenda is organized. The next step is the actual survey that includes: interviewing supervisors, foremen, and operators; observing housekeeping practices; inquiring about standard operating procedures; and gathering information about levels of administrative controls. Waste minimization options are then evaluated. The most promising options are selected for detailed evaluation.

In the feasibility analysis phase, the technical and economic feasibility of selected minimization options is evaluated. This phase includes the installation information (Chapter 3) and data gathered (Chapter 4), waste minimization techniques for the various types of sources and wastes (Chapters 5 to 11), and economic analysis of minimization options for select waste streams (Chapter 12).

Fort Ord should implement the HAZMIN plan according to methodology presented in Chapter 13. Successful implementation of the plan will require command support and commitment. Continuance of the HAZMIN program in the future will require constant evaluation of the goals, reassessment of generators, and developing newer/better procedures for minimizing wastes.

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[19] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[20] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[21] 40 CFR 260, *Hazardous Waste Management System: General* (1985).
[22] *EPA (Environmental Protection Agency) Manual for Waste Minimization Opportunity Assessments*, EPA/600/2-88-025 (USEPA, Hazardous Waste Engineering Research Laboratory, 1988).
[23] R.H. Hemstreet,"How to Conduct your Waste Minimization Audit," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 61-75; M.E. Resch, "Hazardous Waste Minimization Audits Using a Two-Tiered Approach," *Environmental Progress*, Vol 7 (1988), pp 162-166; M. Drabkin, C. Fromm, and H. M. Freeman, "Development of Options for Minimizing Hazardous Waste Generation," *Environmental Progress*, Vol 7 (1988), pp 167-173.

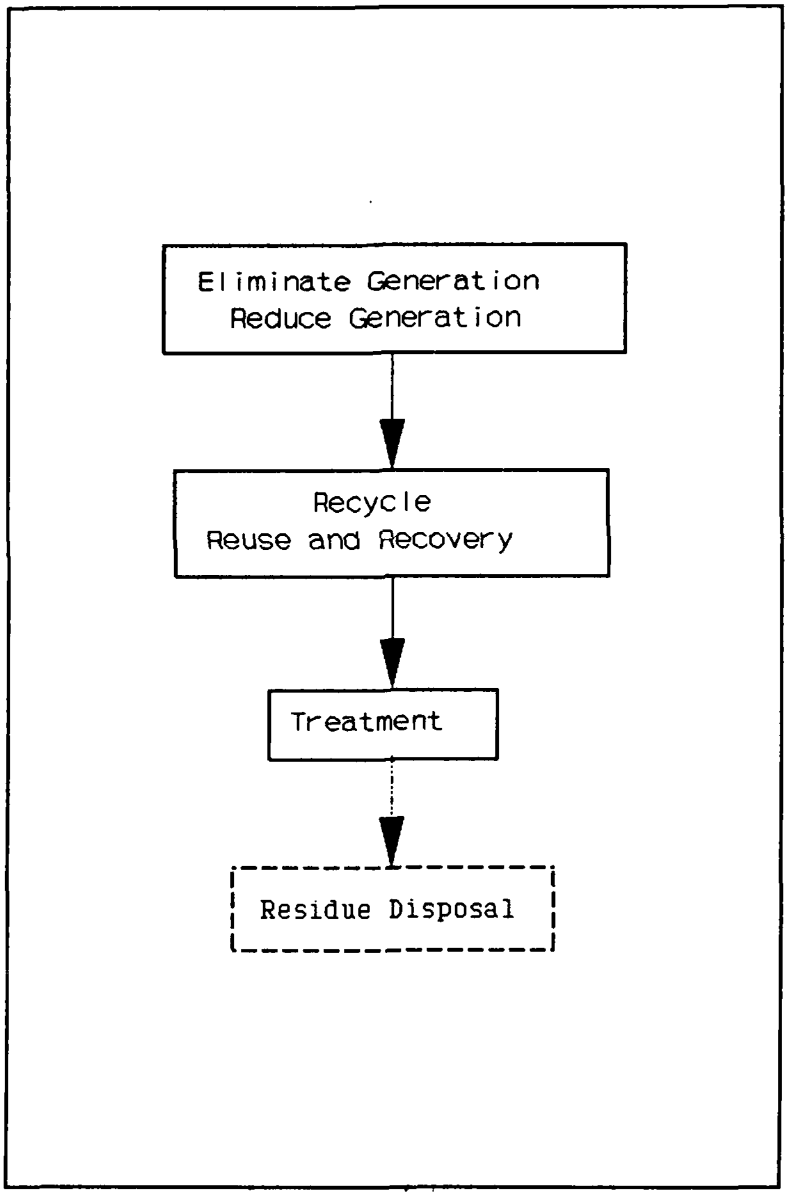

Figure 1. Waste minimization hierarchy.

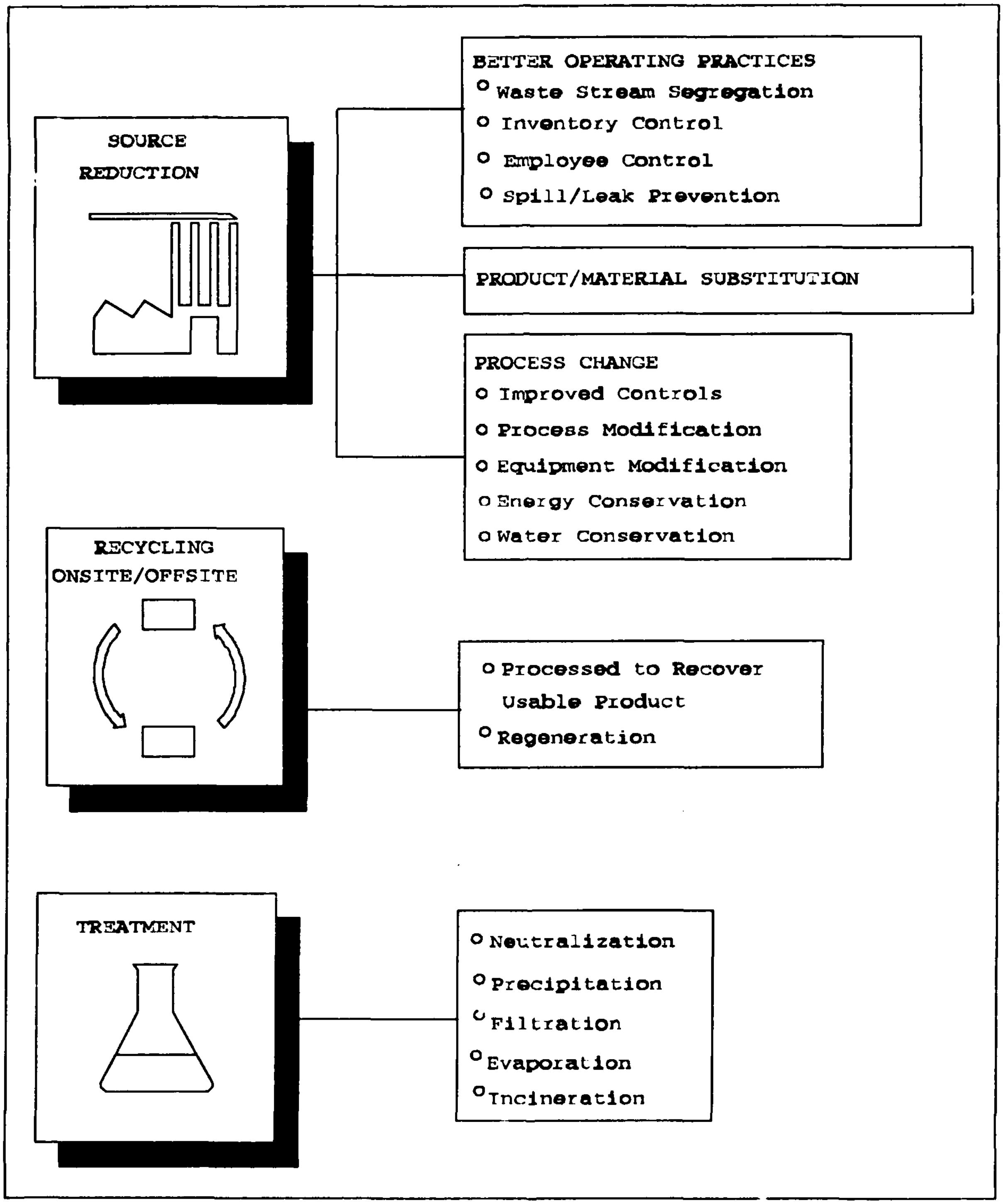

Figure 2. Waste minimization techniques.

Table 1

List of Waste Exchanges[*]

Alberta Waste Materials Exchange
4th Floor Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta
CANADA T6H 5R7
(403) 450-5461

California Waste Exchange
Department of Health Services
Toxic Substances Control Division
714 P Street
Sacramento, CA 95814
(916) 324-1807

Canadian Inventory Exchange[**]
900 Blondin
Ste-Adele, Quebec
CANADA J0R 1L0
(514) 229-6511

Canadian Waste Materials Exchange
Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario
CANADA L5K 1B3
(416) 822-4111

Enkam Research Corporation[**]
P.O. Box 590
Albany, NY 12202
(518) 436-9684

Georgia Waste Exchange[**]
c/o America Resource Recovery
P.O. Box 7178, Station A
Marietta, GA 30065
(404) 363-3022

Great Lakes Regional Waste Exchange
470 Market Street, S.W.
Suite 100-A
Grand Rapids, MI 49503
(616) 451-8992

Indiana Waste Exchange
P.O. Box 1220
Indianapolis, IN 46206
(317) 634-2142

Industrial Materials Exchange Service
2200 Churchill Road
IUSEPA/SLPC-24
Springfield, IL 62706
(217) 782-0450

Industrial Waste Information Exchange
New Jersey Chamber of Commerce
5 Commerce Street
Newark, NJ 07102
(201) 623-7070

Manitoba Waste Exchange
c/o Biomass Energy Institute, Inc.,
1329 Niakwa Road
Winnipeg, Manitoba
CANADA R2J 3T4
(204) 257-3891

Montana Industrial Waste Exchange
Montana Chamber of Commerce
P.O. Box 1730
Helena, MT 59624
(406) 442-2405

Northeast Industrial Waste Exchange
90 Presidential Plaza, Suite 122
Syracuse, NY 13202
(315) 422-2405

Resource Recovery of America[***]
P.O. Box 75283
Tampa, FL 33675-0283
(813) 248-9000

South Waste Exchange
Urban Institute
UNCC Station
Charlotte, NC 28223
(704) 547-2307

Southern Waste Information Exchange
P.O. Box 6487
Tallahassee, FL 32313
(904) 644-5516

Tennessee Waste Exchange
Tennessee Manufacturers and Taxpayers
Association
226 Capitol Blvd., Suite 800
Nashville, TN 37219
(615) 256-5141

Wastelink, Division of Tenecon
Associates[**]
P.O. Box 12
Cincinnati, OH 45174
(513) 248-0012

Western Waste Exchange
ASU Center for Environmental Studies
Krause Hall
Tempe, AZ 85287
(602) 965-1858

Zero Waste Systems[***]
2928 Poplar Street
Oakland, CA 94608
(415) 893-8261

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[*] Source: E.B. Jones, W. Banning, and R.C. Herndon, "Waste Exchanges and Waste Minimization and Reclamation Efforts," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 78-85.
[**] For-profit information exchange.
[***] Material waste exchange.

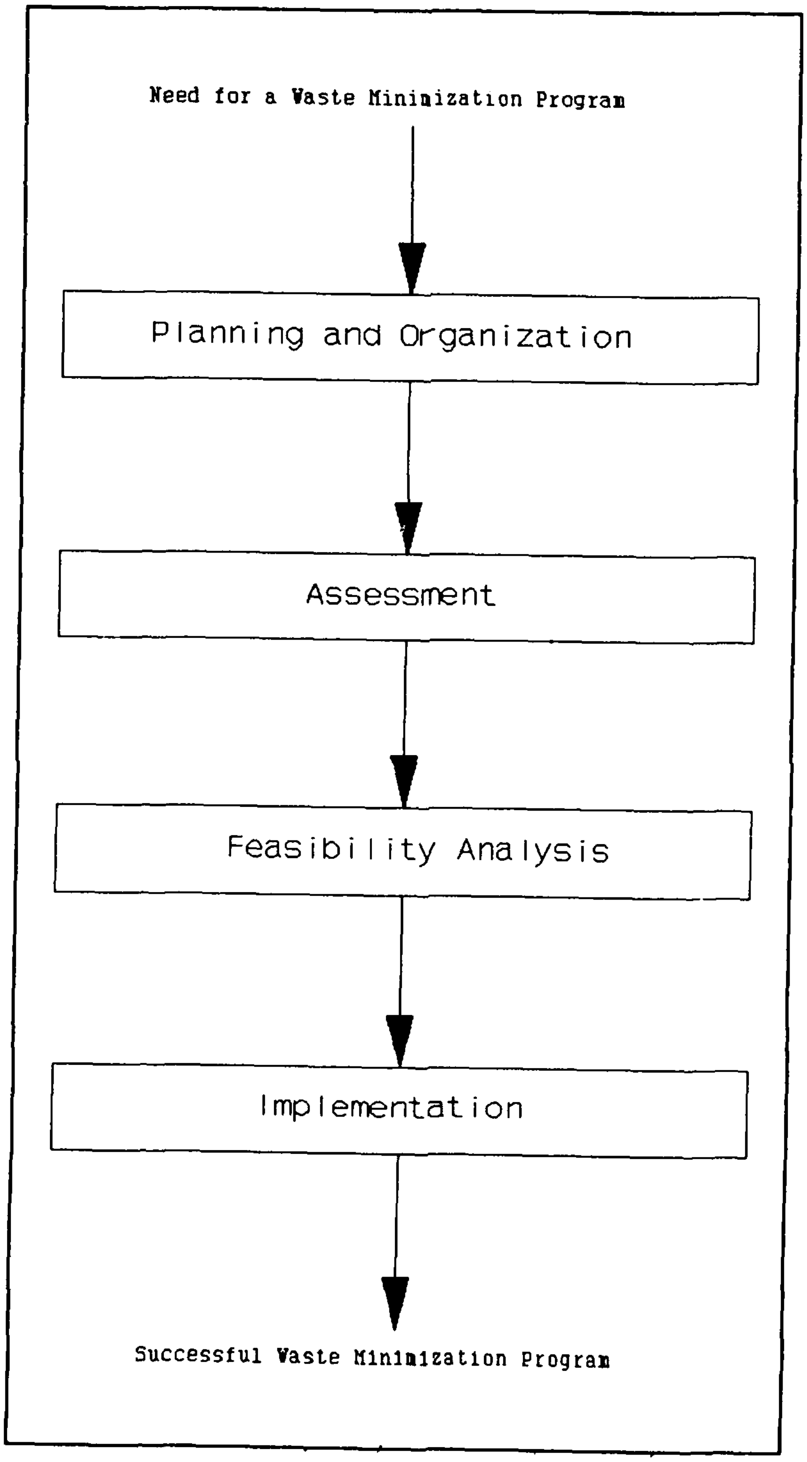

Figure 3. Hazardous waste minimization program development procedure.

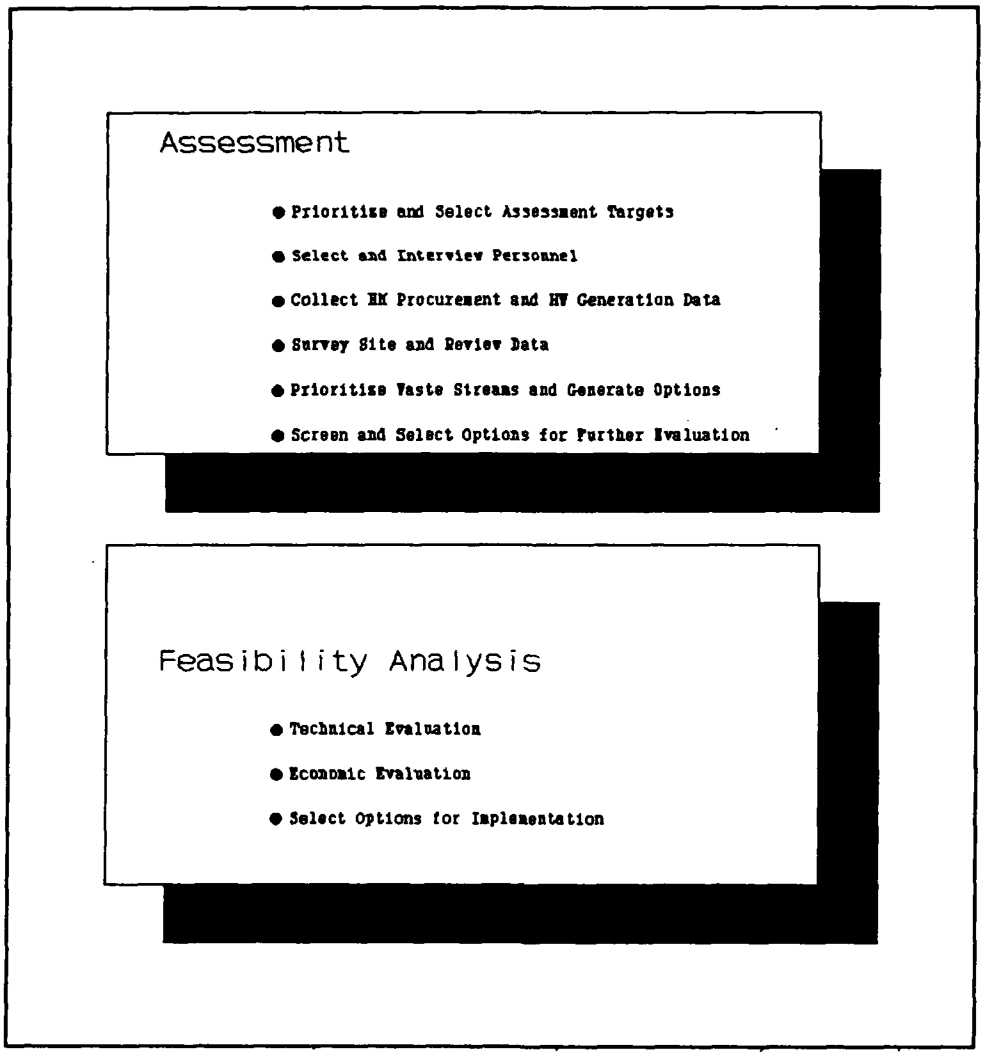

Figure 4. Hazardous waste minimization assessment and feasibility analysis procedure.

3 FORT ORD

History/Geography

Fort Ord is located 5-1/2 miles north of Monterey, CA. It covers an area of 29,610 acres that encompasses terrain ranging from gently rolling hills along the Monterey Bay to more rugged areas inland. The main garrison and cantonment area are located along the western edge of the installation and border Monterey Bay. El Toro Creek and the cities of Seaside and Del Rey Oaks are located on the east and south, respectively.

In 1917, 15,325 acres were purchased from the State of California. The area was called Gigling Field Artillery Range and was primarily a maneuver area and field artillery target range for units stationed at the Presidio of Monterey. In 1933, it was named Camp Ord and then renamed Fort Ord in 1940 when an additional 2000 acres were acquired. With the onset of World War II, 50,000 troops were stationed at Fort Ord which was one of the primary staging areas in the country.

The 4th Replacement Training Center was started at Ford Ord in 1947. In 1957, Fort Ord was designated as a U.S. Army Training and Doctrine Command Infantry Training center providing basic infantry training between 1957 and 1974. With the activation of the 7th Infantry Division in 1974, Fort Ord was designated as a U.S. Army Forces Command (FORSCOM) installation.

The 7th Infantry Division (Light), also known as the "Light Fighters," are known for their quick deployment. They can be deployed to any country at war within 18 hours. To maintain this capability, they possess only light infantry weapons/equipment and require many helicopters and aircraft ready for quick transport. Fort Ord's primary mission is to provide support to the Light Fighters. The Fritzsche Army Airfield is a large airfield that was dedicated in 1960 and further expanded in 1961 for aircraft maintenance and deployment. A 440-bed hospital, the Silas B. Hayes Army Community Hospital, was constructed in 1967 to provide medical and dental care to the military and civilian population on Fort Ord.

Four subinstallations were included under the direction of Fort Ord in 1981: Fort MacArthur, in San Pedro; Presidio of Monterey, in Monterey; Camp Roberts, in Paso Robles; and Fort Hunter Liggett, in King City. Fort MacArthur is now under the jurisdiction of the United States Air Force.

Tenants

Readiness training of the 7th Infantry Division (Light) is the primary mission of Fort Ord which supports a working population of approximately 32,000. The tenants that use the facilities and/or provide support necessary to accomplish the mission are:

1. U.S. Army Intelligence Services Command (USAISC)
2. Regional Data Center (RDC), Monterey
3. USAISC-Satellite Communication (SATCOM) Station
4. 6th Region, U.S. Army Criminal Investigation Division Command (USACIDC)
5. 95th Maintenance Detachment
6. TEXCOM Experimentation Center
7. Army Materiel Command (AMC) Logistics
8. Defense Reutilization and Marketing Office (DRMO)
9. 49th Explosives Ordnance Detachment (EOD)
10. 4th Platoon, A Company, 2/58th Aviation Regiment
11. Headquarters, 3rd Brigade, 91st Division

12. 6253rd U.S. Army Hospital
13. Company D, 13th Engineering Battalion
14. USAMTU #6
15. U.S. Trial Defense Service
16. Army Air Force Exchange Service (AAFES)

Fort Ord provides facilities and training support for the California National Guard, U.S. Army Reserve, Reserve Officers Training Corps, California Cadet Corps, and Reserve Units from the Army, Coast Guard, and Marine Corps.

Environmental Programs

The following information regarding the status of environmental quality as affected by the number of pollution sources located at Fort Ord has been extracted from an *Environmental Operations Review*[24] conducted by USAEHA, other assessments,[25] discussion with the Environmental and Natural Resources Office (ENRO) personnel, and the survey conducted during the course of this study.

Air Pollution

Fort Ord is subject to rules and regulations of the Monterey Bay Unified Air Pollution Control District (MBUAPCD). The State of California has authorized the district board to develop and enforce air pollution control regulations within the Monterey, Santa Cruz, and San Benito Counties. Fort Ord submitted an Air Pollutant Emissions Report in May 1976 in compliance with a USEPA requirement. This report identifies the sources of air pollutants and the emission rates. However, it has not been updated since it was first submitted. A MBUAPCD permit is now required for continued operation of potential air pollution sources. Some of the stationary sources that are assessed annually are: boiler plants, incinerators, open burning/open detonation sites, fuel storage/dispensing, painting, metal cleaning/degreasing, other miscellaneous operations, and sources of fugitive dust and hazardous air pollutants. Mobile sources of air pollution, including vehicles and aircraft, are regulated at the State level by the California Air Resources Board.

Fort Ord and its subinstallations are located in the North Central Coast Air Basin Air Quality Control Region (AQCR). The region is required to comply with the National Ambient Air Quality Standards (NAAQS) and the State of California AAQS that are more stringent. The AQCR is classified as "better than NAAQS" for Total Suspended Particulates (TSP) and Particulate Matter Less Than 10 Microns (PM10); "cannot be classified" for sulfur dioxide; "does not meet primary NAAQS" for ozone; and "cannot be classified or better than NAAQS" for carbon monoxide and nitrogen oxide. Although MBUAPCD is an ozone nonattainment area, no vehicle inspection or maintenance program has been implemented in the region. There are standards for limiting emissions of criteria pollutants from new and used motor vehicles. The standards for new vehicles are implemented by imposing requirements on automobile manufacturers. Manufacturers are required to install pollution control devices on automobiles.

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[24] *Environmental Operations Review - Fort Ord, Fort Hunter Liggett, and The Presidio of Monterey, California*, Study No. 32-24-1376-87 (U.S. Army Environmental Hygiene Agency [USAEHA], Aberdeen Proving Ground, Maryland, June 1987).

[25] *Hazardous Waste Management Survey - Fort Ord, Monterey, California*, No. 37-26-7062-88 (USAEHA, 1988); J.D. Bonds, K.J. Tribbey, and K.A. Civitarese, *Update of the Initial Installation Assessments of Fort Ord and Subinstallations, Presidio of Monterey, and Fort Hunter Liggett*, AMXTH-IR-A-196(U), 196B(U), and 196D(U), (Prepared for the Commander, 7th Infantry Division and Fort Ord, Fort Ord, CA, and the U.S. Army Toxic and Hazardous Materials Agency [USATHAMA], August 1986); *Hazardous Waste Management Survey*, No. 37-26-0389-84 (USAEHA, 1984); and W. Collins, et al., *Installation Assessment of Fort Ord, California*, DRXTH-AS-IA-81196 (Prepared for Commander, Fort Ord, CA, and USATHAMA, 1983).

Boiler plants are the major stationary source of air pollution at Fort Ord. There is no central heating facility. Instead there are 101 high- and low-pressure boilers maintained throughout the installation. Forty-six of them are fired with No. 2 fuel oil and the rest are dual fired with natural gas as the primary fuel and No. 2 oil as the secondary fuel. The emission levels for all the criteria pollutants are well below the MBUAPCD limits of 150 lb/day for nitrogen oxide, total suspended particulates, sulfur dioxide, and hydrocarbons, and 550 lb/day for carbon monoxide.

One natural-gas fired medical waste incinerator is located at Silas B. Hays Army Community Hospital. All pathological waste generated were burned in this incinerator. The emissions are reportedly in compliance with the MBUAPCD opacity standards. An incinerator located in Bldg 1447 has been converted into a steam sterilizer that is used to sterilize all the medical infectious waste generated.

An unlined earthen pit located at Bldg 4400 was used for fire fighting training exercises involving the open burning of contaminated fuels at one time. Use of the pit for this purpose has since been discontinued. Controlled burning on the training ranges is permitted for the purposes of fire prevention and hazard management. A protocol has been developed for such an activity. Open burning/open detonation (OB/OD) of explosive ordnance is conducted by the 49th Explosive Ordnance Detachment on Range 36A. Ammunition rounds, small arms, and ammunition are occasionally destroyed on the demolition range.

Many underground storage tanks used to store fuel (e.g., JP-4, No. 2 oil, MOGAS, diesel, etc.) are located throughout Fort Ord. All tanks between 2000 and 40,000 gal must be equipped with a pressure vacuum device or a vapor control device. Multiple permits may have to be obtained since they are sources regulated for volatile organic compound (VOC) emissions.

Fort Ord has many spray paint booths that are sources of VOCs. All permitted painting facilities use dry filtration media to control booth emissions with the exception of waterfall type systems at Bldgs 1665 and 2252. Currently, the booth at Bldg 2252 is not in use. Spray painting is also conducted at other locations that are not permitted. Additionally, the use of chemical agent resistant coating (CARC) may require modification of all the current operating permits. The hexamethylene diisocyanate constituent of CARC qualifies as a toxic air contaminant under California rules. Additional controls on the paint booths may be required.

Cold cleaning of metal parts is conducted in all the vehicle maintenance and small fabrication shops. Stoddard solvent is the cleaning solvent used in dip tanks ranging between 10 and 20 gal. These tanks are exempt from permitting requirements because of their small capacity. At one time, there were 5 vapor degreasers operated by the Directorate of Logistics (DOL) personnel. All of them were permitted as potential air contaminant sources. Last year there were only two 75-gal tanks containing 1,1,1-trichloroethane that were being used. More recently, all the degreasers have been replaced with hot detergent washers eliminating sources of air pollution and hazardous waste.

Some of the miscellaneous sources of air pollution are: dry cleaning, carpentry, and aircraft stripping. Stoddard solvent is used in the dry cleaning operation. Nearly 3 gal of solvent are lost per each washload. The underground storage tanks containing the solvent are permitted. The spent filters generated from the dry cleaning activity are picked up every month by a private contractor. All the carpentry operations generate sawdust and particulates that are exhausted into the air. The operations are, however, exempt from permitting requirements. Aircraft stripping with halogenated solvents and phenol used to be conducted outdoors at Fritsche Army Airfield. It was an unpermitted operation releasing hazardous, photochemically reactive solvents. Installation of plastic media blasting booths solved this problem. No hazardous wastes or emissions are now generated.

The sources of fugitive dust at Fort Ord that are not permitted are outdoor sandblasting, training activities, range fires, and unpaved roads. The emission of hazardous air pollutants such as asbestos, beryllium, mercury, and other toxic air contaminants are regulated by MBUAPCD. Asbestos emissions are generated when old buildings containing asbestos insulation are razed. USEPA has to be notified when 3 sq ft or 3 linear ft of asbestos are removed or encapsulated. CARC paint aerosol from spray painting and ethylene oxide gas used for sterilization in the hospital are regulated as toxic air contaminants.

Water Pollution Control

The State of California has primacy in enforcing regulations pertaining to water and wastewater. Potable water treated at the water treatment plant met all the National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations limits. Modifications to the chlorination room and additional pumping capacity were recommended in the Environmental Operations Review (EOR). Fort Ord has adequate water storage capacity. Maintenance of records of chemical and microbiological analyses require improvement. Installation of a cross-connection control and backflow prevention program is also necessary to prevent contact between potable and nonpotable water during periods of high demand.

Wastewater treatment plants are located in the Main Garrison, East Garrison, and Fritsche Army Airfield. Until its recent deactivation, approximately 2 to 4 million gallons of waste water were processed daily at the Main Garrison treatment plant prior to discharge into Monterey Bay. Presently, the plant is tied into the county treatment system and functions only as a primary treatment facility. The East Garrison and Fritsche Army Airfield plants handle a much smaller load and still function independently of the county system. Most of the previous discharge violations occurred at the Fritsche plant; one of the primary causes being the outdoor chemical stripping of aircraft that was conducted at the washracks. This practice has been discontinued since installation of plastic media blasting equipment for dry stripping. Other problems noticed were the discharge of boiler blowdown and graphics shop wastewater into the storm sewer instead of the sanitary sewer and washing vehicles at unauthorized locations. Rerouting discharges into the sanitary sewer and building a centralized vehicle washrack facility have been recommended as solutions. The wastewater treatment problems will be eliminated with the use of a regional wastewater treatment facility operated by the Monterey Regional Water Pollution Control Authority. Only the East Garrison wastewater treatment plant will still be operational.

Construction of bermed hazardous material/hazardous waste (HM/HW) storage areas at the vehicle maintenance facilities, updating the Spill Prevention Control and Countermeasure Plan (SPCCP), and Installation Spill Control Plan (ISCP) were recommended in the EOR. All these recommendations have since been implemented.

Solid Waste Management

Fort Ord operates under a regional solid waste management plan prepared by the Monterey County Department of Health. Approximately 10 tons of refuse are generated per year. A solid waste contractor is responsible for cleaning and maintaining the dumpsters. A recycling program for paper, cardboard, wood, and metal materials has recently been implemented.

The solid waste contractor transports all the family housing and cantonment area waste to an offpost landfill. A 30-acre sanitary landfill has been in operation since 1975. It has exceeded its design capacity and is set for closure. A demolition landfill is located adjacent to the sanitary landfill. All types of construction and demolition wastes, tires, scrap wood, etc., are buried here. Problems of uncontrolled, illegal dumping have been encountered. Covering the refuse frequently will reduce the incidence of illegal dumping at the demolition landfill.

Hazardous Materials and Waste Management

The State of California Department of Health Services (DOHS) is the agency having regulatory authority to enforce Federal and State hazardous waste rules and regulations. California has not yet received the final authorization to administer its stringent HW program instead of the Federal program. The California regulations are different from State regulations and include listing of PCBs, waste oil, ethylene glycol, etc., as HW. However, under an agreement with EPA, it has retained authorization to inspect and enforce the Federal (RCRA, HSWA, etc.) and State laws.

Fort Ord is classified as a HW generator and subject to regulations promulgated by the California Department of Health Services. It has a Part A permit for storage of HW in containers and for thermal treatment (open detonation) of HW. A Part B permit application has been submitted for the HW conforming facility operated by the DRMO. While awaiting a response, Fort Ord is required to operate according to interim status general facility standards, specific standards for HW container storage facilities, and other rules stated in the interim status document.

The Installation Commander has the overall responsibility for managing HW and complying with regulations. The routine day-to-day operation of the program has been delegated to ENRO under the Directorate of Engineering and Housing (DEH). In the past, there were many serious unit level HW management problems at the individual generators, including: open containers; improper or nonexistent labeling; exceeding the 90-day accumulation time for temporary storage areas; improper storage facilities; open valves for the containment structures; spills, and environmental contamination; discharge of HW to storm or sanitary sewer systems; deterioration of containers; poor housekeeping; lack of inspection; improper containers; and mixing of different types of HW. Many changes from these past practices were noticed during the course of this study. There is a tremendous improvement in the unit level management of HW. Containment berms, security fencing, HW warning signs, etc., have been built and installed at all the generators. Wastes are segregated in properly labeled containers.

Some of the other serious problems observed in the past were: wet chemical stripping of aircraft by DOL maintenance division personnel at Fritsche; mismanagement of spills and all HW at the DOL vehicle maintenance facilities (Bldgs 2722, 2712, and 2726); disposal of thinner into a floor drain at the Training and Audiovisual Support Center (TASC) graphics shop (Bldg T-1665); improper storage of HW at 206th Attack Helicopter Co. maintenance operations; improper HW management at B Battery, 2-62 Air Defense Artillery (Bldg 1641); and improper HW management at the 707th Maintenance Battalion (Bldg 1640). Almost all the problems observed in the past at these activities have been solved and the management practices refined. The wet chemical paint stripping activities have been replaced by dry plastic media blasting, eliminating generation of hazardous emissions, HW, and wastewater.

The 519th Maintenance Company and 237th Medical Detachment was noted in the past for exemplary HW management activities despite inadequate facilities and a limited budget. Their achievements were due to the initiatives taken by individuals with sufficient practical and regulatory HW management knowledge. Another unit that has made an outstanding effort at implementing proper HW management, observed during the course this study, is the 7th Military Police Company. All the other units at Fort Ord can improve their HW management by following the example of these units.

All the HW generated at Fort Ord is transported and stored at the DRMO conforming storage facility before offsite transport by a contractor. A Part B permit has not yet been obtained for the DRMO facility which is a large yard with a black top surface surrounded with a chain link fence. Berms have been constructed to separate the different types of wastes. HW containers are stored on wooden pallets. This DRMO yard is the major source of legal problems encountered by Fort Ord. Two law suits filed by the State of California against the U.S. Army are pending in Federal courts. Improper operation of the storage yard and noncompliance with Federal and State regulations are the major causes. As a tenant on Fort Ord, the DRMO is subject to the authority of the Installation Commander who is ultimately liable for all issues of regulatory noncompliance. Interaction problems between Headquarters, Fort Ord, and DRMO that may have been partially responsible for the Notice of Violations (NOVs) issued by the State have reportedly been resolved.

Equipment contaminated by polychlorinated biphenyls are stored in Bldg 111, which is also operated by the DRMO. It is a conforming storage facility with the exception of requirements for proper curbing. The curb is only 4 in. high; the required height is 6 in. Transformers removed from service are transported and stored outside Bldg 3100 (DEH complex) on a metal drip pan. A sample of the oil is sent to a certified California laboratory to determine its PCB content. The oil is pumped out of the transformers. Oil from non-PCB transformers is treated as a HW. The transformer casings are triple rinsed and recycled as scrap metal. PCB-transformer casings and the oil contaminated with PCB are treated and handled as PCB waste that is regulated under the Toxic Substances Control Act (TSCA).

The California limits (> 5 parts per million [ppm]) are more stringent than the Federal limits (> 50 ppm) for classification of equipment/liquids based on PCB concentration. New non-PCB transformers procured from outside California have been found to contain more than 5 ppm of PCB and therefore have to be handled as PCB transformers. Changes have been made in the supply/procurement process for new transformers requiring analysis and specifically restricting PCB content to less than 5 ppm. Once the new procurement is in place, all the transformers in service must be tested for PCB content and an inventory maintained. The oil should not be drained from PCB-transformers.

Waste oil is a HW in California unless proven otherwise. A large quantity (44,044 gal/yr) of lubricating and synthetic oil is generated from vehicle and aircraft maintenance activities. In the past, the practices for collection, storage, and control of the oil were extremely poor. There were spills at all the collection points with staining of soil and hard stands. Mixing waste oil and other wastes (e.g., solvents, fuels, etc.) was very common. Much improvement in management practices were noticed during the course of this study. Waste oil is segregated properly in 55-gal drums and transported to the DRMO yard. Further improvements in the management practices are anticipated with the construction of a centralized tank farm for accumulation of waste oil before disposal.

The command level emphasis on proper HW management has increased, particularly after the two law suits filed by the State of California. However, Fort Ord does not have a proper HW management plan that complies with Army Regulation (AR) 200-1.[26] In the absence of a plan, a HW management standing operating procedure (SOP) document[27] prepared by the ENRO was used for guidance. The SOP established procedures for managing hazardous wastes in compliance with State laws and U.S. Army regulations. With subsequent modification, including a complete inventory of HW generators and all storage sites, the SOP has been formally upgraded to Fort Ord Regulation 200-1 and now functions as the installation's HW management plan.

Although no written inspection plan exists, all the HW generators are inspected periodically by ENRO personnel. HW coordinators at the individual units conduct weekly inspections to ensure compliance with HW management SOP. As formal training is also required for all personnel routinely involved in any phase of hazardous waste management, in the form of classroom instruction or while on-the-job, a comprehensive training program has recently been implemented by ENRO to keep coordinators at the unit level abreast of changing policies and updated procedures.

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[26] Army Regulation (AR) 200-1, *Environmental Quality: Environmental Protection and Enhancement* (HQDA, April 1990).
[27] *Hazardous Waste Management SOP*, Command Policy Number 5-88 (Prepared by ENRO, Directorate of Engineering and Housing, Fort Ord, CA, 7 December 1988).

A comprehensive inventory of HW generation should be compiled and updated annually to comply with AR 420-47. Such information is useful for effective HW management and minimization. Fort Ord does not have used solvent elimination (USE) or hazardous waste minimization (HAZMIN) programs in effect. This report will help in compiling a HW inventory and establishing a HAZMIN program. Further details of actual HW generation and management are provided in Chapter 4.

Pesticide/Pest Management

The installation pest management program complies with all applicable requirements contained in AR 420-76, AR 200-1, and AR 200-2.[28] The ENRO personnel have the responsibility of conducting safe and effective pest management operations including maintaining adequate pesticide storage and mixing facilities, assuring safe application of pesticides, assuring proper pesticide disposal, and conducting surveillance of pests. Environmental protection is a very important requirement of the program. The installation SPCCP and ISCP have recently been updated to include pesticide storage facilities and the impact of pest management is being addressed in an installation Environmental Assessment report.

[28] AR 200-1; AR 200-2, *Environmental Effects of Army Actions* (HQDA, 23 December 1988); AR 420-76, *Pest Management* (HQDA, 3 June 1986).

4 SOURCES OF WASTE GENERATION AND TYPES OF WASTES

FORSCOM installations are generally administrative, hospital/medical, or active troop installations. Various quantities of hazardous wastes are generated at these installations depending on their respective missions. Table 2 shows the quantities of hazardous waste generated at 22 installations.[29] Fort Ord generated 190.9, and 293.9 metric tons in 1985 and 1986, respectively, as reported in the survey and in their annual Defense Environmental Status Reports (DESR). These are wastes that were turned in to the DRMS for proper disposal. These numbers do not reflect quantities of: waste oil that is being recycled for heat recovery; acid drained and neutralized from lead-acid batteries; gasoline and aviation fuel burned at the fire training area; contaminated water treated at the wastewater treatment plant; hazardous air emissions; etc.

The data presented in this chapter were obtained from a survey of the various generators, offsite shipping manifests, and IDMS[30] data. An analysis of the data indicates that the average waste (including hazardous and nonhazardous) generation rate is 991,921 lb/yr.

Source Types

Many different source types generate hazardous wastes. It is necessary to understand each of the source types and the wastes generated before attempting to minimize the total quantities generated.

Fort Ord is an active troop installation with few tenants. A number of major waste streams and small quantities of many different types of miscellaneous wastes are generated. Each generator of wastes was assessed during development of the HAZMIN plan. The first step, therefore, was to identify and prioritize all the generators on the installation. Next, each generator was considered in order of decreasing importance for characterization of waste streams generated. The most important waste streams were then studied to determine the minimization options and their technical feasibility.

Three different criteria were used to determine the ranking of the different types of sources. The first is the number of such sources on an installation, which can vary depending on the mission of the installation. The second is the numbers and quantities of waste streams generated at each type of source, which is generally known or can be estimated. And the third is the minimization potential (including provision for cost of managing wastes) for the wastes for each type of source, which is important in developing a feasible waste minimization plan. Based on the above criteria, each source type was scored on a scale of 1 to 5. The ranking of sources, shown in Table 3, is in decreasing order of the total scores. Each source type is discussed in the same order below.

Motor Pools and Vehicle Maintenance Facilities (MPVM)

FORSCOM installations typically have a variety of motor pools and vehicle maintenance facilities for tactical and nontactical vehicles. Nontactical vehicle motor pools are used to service and maintain all the administrative vehicles (e.g., cars, vans, trucks, etc.), engineering maintenance vehicles (e.g., trucks, bulldozers, forklifts, etc.) and grounds maintenance vehicles (e.g., tractors, mowers, etc.) on the installation. Servicing and maintaining tactical vehicles is performed at various troop and tactical vehicle motor pools. Tactical vehicles can be divided into track-laying vehicles (e.g., self-propelled

[29] V.J. Ciccone & Associates, Inc., p C-4.
[30] IDMS Database, Defense Reutilization and Marketing Service, Defense Logistics Agency, Battle Creek, Michigan.

howitzers, guns, mortars, armored personnel carriers, recovery vehicles, etc.) and wheeled vehicles (e.g., cargo trucks, ambulances, truck tractors, wreckers, etc.). Fort Ord has a number of motor pools and vehicle maintenance facilities as shown in Table 4.

Various levels of services are performed on the vehicles at each of the motor pools and vehicle maintenance facilities. Included in the services are: periodic maintenance (e.g., fluids change, tuneup, etc.), transmission maintenance, engine repair, brake servicing, battery repair/servicing, suspension realignment, and unique repairs (as required, for different tactical vehicles). The typical repair operations that use hazardous materials and generate hazardous wastes are: oil and grease removal, engine parts and equipment cleaning, solution replacement, and paint stripping and painting (discussed later under *Paint Shops*). Equipment commonly used at motor pools and vehicle maintenance facilities includes: solvent sinks (parts cleaning), hot tanks (for engine and radiator cleaning), and spray equipment.

Some general categories of hazardous materials used at motor pools and vehicle maintenance facilities are: batteries, oils, petroleum distillates, mineral spirits, halogenated solvents, aromatic hydrocarbons, oxygenated hydrocarbons, mixtures, acids, and alkalis. A variety of nonhazardous materials (e.g., sorbent, rags, etc.) are also used in conjunction with these hazardous materials and also generate hazardous wastes.

Each motor pool generates different quantities of wastes (Table 5). The blanks in Table 5 (and similar tables throughout this report) do not represent zero waste generation, but rather that the data was not available. Fort Ord should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use. For comparison, some of the hazardous and nonhazardous materials used that lead to the generation of wastes are listed in Table 6.

MPVM account for 72 percent of all hazardous wastes generated on Fort Ord and are the primary sources of used oil, spent antifreeze solution, and spent degreasing solvent. MPVM #25 [519th MNT Co, Bldg 3897], is the largest generator of the MPVMs. Repair and maintenance activities at this facility generate approximately 47,174 pounds of hazardous wastes per year, which accounts for almost 5 percent of the total. Spent degreasing solvent (18,000 lb/yr) and spent antifreeze solution (6030 lb/yr) are the major waste streams from this MPVM, and comprise 50 percent of its total hazardous waste generation. The 519th MNT Co is attached to the 707th MNT Bn of DISCOM and provides direct support level maintenance for several line units within the support mission of DISCOM. The 519th is comprised of eight different maintenance sections and assists in the operation of the Technical Supply Office (TSO), a parts exchange/ procurement facility for all Division MPVMs. Used oil and POL-contaminated wastes (filters, rags, and sorbent) are the next largest waste sources, cumulatively representing 25 percent of its total hazardous waste generation.

MPVM #30 [Headquarters and Supply Company, HSC, 7th Supply and Transportation Bn, Bldg 1679] and MPVM #28 [Headquarters Main Support Company, HMSC, 707th MNT Bn, Bldg 4885] are the second and third largest MPVM generators, respectively. Headquarters and Supply Company is one of seven subordinate (HSC, A Co, B Co, C Co and D Co) or attached (301st Trans Co and 590th Service and Supply Co) elements of the 7th Supply and Transportation Battalion. Used oil is the largest waste stream generated at MPVM #30 (30,000 lb/yr), accounting for 66 percent of its total waste generation. Spent antifreeze solution (5400 lb/yr) and spent degreasing solvent (3400 lb/yr) are the next largest waste streams. Headquarters and Main Support Company (HMSC) of the 707th MNT Battalion is a direct support level maintenance facility under the immediate command of DISCOM on Fort Ord. HMSC is organized into various maintenance and repair sections, shop offices, and inspection and supply units. Of these, the activities associated with the Engineering and Automotive Equipment Repair sections and the Company motor pool generate the greatest percentage of hazardous wastes reported from MPVM #28. Used transmission fluid (14,400 lb/yr) is the largest reported waste stream, representing 23 percent of its total, followed by used engine oil (10,350 lb/yr) and caustic detergent (5060 lb/yr). Spoiled paint and other paint related materials are lesser volume waste streams generated from small scale, touchup painting operations in the Engineering Equipment Repair Section. Although they represent only 3 percent of the waste total for MPVM #28, their rate of generation at MPVM #28 exceeds all other MPVM facilities on Fort Ord.

MPVM #26 [A Co and B Co of the 707th MNT Bn, Bldg 4860] is the fourth largest generator with used oil accounting for 22 percent (9188 lb/yr) of its reported total. Spent degreasing solvent (6700 lb/yr) and used transmission fluid (5280 lb/yr) are the next largest waste streams, followed by spent sorbent (4275 lb/yr) and spent antifreeze solution (4100 lb/yr).

MPVM #22 [DPCA-Auto Crafts Shop, Building 4492], is the fifth largest MPVM facility and reports an estimated hazardous waste generation rate of 35,950 lb/yr. The Auto Crafts Shop represents 5 percent of the total for all MPVM facilities and almost 4 percent of all hazardous wastes generated on Fort Ord. The Auto Crafts Shop is a large facility, constructed in August 1988, that offers a variety of modern automotive diagnostic and repair equipment for use by both civilian and military employees for maintenance and improvement of their personally owned vehicles. Patrons of the facility are charged a variable hourly rate, depending on the type of work to be done and the equipment required. Each user must provide their own replacement/repair materials and is required to leave all generated wastes at the facility. A portion of the service fee charged is used for disposal of generated wastes. Used oil, which is commingled with spent degreasing solvent (PD 680-II), is the largest waste stream from this facility at approximately 2348 lb/mo and accounts for 78 percent of all wastes generated at the facility. Of this quantity, approximately 7 percent (167 lb) is comprised of spent degreasing solvent generated from one of the facility's three parts washers. Spent antifreeze solution (495 lb/mo) and contaminated fluid filters, fuel, transmission, or engine oil (400 lb/mo) are the next largest waste streams. Two dry filter type paint booths are provided at MPVM #22. At the time of the site visit, neither had been used enough to require filter replacement. Spent paint thinner generated from cleaning the spray paint equipment had not been turned in for disposal since the facility opened in August 1988.

All the above MPVM facilities generate more than 35,000 lb/yr of wastes. They are followed in ranking by MPVM #34 [7/15th FA Bn, DIVARTY], #27 [C Co of the 707th MNT Bn], #17 [14th Engineering Bn, Bayonet Combat Support Group], #19 [8th Evac, Bayonet Combat Support Group], and #31 [2/8th FA Bn, DIVARTY], which generate between 25,000 to 35,000 lb/yr. Quantitatively, these ten MPVM facilities account for 50 percent of total MPVM wastes and 36 percent of all hazardous and potentially hazardous wastes generated on Fort Ord. Of the total wastes reported from MPVMs (714,848 lb/yr), used oil is the largest (260,454 lb/yr), followed by nonserviceable lead/acid batteries that are recycled with their acid (93,200 lb/yr), spent antifreeze solution (65,608 lb/yr), contaminated transmission fluid (39,024 lb/yr), and POL-contaminated sorbent (37,934 lb/yr).

Industrial Maintenance and Small Arms Shops (IMSS)

The DOL and DEH are usually responsible for the major industrial maintenance and small arms shops on a FORSCOM installation. The DOL and DEH industrial operations shops repair and maintain everything from office machines and furniture to small arms and nuclear weapons. Tenant units may also have industrial operations shops conducting maintenance and repair on a small scale. Table 7 lists the IMSS at Fort Ord.

Industrial shops typically use vapor degreasers for degreasing operations, caustic dip tanks for cleaning iron and aluminum parts, battery recharging and neutralization tanks used for battery repair/ replacement, painting and paint-stripping operations (discussed under *Paint Shops*), and phosphoric/ chromic acid tanks for small arms refinishing. These operations use hazardous materials and generate hazardous wastes. Table 8 shows a list of wastes that may be generated from industrial shops.

Many different kinds of hazardous materials are used at IMSS, including halogenated solvents (e.g., 1,1,1-trichloroethane), paint thinners (xylene, toluene etc.), corrosive chemicals (alkalis, acids, etc.), and radioactive materials. Most of the hazardous and nonhazardous materials used are listed in Table 9.

All of the IMSSs listed in Table 7 are under the DOL Maintenance Division with the exception of IMSS #8 [DPTM-Nuclear Weapons Support Branch] and IMSS #7 which reflects IDMS data unattributable to a specific generator within DOL. IMSS 1 through 6 are located throughout Fort Ord. A seventh waste generating maintenance section of the DOL Maintenance Division [DOL-Aircraft Maintenance Section] is located at Fritsche Army Airfield and is discussed later with other Aviation Maintenance Facilities. No waste generation data were available from the Army Oil Analysis Lab which is also under the administrative responsibility of the DOL Maintenance Division.

IMSS #5 [DOL-Vehicle Maintenance Section, Building 2722], is the largest IMSS generator on Fort Ord. It is a support maintenance shop, and as such, is responsible for repairing several different types of tactical transportation and material handling equipment (i.e., Humm-Vs, 2.5- and 5-ton trucks, buses, flatbed trailers, forklifts, and field generators). Used engine oil is the largest waste stream from this section (15,000 lb/yr) and accounts for 12 percent of total IMSS generation and 4 percent of the used POL waste stream. Used oil is temporarily stored in one of two 400-gal tanks until removed for disposal by a representative from DRMO. Lead/acid batteries and battery electrolyte are the third and fourth largest waste streams from the Vehicle Maintenance Section at reported generation rates of 6550 lb/yr and 2025 lb/yr, respectively. Dead lead/acid batteries are brought to the battery shop of IMSS #5 for servicing or replacement. Serviceable batteries are recharged and returned to the unit of origin. Nonserviceable batteries, those that are cracked or closed cell batteries that will not hold a charge, are drained only if they are leaking and turned in to DRMO with the acid for disposal. Contaminated transmission fluid (1920 lb/yr) and hazardous parts (1700 lb/yr) are the next largest waste streams from IMSS #5. Transmission fluid is generated primarily from servicing transmission components that require removing the fluid reservoir pan. Parts subsequently removed for repair may be washed in one of two solvent degreasing tanks or a hot water jet washer provided in the shop area. Oils washed from the work piece in the jet washer are skimmed and added to the appropriate waste container in the designated waste storage area. Hazardous parts may include: asbestos lined brake pads, asbestos dust vacuumed from brake shoes, clutch linings, oil filled shock absorbers, or other POL-contaminated faulty parts. Such wastes are commonly overpacked in used sorbent and disposed of through DRMO.

IMSS #4 [DOL-Organizational Maintenance Section, Building 1672], is the second largest IMSS generator (15,560 lb/yr). It provides regularly scheduled maintenance for approximately 650 nontactical vehicles. Used oil (13,500 lb/yr), spent degreasing solvent (1400 lb/yr), and spent sorbent (600 lb/yr) are the three largest waste streams from this IMSS.

IMSS #3 [DOL-Heavy Equipment Section, Building 4900], is the third largest generator. This section provides organizational and field support maintenance for a variety of heavy equipment used by both DOL and DEH. Used oil (7650 lb/yr), spent antifreeze solution (2592 lb/yr), and spent degreasing solvent (1200 lb/yr) are the most significant waste streams from this section.

IMSS #1, #2, and #6 are each units of the DOL-Maintenance Division that reported relatively small quantities of hazardous or potentially hazardous wastes. IMSS #8 [DPTM-Nuclear Weapons Support Branch, Building 3728], is a small facility that occasionally engages in the repainting or repair of classified communications, electronics, and ballistic equipment. A small dry-filter type paint booth had been installed recently at this facility but had not been used due to problems associated with the poor design of its air exchange system.

Of the total quantity of wastes generated at IMSS facilities on Fort Ord (129,398 lb/yr), the largest waste stream is scrap fuel tanks (42,635 lb/yr) reported through review of IDMS data as unattributable to a specific DOL generator. Next in order of significance are: used oil (39,574 lb/yr); spent degreasing solvent (13,000 lb/yr); lead/acid batteries (6500 lb/yr); and contaminated MOGAS (4000 lb/yr-IDMS data).

Aviation Maintenance Facilities (AMF)

Most FORSCOM installations have aviation maintenance facilities for maintaining different sizes of helicopters and airplanes. Various levels of service are performed on the aircraft at the facilities, including: periodic maintenance (e.g., fluids change, tuneup, etc.), engine repair, brake servicing, battery repair/servicing, and unique repairs (as required, for different aircraft). There are eight AMF at Fort Ord as shown in Table 10.

The typical repair operations that use hazardous materials and generate hazardous wastes are: oil and grease removal, engine parts and equipment cleaning and solution replacement, and paint stripping and painting (discussed later under *Paint Shops*). Equipment commonly used at AMF include: solvent sinks (parts cleaning), hot tanks (for engine cleaning), and spraying equipment. Table 11 lists the wastes generated at the AMF at Fort Ord.

Some general categories of hazardous materials used at AMF are batteries, oils, petroleum distillates, mineral spirits, halogenated solvents, aromatic hydrocarbons, oxygenated hydrocarbons, mixtures, acids, and alkalis. A variety of nonhazardous materials (e.g., sorbent, rags, etc.) are used in conjunction with hazardous materials and also generate hazardous wastes. The hazardous and nonhazardous materials used at the AMF at Fort Ord are listed in Table 12.

AMF #4 [3/123rd Aviation Regiment-Combat Aviation Brigade, Bldg 507] generates the largest quantity (8685 lb/yr) of wastes of the AMF. Oily dirt (3000 lb/yr) generated from the handling and transfer of used POL products in the maintenance bay and designated waste storage area is the largest waste stream, followed by paint related materials (840 lb/yr), and contaminated hydraulic fluid (1450 lb/yr). Waste generation from this facility represents 20 percent of the AMF total and less than 1 percent of all wastes generated on Fort Ord. AMF #3 [2/9th Reconnaissance Squadron-Combat Aviation Brigade, Bldg 510] is the second largest total waste generator (8250 lb/yr) and the largest source of used aircraft engine oil (2110 lb/yr) and spent sorbent (1100 lb/yr) of the AMF. AMF #5 [HHC-Combat Aviation Brigade, Bldg 4464] follows in rank generating 5749 lb/yr. AMF #5 is a large generator of contaminated aviation fuel, JP-4 (2000 lb/yr), contaminated hydraulic fluid (1295 lb/yr), and used aircraft engine oil (840 lb/yr). AMF #2 [E Co-1/123rd Aviation Regiment-Combat Aviation Brigade, Bldg 524] is ranked fourth (5636 lb/yr), followed by AMF #1 [D Co-1/123rd Aviation Regiment-Combat Aviation Brigade, Bldg 527] (5505 lb/yr), and AMF #7 [DOL-Maintenance Division-Aircraft Maintenance Section, Bldgs 533 and 535] (5095 lb/yr). AMFs #1 and #7 generate the largest quantity of paint related materials (1300 lb/yr) and spent degreasing solvent, PD 680-II (3000 lb/yr).

Of the total wastes generated by AMF (44,410 lb/yr), contaminated aviation fuel (8420 lb/yr, 19 percent of AMF total), spent degreasing solvent (6350 lb/yr, 14 percent of total), used aircraft engine oil (5805 lb/yr, 13 percent of total), and oily dirt (5035 lb/yr, 11 percent of total), are the most significant waste streams. Total waste generation from AMF represents 4 percent of all hazardous and potentially hazardous wastes reported from Fort Ord.

Paint Shops (PS)

A FORSCOM installation has painting operations ranging from spray painting with cans to painting of large vehicles. DEH paint shops have the responsibility of painting buildings, preparing signs, and painting the fleet of grounds maintenance and other vehicles. DOL paint shops have large paint booths for painting tactical and nontactical vehicles. Paint cans, if empty and dry, are not classified as hazardous waste and may be crushed and disposed as ordinary solid waste. Paint thinners used in large painting operations result in generation of large quantities of hazardous waste.

Table 13 lists the paint shops located on Fort Ord. The generated wastes are listed in Table 14; the corresponding materials use is in Table 15. Of all the PS, the three largest generators of wastes are under the organizational elements of the DEH, PS #1 [DEH-Operation and Maintenance Division-Paint and Sign Shop, Bldg 4897], and the DOL, PS #3 [DOL-Maintenance Division-Aircraft Maintenance Section, Bldg 535], and PS #5 [DOL-Maintenance Division-Vehicle Maintenance Paint Section, Bldg 2726]. They are followed in total generation by PS #1 [Bayonet Combat Support Group-Personnel Control Facility, Bldg 2361], PS #4 [DOL-Maintenance Division-General Equipment Paint Section, Bldg 2429], and PS #8 [DPTM-Training and Support Center, Bldg 2842]. PS #6 [DPCA-Arts and Crafts Section, Bldg 2251], and PS #8 [DPTM-Nuclear Weapons Support Branch, Bldg 3708], are the smallest reported generators.

Of the total quantity of wastes reported by PS (11,525 lb/yr) on Fort Ord, spent paint thinner (8294 lb/yr), spoiled or unused paint (800 lb/yr), and contaminated filters from paint booth air exchange systems (658 lb/yr) are the waste streams of greatest generation. All paint booths on Fort Ord use dry air filtration systems with the exceptions of PS #6 and PS #8. As mentioned previously, the dry filter booth recently installed at PS #7 (IMSS #8) is not yet operational.

Photography, Printing, and Arts/Crafts Shops (PPAS)

FORSCOM installations have photography and print shops that conduct a wide range of printing operations including standard forms, brochures, pamphlets, newsletters, and circulars. The shops perform image and plate processing. Image processing is a method for preparing artwork that includes typesetting and photoprocessing. The photographic process produces a negative with the light portions of the photographed object filled with large deposits of silver. Among the steps involved in a photographic process are: developing, fixing, washing, and reducing/intensifying. Wastes produced by the photographic processes include: chemical wastes, bath dumps, and wastewaters containing photoprocessing chemicals, silver, etc.

The printing process requires an image carrier (manual, mechanical, electrostatic, or photomechanical) which takes the ink from a roller and transfers it to a rubber blanket. The image is then transferred from the rubber blanket to a paper. Wastes produced from the printing process include: waste inks, trash, used plates, used ink containers, damaged or worn rubber blankets, waste press oils (lubricating oils), cleanup solvents, and rags.

There are five PPAS on Fort Ord as listed in Table 16. The quantities of wastes generated by the different shops is shown in Table 17. For comparison the materials use is shown in Table 18. Three of the PPAS are under the Directorate of Plans, Training, and Mobilization (DPTM) and are associated with the mission responsibilities of the Training and Audiovisual Support Center (TASC). PPAS #2 [TASC-Photographic Shop, Building 2850], is the largest generator of wastes (7822 lb/yr) followed by PPAS #3 [TASC-Visual Information Media Section, Bldg 2842], at a reported 1750 lb/yr. Wastes from both these facilities consist primarily of spent photographic processing solutions. PPAS #2 generates the largest quantity of both photographic developer (2534 lb/yr) and photographic fixer (1886 lb/yr) followed by PPAS #3 which generates approximately 520 lb/yr of both developer and fixer. Silver is recovered, as part of a precious metals recovery program operative throughout Fort Ord, from all silver contaminated waste solutions before they are turned in to DRMO for disposal or discharge to the sanitary sewer system. Spent photo fixer (ammonium triosulfate, acetic acid solution) generated by processing black and white slide and print film contains the highest concentration of recoverable silver. Spent fixer solution is commonly transferred manually to in-house recovery units where it is gravimetrically passed through a two-stage filter. Contained silver is concentrated into an aqueous sludge and removed periodically by a private contractor. PPAS generate approximately 1.1 percent (11,031 lb/yr) of the reported total generation for Fort Ord. Of this quantity, approximately 29 percent (3246 lb/yr) is composed of spent photographic developer and 23 percent (2502 lb/yr) spent photographic fixer. Smaller quantity waste streams unique to PPAS include spent Blankrola solvent used to clean printing plates (300 lb/yr), photographic stabilizer (646 lb/yr), and photographic bleach (806 lb/yr).

Hospitals, Clinics, and Laboratories (HCL)

A typical FORSCOM installation has at least one hospital (or medical center) providing full medical and dental services for active duty and retired military personnel and dependents on the installation. Each hospital has many clinics supporting different medical departments (anesthesiology, dermatology, internal medicine, obstetrics and gynecology, pathology, radiology, surgery, urology, etc.). Each department has laboratories that use hazardous materials and generate hazardous wastes. An installation may have teaching facilities and laboratories for training personnel belonging to medical activities in the military services. Other dental and veterinary clinics and facilities may also be located on the installation. Table 19 lists the HCL on Fort Ord that responded to circulated survey forms.

The preventive medicine department of the hospital is primarily responsible for the safety and security of medical staff and patients that may be exposed to hazardous materials/wastes and emissions. Many hazardous and radioactive materials are used in HCL. The wastes include chemical waste, infectious solid waste, noninfectious waste, pharmaceutical waste, and radioactive waste. The wastes generated and materials used are listed in Tables 20 and 21, respectively.

The Silas B. Hayes Army Community Hospital, HCL #2, located in Bldg 4385 is responsible for 100 percent of the reported waste generation from HCL on Fort Ord and is a tenant unit under the administration of the Directorate of Health Services (DHS). Of the 21,216 lb/yr of hazardous and potentially hazardous wastes reported from HCL #2, approximately 40 percent (8400 lb/yr) consists of medical infectious wastes generated from in-house laboratories, wards, and departments, and from affiliated dental and medical facilities throughout Fort Ord. Medical infectious wastes are segregated at the site of generation into specially designated receptacles or containers and transported by specially trained personnel to the post sterilization unit which renders these wastes suitable for disposal in the local landfill. These wastes consist of tissue, blood, and other bodily fluids, clothing and disposable equipment contaminated with these substances, medical cultures, and a variety of sharps (syringes, needles, scalpels, etc.). Efforts are currently being made by in-house staff to reduce the quantity of medical infectious wastes by 50 percent through improved segregation procedures and source reduction. Expired pharmaceuticals comprise the next largest waste stream from HCL #2 (5400 lb/yr); they are turned in to DRMO every 90 days for proper disposal. Pathological waste (2520 lb/yr) is the third largest waste stream and consists primarily of placentas, and to a lesser extent biopsy remains, amputated limbs, and dead animals. These items are containerized as they are generated and transported to the post pathological incinerator for destruction. A combination of spent photographic fixer and developer is the next significant waste stream (2400 lb/yr) generated by HCL #2. These wastes are produced during X-ray film processing and are recovered for their silver content before being turned in to DRMO for disposal. Contaminated xylene is the fifth largest waste stream from HCL #2 (1950 lb/yr) and is generated primarily from preparing and cleaning microscope slides in the Histology Laboratory. The spent xylene contains paraffin (used to attach the specimen to the slide plate) and small quantities of tissue. Presently, spent xylene from the Histology Lab is containerized, labeled, and disposed of through DRMO as an ignitable hazardous waste.

Other Source Types

Other source types at a typical FORSCOM installation include: heating and cooling plants, laundry and drycleaning facilities, sanitary landfills, wastewater treatment plants, troop units, industrial wastewater treatment plants, fire departments, hazardous waste storage facilities, POL storage yards, golf courses, grounds maintenance/garden shops, entomology shops, electrical maintenance shops, other storage warehouses, water treatment plants, and miscellaneous sources unique to each installation.

Table 22 lists troop units on Fort Ord that generated wastes different from those summarized under maintenance related source types (i.e., MPVM, IMSS, AMF, etc.). Waste generation data presented in Table 23 were derived from the review of the IDMS database and as a result, no corresponding hazardous/nonhazardous materials consumption table could be generated. Of the total wastes attributed to troop units (54,348 lb/yr), unserviceable batteries and expired chemicals comprise the largest percentage. Spent magnesium oxide batteries (16,080 lb/yr) is the largest individual waste stream, followed by spent lithium battery cartridges (15,004 lb/yr), and mercury batteries (10,405 lb/yr). These waste items are generated from the operation of communications and other electronic equipment by individual troop units while in the field, during training maneuvers offbase, or from the natural discharge of the equipments' power packs while in storage. These items are considered hazardous by RCRA reactivity (magnesium oxide and lithium batteries) and EP toxicity (mercury batteries) characteristic criteria. The largest percentages of all three types of these batteries were traceable through review of IDMS data to Troop Unit #10 [DISCOM]. These wastes streams are overpacked in DOT-approved wooden crates or triwall cardboard boxes lined with heavy gauge plastic, properly labeled, and shipped off post by DRMO for disposal. Waste DS-2 (decontamination solution-2) is the fourth largest waste stream from troop units (6753 lb/yr) but was unattributable to a specific generator. DS-2 is never used at the installation or during training missions and is turned in for disposal primarily because it is expired or the container is corroded. DS-2 is centrally stored and distributed to individual units by the DOL for use in the event of chemical warfare. Waste DS-2 is turned in to DRMO for disposal as a corrosive hazardous waste. Other significant waste streams tracked to troop units through IDMS include: other expired materials (1000 lb/yr); empty containers that previously held hazardous materials (940 lb/yr); waste Supertropical Bleach (STB), 810 lb/yr; and waste Lindane (800 lb/yr). Lindane is one of the few chlorinated hydrocarbon-based insecticides still approved for use by troop units. The insecticide (1 percent Lindane powder) is used to combat body lice during extended field training missions.

Table 24 lists miscellaneous generators on Fort Ord that reported waste generation on a survey form that was distributed. Each of the six generating activities listed are under the DEH or the DPCA and staffed primarily by civilian personnel. Of the total wastes reported (4105 lb/yr), MISC #4 [DPCA-Golf Course Grounds Maintenance, Bldg 4110], is the largest generator (3355 lb/yr). The greatest percentage of this total is used engine oil (2475 lb/yr) and contaminated hydraulic fluid (440 lb/yr) generated from the regular servicing of grounds and greens maintenance equipment (i.e., tractors, mowers, spray rigs, etc.). These wastes are properly segregated and temporarily stored onsite before disposal through DRMO. MISC #3 [AAFES subcontracted Economy Cleaners, Bldg 1434], generates spent drycleaning fluid filters that are managed as hazardous wastes through a private disposal contract. The spent filters contain diatomaceous earth, darco carbon, lint, and possibly residual quantities of dry cleaning fluid (PD680-II). The contractor provides recyclable disposal containers for spent filters as well as replacement filter elements. Filters require replacement for approximately every 18,000 lb of clothes drycleaned and are picked up regularly by the contractor. The monthly service charge associated with this service ranges from $300 to $800 depending on the actual quantity of spent filters generated.

Potential sources not listed in Table 24 include: DEH-Entomology Section (insecticides, rodenticides, herbicides, fertilizers); DEH-Exterior Electrical Maintenance Section (PCB-contaminated transformers, capacitors); the 49th EOD (contaminated fuels and spent solvents); and DRMO (the designated interim hazardous waste storage facility on Fort Ord). Since these operations are not directly involved in the regular generation of hazardous wastes, as disclosed during the onsite inspection/personal interview phase of this project, they were omitted from the tables in this chapter.

Wastes Selected for Technical/Economic Analysis

Waste streams chosen for technical/economic analysis were selected based on the generation quantity, the availability of specific minimization/management alternatives, and the feasibility of implementing such alternatives on Fort Ord. Table 25 summarizes the data presented in the previous section that were obtained during the HAZMIN survey. Also included are waste disposal data obtained from DRMO hazardous waste turn-in documents (Form DD-1348), hazardous waste manifests, and the IDMS database. In some instances it was difficult to allocate IDMS waste disposal information to a specific generator. However, IDMS proved useful in tracking infrequently generated, small volume waste streams to general source types (i.e., MPVM, IMSS, AMF, etc.), and as a comparative data source for information collected from survey forms. The ten different waste categories considered in Table 25 are listed on its last page. Categorical totals represent the cumulative total of respective waste stream units. Waste generation data on Fort Ord was collected and summarized at the waste stream unit level. Table 26 presents the total waste generation rate according to each waste category and the generator source type. PCB-contaminated equipment has not been included in the summaries.

As listed in Table 26, MPVM generate the largest quantity (714,848 lb/yr) of wastes consisting primarily of used POL products (342,063 lb/yr), miscellaneous materials (231,590 lb/yr), spent alcohols (66,648 lb/yr), spent nonhalogenated degreasing solvent (36,302 lb/yr), and spent acids and bases (24,272 lb/yr). IMSS generate the next highest quantity of total wastes (129,398 lb/yr), primarily miscellaneous materials (54,307 lb/yr), used POL products (46,932 lb/yr), and spent nonhalogenated degreasing solvent (13,000 lb/yr). Other significant waste streams from IMSS include paint related materials (5647 lb/yr), and spent alcohols (3672 lb/yr). IMSS are the largest generators of spent halogenated degreasing solvents (2695 lb/yr) resulting from the solvent vapor-tank degreasing operations active within DOL. These tanks are scheduled for replacement with hot water jet washers which should eliminate this waste stream completely. Troop units are overall the third largest generators (54,348 lb/yr) with miscellaneous materials (43,143 lb/yr) accounting for 79 percent of their reported total. AMF are ranked fourth (44,410 lb/yr) in total generation and generate waste streams similar in type but lower in quantity to those reported from MPVM. They are: used POL products (18,350 lb/yr); miscellaneous materials (9738 lb/yr); and spent nonhalogenated degreasing solvent (6350 lb/yr). HCL (21,216 lb/yr) and PS (11,525 lb/yr) are the fifth and sixth largest generators, respectively. Wastes from HCL consist primarily of miscellaneous waste materials (10,920 lb/yr) and waste chemicals (7896 lb/yr). HCL are the largest source of contaminated xylene (1950 lb/yr). Spent paint thinner (8294 lb/yr) is the largest waste stream from PS which are the primary sources of this waste stream.

PPAS and other generators (i.e., DPCA Golf Course, Beach Aerospace Services Inc., the Post Fire Department, Water Treatment Facility, and Economy Cleaners) are the smallest reported generators of hazardous and potentially hazardous wastes (combined less than 2 percent of the total). Heating and hot water facilities operated and maintained by the DEH-Utilities Branch are potentially large quantity generators of wastes (caustic boiler blowdown, contaminated heating fuel, spent boiler cleaning chemicals, etc.) as demonstrated at other FORSCOM installations. However, conclusive waste generation rates could not be derived for these facilities on Fort Ord.

In terms of total waste generation rates on Fort Ord, used POL products represents the largest waste stream (411,040 lb/yr, 41.2 percent of the total), of which 75 percent (308,308 lb/yr) consists of used engine oil. It is followed by miscellaneous materials (351,165 lb/yr, 35.4 percent of the total), spent alcohols and glycols (71,228 lb/yr, 7.2 percent of the total; 94 percent is spent antifreeze solution), spent nonhalogenated degreasing solvent (55,732 lb/yr, 5.6 percent of the total), spent acids and bases (26,557 lb/yr, 2.7 percent of the total; 91 percent is spent battery acid), paint related materials (22,446 lb/yr, 2.3 percent of the total), miscellaneous chemicals (22,345 lb/yr, 2.7 percent of the total), and spent paint thinner (12,740 lb/yr, 1.3 percent of the total). Spent photographic and print processing chemicals and spent halogenated degreasing solvents account for the remaining 1.6 percent of wastes reported.

Waste streams or waste generating processes selected for technical and economic analysis are used engine oil, spent antifreeze solution, spent nonhalogenated degreasing solvent, spent paint thinner, contaminated xylene specific to Silas B. Hayes Army Community Hospital, spent halogenated degreasing solvent specific to 1,1,1 trichloroethane use at the DOL-Maintenance Division, and wet to dry filter type paint booth conversion. An ancillary economic analysis is provided for two disposal alternatives for drycleaning fluid filter wastes currently generated at the Economy Cleaners. Although this waste management analysis provides no waste minimization incentives, it does indicate that a substantially less expensive disposal option may be available to replace the current procedure.

Table 2

Hazardous Waste Generation at FORSCOM Installations*

Installation	Quantity of Waste Generated (metric tons)			Quantity of Waste Generated Onsite (metric tons)			Quantity of Waste Generated Offsite (metric tons)		
	1985	1986	1987	1985	1986	1987	1985	1986	1987
A.P. Hill	n/a	0.6	810.7	n/a	0.6	810.7	0.0	0.0	0.0
Bragg	94.5	246.9	258.2	94.5	236.3	242.3	0.0	10.6	15.9
Buchanan	-	-	-	-	-	-	-	-	-
Campbell	181.1	42.3	83.7	181.1	42.3	83.7	0.0	0.0	0.0
Carson	37.5	29.1	28.9	37.5	29.1	28.9	0.0	0.0	0.0
Devens	1142.6	359.4	412.4	1142.6	359.4	412.4	0.0	0.0	0.0
Drum	18.4	89.0	0.7	18.4	89.0	0.7	0.0	0.0	0.0
Hood	46.5	238.5	129.8	46.5	223.0	129.6	0.0	15.5	0.3
Irwin	2090.4	1019.6	1224.1	2090.4	1019.6	1224.1	0.0	0.0	0.0
Lewis	n/a	214.3	668.3	n/a	187.3	649.3	n/a	27.0	19.0
McCoy	62.6	35.1	64.0	23.9	23.5	26.2	38.7	11.6	37.8
McPhearson	0.1	2.4	n/a	0.1	2.4	n/a	0.0	0.0	n/a
Meade	n/a	3.1	3.5	n/a	3.1	3.5	n/a	0.0	0.0
Ord	190.9	293.9	n/a	190.9	290.8	n/a	0.0	3.1	n/a
Polk	0.1	20.7	11.5	0.1	20.7	11.5	0.0	0.0	0.0
Presidio, SF	-	-	-	-	-	-	-	-	-
Richardson	21.1	16.4	4.8	21.1	16.4	4.8	0.0	0.0	0.0
Riley	18.6	18.6	18.6	18.6	18.6	18.6	0.0	0.0	0.0
Sam Houston	34.7	33.4	19.8	34.7	32.7	18.5	0.0	0.7	1.3
Sheridan	4.9	4.9	4.9	4.9	4.9	4.9	0.0	0.0	0.0
Stewart Hunter	7.7	302.4	445.8	7.7	302.4	445.8	0.0	0.0	0.0
Wainright	27.2	16.9	63.6	19.4	16.1	29.3	7.8	0.7	34.3
Total	3978.9	2987.5	4253.3	3932.4	2918.2	4144.8	46.5	69.2	108.6

*Source: V.J. Ciccone and Associates, Inc., p C-4.

Table 3

List of Sources Ranked In Order of Importance

Rank	Source Types	Numbers	Numbers and Quantities of Waste Streams	Minimization Potential	Total
I	Motor pools and vehicle maintenance facilities	5	5	5	15
II	Industrial maintenance, small arms shops, etc.	4	5	5	14
III	Aviation maintenance facilities	4	4	5	13
IV	Paint shops	4	4	4	12
V	Photography, printing and arts/crafts shops	3	4	4	11
VI	Hospitals, clinics, and laboratories	4	3	3	10
VII	Troop units	2	4	2	8
VIII	Grounds maintenance and entomology shops	3	3	2	8
IX	Electrical maintenance facilities	2	2	2	6
X	Hazardous waste storage facilities	1	2	1	4
XI	Wastewater treatment facilities	1	1	1	3
XII	POL storage yards	1	1	1	3

Table 4

Motor Pools and Vehicle Maintenance Facilities

1. 1st Brigade - 9th Regiment - Brigade Motorpool - Building 4499E
2. 2nd Brigade - Brigade Motorpool - Building 4512S
3. 3rd Brigade - Brigade Motorpool - Building 4538
4. 2/62nd Air Defense Artillery - A Battery Motorpool - Building 1643
5. 2/62nd Air Defense Artillery - B Battery Motorpool - Building 1641
6. 2/62nd Air Defense Artillery - HHB Battery Motorpool - Building 3864
7. 13th Engineer Battalion - Battalion Motorpool - Building 4548
8. 63rd ARCOM - AMSA 14 SUB Shop - Motorpool - Building 0701
9. 107th Military Intelligence Battalion - Battalion Motorpool - Building 3772
10. 127th Signal Battalion - Battalion Motorpool - Building 4548
11. Aviation Brigade - 1/123rd Aviation Battalion Motorpool - Building 4506W
12. Aviation Brigade - 1/123rd Aviation - E Company Motorpool - Building 1697S
13. Aviation Brigade - 2/9th Reconnaissance Squadron - 2/9th Recon Motorpool - Building 4495
14. Aviation Brigade - 3/123rd Aviation - Battalion Motorpool - Building 4506E
15. Aviation Brigade - HHC - HHC Motorpool - Building 0509
16. Bayonet Combat Support Brigade - 14th Engineer Bn. - 761st Chem. Co. Motorpool - Building 1654
17. Bayonet Combat Support Brigade - 14th Engineer Battalion - Battalion Motorpool - Building 4534
18. Bayonet Combat Support Brigade - 56th Medical Battalion - Motorpool - Building 4499W
19. Bayonet Combat Support Brigade - 8th Evacuation Hospital - Motorpool - Building 4522
20. DEH - Operations and Maintenance - Yard
21. DPCA - AAFES - Main Service Station - Building 4220
22. DPCA - Auto Crafts Shop - Building 4492
23. DPCA - Auto Maintenance Shop - Building 0138
24. DPCA - Auto Shop - Building 1439
25. DISCOM - 707th Maintenance Battalion - 519th Maintenance Company - Motorpool - Building 3897
26. DISCOM - 707th Maintenance Battalion - A & B Company - Motorpool - Building 4860
27. DISCOM - 707th Maintenance Battalion - C Company - Motorpool - Building 4855
28. DISCOM - 707th Maintenance Battalion - HMSC - Motorpool - Building 4885W
29. DISCOM - 7th Medical Battalion - Battalion Motorpool - Building 1697
30. DISCOM - 7th Supply and Transportation Battalion - HSC Company Motorpool - Building 1679
31. DIVARTY - 2/8th Field Artillery - Battalion Motorpool - Building 1483
32. DIVARTY - 5/15th Field Artillery - Battalion Motorpool - Building 1495
33. DIVARTY - 6/8th Field Artillery - Battalion Motorpool - Building 1483
34. DIVARTY - 7/15th Field Artillery - Battalion Motorpool - Building 1489S
35. DIVARTY - B Battery/15th Field Artillery - Battalion Motorpool - Building 1489N
36. DIVARTY - HHB - HHB Motorpool - Building 1483
37. HHC 7th ID (L) - HHC & 602nd Tactical Air Command Motorpool - Building 4518E
38. Law Enforcement Command - 571st Military Police Company - Company Motorpool - Building 1689
39. Law Enforcement Command - 7th Military Police Company - Company Motorpool - Building 1647
40. Unknown Generators - Motor Pool Wastes

Table 5

Quantities of Wastes Generated at MPVM Facilities*

Type of Waste	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Degreasing Solvent	**	1000	600	550	200	800	3000	504	600	360	1320		1440	
Carburetor Cleaner														
Waste Oil - Normal				1600				160	2140	100	500	168	900	990
Waste Oil - Water						880						41		
Waste Oil - Solvent												30		
Waste Oil - Petroleum									420					
Fog Oil														
Waste Oil - Paint														
Antifreeze		2700	1620	180	180	1080	1125	333	540	1080	1296		1080	1296
Lead-Acid Batteries			8400		500	1600			2150	6000				
Battery Acid		1125												
Detergent / Caustic														
Oily Dirt w/ Metal		704							100	2800			2500	
Spent Sorbent		554	3000	1680		102	2676		250	1600	3360	530	3360	2400
MOGAS		780		40									40	
Diesel			960						400	659		450	80	
Dirty Rags		200		120					40	12	360	360	240	360
Sludges						200								
Contaminated Water														
Transmission Fluid		1600	3072	480	160	120			120		72		576	960
Brake Fluid		516				172	475	118			40			42
Hydraulic Fluid							121				417			
Mixed Wastes									500					
Hazardous Wastes											10			
Miscellaneous							10							
Paint								4						
Paint Related Material								2						
Filters	453	282	375	220	216	300	186	1330	586	423	416	120	1307	
Thinner														
Empty Cans	70	246	150				1268	125	40	970	161	45	80	
Penetrating Oil		38					900							
Xylene							800							
Methanol		675					200							
Adhesive							30							
Grease		700	72				30							
Corrosion Inhibitor										400				
Empty Tanks										55	173			
Sealing Compound														
Total	523	11120	18249	4870	1256	5254	10821	2576	7886	14459	8125	1749	11603	6006

*Quantities are reported in pounds per year.

** A blank in this and similar tables does not mean zero generation. Where data is unavailable, Fort Ord should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use in helping meet HAZMIN goals.

Table 5 (Cont'd)

Type of Waste	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Degreasing Solvent	1800		2500		240		3600	2000				6700	2050	500
Carburetor Cleaner									990					
Waste Oil - Normal	500		4077		925		81000	28180			18000	9188	5250	10350
Waste Oil - Water			3200									610	400	
Waste Oil - Solvent	500										378	510		566
Waste Oil - Petroleum	875										440	208		
Fog Oil		8213												
Waste Oil - Paint														
Antifreeze	1836		1800		1080		12420				6030	4100	7200	4600
Lead-Acid Batteries			500				51000	300			5000		2250	
Battery Acid		112											169	23
Detergent/Caustic					15000		480					2000	150	5060
Oily Dirt w/Metal			3785		5750						5400	520		1765
Spent Sorbent	1250		800		500		1500				2700	4275	2000	1500
MOGAS				920										
Diesel	20		600		2000						400	4000	5360	1400
Dirty Rags	360	360		10		20	540				2000	700	400	400
Sludges	400							120				30		
Contaminated Water												100		
Transmission Fluid	1056		800		240		1152	400			2400	5280	3080	14400
Brake Fluid		215											138	
Hydraulic Fluid			1600		255									307
Mixed Wastes													2800	
Hazardous Wastes			15				10800					30	200	230
Miscellaneous											160			42
Paint			300								1930	273		725
Paint Related Material		3500												435
Filters	193						5400	4800			460	640		375
Thinner			200						10					250
Empty Cans	445	655	2116	25	20			150			1876	245	280	1268
Penetrating Oil														
Xylene														
Methanol														
Adhesive	175													
Grease			90										20	
Corrosion Inhibitor														
Empty Tanks		70										1980		
Sealing Compounds														
Total	9452	8868	27210	25	26030	0	16882	35950	10	0	47174	41389	31747	44196

Table 5 (Cont'd)

Type of Waste	29	30	31	32	33	34	35	36	37	38	39	40	Waste Stream Totals
Degreasing Solvent	120	3400	360	280	500	133	500	100	650			495	36302
Carburetor Cleaner													990
Waste Oil - Normal	225	30000	2000		2625	30000	2700	1010	2100	825	75	4225	239813
Waste Oil - Water					1227								6358
Waste Oil - Solvent	164	20		440	916							1241	4765
Waste Oil - Petroleum		30		440					890				3303
Fog Oil													8213
Waste Oil - Paint												6215	6215
Antifreeze	105	5400	5400	350	775	531	540	270	211	450			65608
Lead-Acid Batteries			12000				1000			2500			93200
Battery Acid	80						23						1532
Detergent/Caustic							50						22740
Oily Dirt w/Metal		931		1730	3495	917	1955	1955					34307
Spent Sorbent	350		1800		550	247	700		100	150			37934
MOGAS	160	252		225	520		35						2972
Diesel	300	1250	1920	1250	540	270	800						22659
Dirty Rags		600	600		50					150	50		7572
Sludges							400		100				1250
Contaminated Water													100
Transmission Fluid		516	960		450	300		350	240	240			39024
Brake Fluid		100					43			172			2031
Hydraulic Fluid	211	48		35		164			8		160		3326
Mixed Wastes													3300
Hazardous Wastes	500			50				100					11935
Miscellaneous		513		25	90			12	73			40	965
Paint	45	420		350	100	60		370					4577
Paint Related Material	265	80		240	50		20		415			84	5091
Filters		570		550	850	360	200	915	375	400		1100	23407
Thinner					450		300						1210
Empty Cans	52	476		744	876	269	305	212	320				13489
Penetrating Oil		144											1082
Xylene		40						440					1280
Methanol	36	2				7	120						1040
Adhesive		10							22				62
Grease		501		159		195	360						2302
Corrosion Inhibitor	300						8						708
Empty Tanks				153								1700	4131
Sealing Compounds	55												
Total	2913	45358	25040	7021	14064	33453	10059	5734	5504	4487	285	15100	714848

Table 6

Quantities of Materials Used at MPVM Facilities*

Material Procured	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-18	19	20
Cleaning Solvent		2000	600	2000	400	800	3650		600	360	1800	2400	2400	2400	2400		240	
Carburetor Cleaner																		
Engine Oil		6750	6000	450	600	1200	3300		630	1170	1080	1080	1350	1350	1350		5250	
Antifreeze		2700	1620	1350	180	1440	990		540	1080	1620		1620	2160	2160		6300	
Lead - Acid Battery			8400		500	1600												
Electrolyte		1125																
Detergent/Caustics																		
Floor Wash					80	50					1440	600	600	6000	1200		7000	
Sorbent		2000	3000	1680		102	800		250	1200	4000	680	4000	2700	1800			
MOGAS				4800		6400											160	
Diesel						38400						79682	23040	178560	275040		3200	
Rags			840	120		800	100		80	300	480	480	360	360	360		20	
Transmission Fluid		2400	3072		288	144			120		384	960	1440	1920	1920		240	
Brake Fluid		860		516	172	138	258				52	310	103	516	206			
Hydraulic Fluid																		
Miscellaneous																		
Paint																		
Paint Related Material																		
Filters																		
Thinner		340																
Brake Cleaner																		
Methanol		1350																
Grease		2100																
Penetrating Oil		180																
Total	0	21805	23532	10916	2140	51104	9148	0	2220	4110	10856	86192	34913	195966	286436	0	23910	0

*Quantities are reported in pounds per year.

Table 6 (Cont'd)

Materials Procured	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Material Input Totals
Cleaning Solvent	3600	5082				6900	2050	500	250	5400	360		500	140	550		500				47882
Carburetor Cleaner	120																				120
Engine Oil	8437					9190	5250	11100	865	30000	3600		3000	1260	750		2100				107112
Antifreeze	12420	5808			18000	5175	7200	7695	225	5400	5400		675	270	270		90	1125	115		93628
Lead - Acid Battery	51000	300			5810		2250											585			70445
Electrolyte					5000		169	25										2500			8819
Detergent, Caustic	120				565		150	5060													7395
Floor Wash						2000		200	50									10			19230
Sorbent	1200					5150	600	1600	25		1800		650	300			300	50	20		33907
MOGAS					3800			5200					2400					'50	30		22940
Diesel					1000		6000	30000			540		96000					160			731622
Rags	480				4000	1320		650	50	600				500	320		200	80000			92420
Transmission Fluid	1152	420			3550	5280	3080	14400	160		680		800	210			255		50		42925
Brake Fluid	516				4000	140			90					35							7912
Hydraulic Fluid															40						40
Miscellaneous																					0
Paint						1440							200								1640
Paint Related material																					0
Filters																					0
Thinner		1115						150					500								2105
Brake Cleaner	3600																				3600
Methanol																					1350
Grease																					2100
Penetrating Oil																					180
Total	82654	14165	0	0	45725	35155	26749	76780	1715	41400	12380	0	104525	2715	1930	0	3445	84580	215	0	1297372

Table 7

Industrial Maintenance and Small Arms Shops

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1. DOL - Maintenance Division - Electronics Section - Building 2048
2. DOL - Maintenance Division - General Equipment Section - Building 2428
3. DOL - Maintenance Division - Heavy Equipment Section - Building 4900
4. DOL - Maintenance Division - Organizational Maintenance Section - Building 1672
5. DOL - Maintenance Division - Vehicle Maintenance Section - Building 2722
6. DOL - Maintenance Division - Weapons Section - Building 4900
7. DOL - Waste Unattributible to a Particular Generator
8. DPTM - Nuclear Weapon Support Branch - Building 3728

Table 8

Quantities of Wastes Generated at IMSS*

Type of Waste	IMSS# 1	2	3	4	5	6	7	8	Waste Type Totals
Waste Oil		525	7650	13500	15000				36675
Oil Contaminated w/Water							630		630
Oily Dirt							1733		1733
Grease							18		18
Oily Rags									0
Carburetor Cleaner							60		60
MOGAS							4000		4000
Empty Cans							170		170
Diesel							840		840
Filters							2587		2587
Paint							3060		3060
Paint Related Material							120		120
Scrap Fuel Tanks							42635		42635
Oil w/Solvent							2269		2269
TCE								10	10
TCA							2625		2625
Dry Cleaning Solvent		1400	1200	1400	9000				13000
Paint Thinner							1000	20	1020
Hydraulic Fluid		250	150					30	430
Caustic Chemicals					1040				1040
Chromic Acid									0
Phosphate Solution						60			60
Tank Bottom Sludges									0
Sand Blasting Wastes									0
Steam Cleaning Compound									0
Radioactive Wastes									0
Lead Acid Batteries					6550				6550
Electrolyte	40				2025				2065
Miscellaneous	40	80	120	60	75				375
Antifreeze			2592		1080				3672
Sorbent			90	600					690
Transmission Fluid					1920				1920
Brake Fluid					150				150
Hazardous Parts					1700				1700
Nikel Cadmium Batteries					334				334
Total	80	2255	11802	15560	38874	60	61747	60	130438

*Quantities are reported in pounds per year.

Table 9

Quantities of Materials Used at IMSS*

Type of Material	IMSS#	1	2	3	4	5	6	7	Material Input Totals
TCE								10	10
1,1,1-Trichlroethane									0
Degreasing Solvent			1500	1200	1500	12000			16200
Thinner								20	20
Surface Cleaner									0
Lube Oil									0
Motor Oil			563	7650	13500	15000			36713
Hydraulic Fluid			152						152
Caustic Soda									0
Phosphoric Acid			240						240
Chromic Acid									0
Phosphate									0
Corrosive Chemicals									0
Alkali									0
Radioactive									0
Lead Acid Batteries						5000			5000
Electrolyte									0
Miscellaneous		40		120					160
Antifreeze				5400		1080			6480
Sorbent									0
Carburetor				144					144
Transmission Fluid									0
Brake Fluid									0
Unit Totals		40	2455	14514	15000	33080	0	30	65119

*Quantities are reported in pounds per year.

Table 10

Aviation Maintenance Facilities

1. Aviation Brigade - 1/123rd Aviation - Battalion Flight Maintenance - Building 0527
2. Aviation Brigade - 1/123rd Aviation - E Company Flight Maintenance - Building 0524
3. Aviation Brigade - 2/9th Reconnaissance Squadron - 2/9th Recon Flight Maintenance - Building 0510
4. Aviation Brigade - 3/123rd Aviation - Battalion Flight Maintenance - Building 0507
5. Aviation Brigade - HHC - Aviation Maintenance Facility - Building 4464
6. Bayonet Combat Supprot Brigade - 8th Evacuation Hospitol - Aviation Maintenance Facility - Building
7. DOL - Maintenance Division - Aircraft Maintenance Section - Building 0533
8. DPTM - Aviation Division - Building 520

Table 11

Quantities of Wastes Generated at AMF*

Type of Waste	1	2	3	4	5	6	7	8	Waste Totals
Cleaning Solvent	510	330	850	200	460	1000	3000		6350
MEK	100	245	130	200	50	20			745
Calibrating Fluid	400	50	40						490
Paint Stripper			100						100
Filters			100						100
Used Paint Cans	150	105	50	40		50			395
Waste Engine Oil	375	840	2110	515	840	750	375		5805
Deicer Solution		40	100				60		200
Nicad Cells			210						210
Nicad Electrolyte		140							140
Detergent / Caustic	500	660	400						1560
Floor Wash			740	1000					1740
Oily Dirt		35	2000	3000					5035
Sorbent	100		1100	50					1250
Avgas	950	650		700	2000	1920	600	1600	8420
Rags	200	50	100			150			500
Sludges		110							110
Contaminated Water		270							270
Miscellaneous		370			25				395
Paint	470	40	15						525
Paint Related Material	1300	150	10	840			470		2770
Thinner		10					185		195
Cleaning Compound	30		125						155
Xylene		31			560				591
Paint Remover		7							7
Corrosion Preventative			70		14				84
Grease		110	20						130
Empty Cans		45		90	103				238
Sealing Compound		180							180
Hazardous Parts		30		800					830
Used Tanks				800					800
Methanol					402				402
Hydraulic Fluid	417	118		1450	1295		405		3685
Adhesive	3								3
Total	5505	5636	8250	8685	5749	3890	5095	1600	44410

*Quantities are reported in pounds per year.

Table 12

Quantities of Materials Used at AMF*

Materials Procured	1	2	3	4	5	6	7	Material Input Totals
Cleaning Solvent	600	1200	850	1000		1000	6000	10650
MEK	150	1160	130	250		25	500	2215
Calibrating Fluid	400	768	40					1208
Paint Stripper		400	100					500
Paint Thinner	100	150	100					350
Paint Filters			50					50
Engine Oil	375	1650	1500	3750		825	375	8475
Deicer	50		100					150
Nicad Cells								0
Nicad Electrolyte								0
Caustic/Detergent	500		400					900
Floor Wash	100	1700	1000	300				3100
Sorbent	100	1160	1100	200				2560
Avgas	60000	1200	250000	300000	384000			995200
Rags	200	100	100	100	500			1000
Miscellaneous								0
Paint								0
Paint Related Material								0
Hydraulic Fluid				2000				2000
Antifreeze				1800				1800
Total	62575	9488	255470	309400	384500	1850	6875	1030158

*Quantities are reported in pounds per year.

Table 13

Paint Shops

1. Bayonet Combat Support Brigade - Personel Control Facility - Building 2361
2. DEH - Paint and Sign Shop - building
3. DOL - Aircraft Section Paint Facility - Building 535
4. DOL - General Equipment Paint Shop - Building 2429
5. DOL - Vehicle Section Paint Shop - Building 2726
6. DPCA - Arts and Crafts Shop - Building 2251
7. DPTM - Nuclear Weapons Support Branch - Building 3708
8. DPTM - TASC - Building 2842

Table 14

Quantities of Wastes Generated at PS*

Type of Waste	1	2	3	4	5	6	7	8	9	Waste Type Totals
Paint Cans	90					20				110
Paint	600					200	30			830
Thinner		3300	2520	500	1800	24	150			8294
Stripper							10	180		190
Caustic										0
Floor Wash										0
Oily Dirt										0
Sorbent			40							40
Rags	60	200								260
Sludges		450								450
Contaminated Water										0
Filters		40	384	14	220					658
Miscellaneous										0
Alcohol		506								506
Poly Casting Resin								187		187
Total	750	4496	2944	514	2020	244	190	367	0	11525

*Quantities are reported in pounds per year.

Table 15

Quantities of Materials Used at PS*

Type of Material	1	2	3	4	5	6	Material Input Totals
Paint		2250				90	2340
Thinner				1100	1800	70	2970
Stripper							0
Caustic							0
Floor Wash							0
Sorbent			40			20	60
Rags	60	200					260
Filters			384	14	220		618
Miscellaneous							0
Total	60	2450	424	1114	2020	180	6248

Table 16

Photography, Printing, and Arts/Crafts Shops

1. DPTM - Graphics Section - Building
2. DPTM - Photolab - Building 2850
3. DPTM - TASC - Building 2842
4. DOIM - USAISC - Building 2353
5. DOIM - DPI - Building 2434

*Quantities are reported in pounds per year.

Table 17

Quantities of Wastes Generated at PPAS*

Type of Waste	1	2	3	4	5	Waste Stream Totals
Blankrola Solvent				300		300
Inks						0
Photo Electro. Chemicals	25			200		225
Printing Electro. Chemicals				200		200
Bath Dumps		390	520			910
Paint Wastes	200					200
Miscellaneous		1560	96			1656
Thinner	150					150
Developer		2534	520		192	3246
Fixer		1886	520		96	2502
Bleach		806				806
Stabilizer		646				646
Ammonium Hydroxide			64		96	160
TCA			10			10
Empty Cans			20			20
Total	375	7822	1750	700	384	11031

*Quantities are reported in pounds per year.

Table 18

Quantities of Materials Used at PPAS*

Type of Material	1	2	3	4	5	6	Material Input Total
Blankrola				8000			8000
Deglazing Solvent				200			200
Inks				175			175
Photo Chemicals				200			200
Printing Chemicals				1500			1500
Miscellaneous				240			240

*Quantities are reported in pounds per year.

Table 19

Hospitals, Clinics, and Laboratories

1. Bayonet Combat Support Brigade - 8th Evacuation Hospital - Building 4522
2. DHS - Silas B. Hayes Hospital - Building 4385
3. DISCOM - 7th Medical Batallion - Building 1697

Table 20

*Quantities of Wastes Generated at HCL**

Types of Waste	1	2	3	Waste Totals
Pathological		2520		2520
Medical Infectious		8400		8400
Pharmaceutical		5400		5400
Xylene		1950		1950
Formaldehyde		498		498
Mercury		48		48
Photographic				0
Alcohol				0
Acetone				0
Photo Solution		2400		2400
Total	0	21216	0	21216

*Quantities are reported in pounds per year.

Table 21

Quantities of Materials Used at HCL*

Material Input	1	2	3	Material Input Totals
Xylene		1950		1950
Formaldehyde		498		498
Mercury				0
Developer		38900		38900
Fixer		46080		46080
Alcohol				0
Acetone		450		450
Total	0	87878		87878

*Quantities are reported in pounds per year.

Table 22

Troop Units

1. 1st Brigade
2. 2nd Brigade
3. 3rd Brigade
4. 13th Engineer Battalion
5. 107th Military Intelligence Battalion
6. 127th Signal Battalion
7. 2/62nd Air Defense Battalion
8. Bayonet Combat Support Brigade
9. Combat Aviation Brigade
10. DISCOM
11. DIVARTY
12. Law Enforcement Command
13. Troop Wastes Not Attributable to a Specific Unit

Table 23

Quantities of Wastes Generated at Troop Units*

Type of Waste	1	2	3	4	5	6	7	8	9	10	11	12	13	Waste Stream Totals
Lithium Batteries							15			14877			112	15004
Mercury Batteries										10362			43	10405
Magnesium Batteries										15900			180	16080
Insecticide		10		516						10	55			591
DS - 2									3	555			6195	6753
Super Tropical Bleach											42		60	102
Sealant													48	48
Miscellaneous													68	68
Lindane				800										800
Rifle Bore Cleaner				400										400
Nickel Cadmium Batteries										48				48
Calcium Hypochlorite										708				708
Paint													733	733
Paint Related Material													118	118
Empty Cans				850								90		940
Shelf Life Chemicals				1000										1000
Contaminated Soil				500										500
Contaminated Water									50					50
Total	0	10	0	4066	0	0	65	0	3	42460	97	0	7647	54348

*Quantities are reported in pounds per year.

Table 24

Miscellaneous Generators at Fort Ord

1. DEH - Heating and Cooling Plants - Building 4898
2. DEH - Water Treatment Plant - Building 4974
3. DPCA - AAFES - Economy Cleaners - Building 1434
4. DPCA - AAFES - Golf Course - Building 4110
5. DPCA - Beach Aerospace Services Inc. - Building 524
6. DEH - Fire Department - Building 514

Table 25

Quantities of Wastes Generated by Miscellaneous Sources*

Waste Stream	1	2	3	4	5	6	Waste Stream Totals
Fuel Oil	600						600
Caustic Chemicals							0
Boiler Blowdown							0
Waste Oil				2475			2475
Fire Fighting Foam							0
Sorbent				125			125
Rags							0
Antifreeze				175			175
Filters				40			40
Miscellaneous							0
Miscellaneous Chemicals							0
Hydraulic Fluid				440			440
Solvent				80			80
Thinner							0
Paint							0
Paint Related Material							0
Cleaners							0
Paint Strippers							0
Hazardous Containers		150					150
Lead-Acid Batteries							0
Electrolyte							0
Sludges				20			20
Pesticides							0
Herbicides							0
Total	600	150	0	3355	0	0	4105

*Quantities are reported in pounds per year.

Table 26

Quantities of Materials Used by Miscellaneous Sources*

Material Input	1	2	3	4	5	6	Total Material Input
Fuel Oil							0
Caustic Chemicals							0
Oil				2438			2438
Water						1042500	1042500
Fire Fighting Foam						500	500
Sorbent				100		100	200
Rags					3460	10	3470
Antifreeze				180			180
Filters				60			60
Miscellaneous							0
Miscellaneous Chemicals							0
Solvent				100	340		440
Thinner							0
Paint							0
Cleaner					408		408
Paint Stripper					30		30
Pesticides				2000			2000
Herbicides				80000			80000
Fertilizers				150000			150000
Algicides				1000			1000
Fungicide				20000			20000
Hydraulic Fluids					168		168
Total	0	0	0	255878	4406	1043110	1303394

*Quantities are reported in pounds per year.

Table 27

Fort Ord Hazardous Waste Generation Summary

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Motor Pools - Excluding DOL	1	36302	36302	PD 680 - II
	2	990	990	Carburetor Cleaner
	3	342063	239813	Waste Engine Oil
			39024	Waste Transmission Fluid
			22659	Waste Diesel Fuel
			6358	Waste Oil Contaminated with Water
			8213	Waste Fog Oil
			6215	Used Oil Contaminated with Paint
			4765	Used Oil Contaminated with Solvent
			3303	Used Oil Contaminated with Other Fuel
			2302	Grease
			3326	Hydraulic Fluid
			2972	MOGAS
			2031	Brake Fluid
			1082	Penetrating Oil
	4	66648	65608	Antifreeze (Ethylene Glycol)
			1040	Methanol
	5	24272	1532	Lead-Acid Battery Electrolyte
			22740	Detergent/Caustic
	6	2490	1280	Xylene
			1210	Paint Thinner - Unspecified
	7	10376	4577	Paint
			5091	PRM - Unspecified
			708	Corrosion Inhibitor
	9	117	62	Adhesives
			55	Sealing Compounds
	10	231590	93200	Lead - Acid Batteries
			34307	Oily Dirt
			37934	Spent Sorbent
			7572	Dirty Rags

Table 27 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
			13489	Empty Cans
			11935	Hazardous Parts
			23407	Filters
			9746	Other
Aviation Maintenance Facilities	1	6350	6350	PD 680-II
	2	852	745	MEK
			107	Paint Stripper
	3	18530	5805	Used Engine Oil
			8420	Avgas
			490	Calibrating Fluid
			130	Grease
			3685	Hydraulic Fluid
	4	402	402	Methanol
	6	786	591	Xylene
			195	Thinner (unspecified)
	7	3774	525	Paint
			2770	Paint Related Material (unspecified)
			84	Corrosion Preventative
			395	Empty Paint Caustics
	9	3978	3	Adhesives
			180	Sealing Compound
			155	Cleaning Compound
			1740	Floor Wash
			1560	Detergent
			140	Nicad Electrolyte
			200	Deicer Solution
	10	9738	210	Nicad Cells
			100	Filters
			1250	Sorbent
			5035	Oily Dirt
			830	Hazardous Pants

Table 27 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
			2313	Other
Industrial Maintenance Facilities and Small Arms Shops	1	13000	13000	PD 680 - II
	2	2695	2625	TCA
			10	TCE
			60	Carburetor Cleaner
	3	46932	36675	Used Oil
			630	Oil Contaminated with Water
			18	Grease
			4000	MOGAS
			840	Diesel
			2269	Oil Contaminated with Solvent
			430	Hydraulic Fluid
			1920	Transmission Fluid
			150	Brake Fluid
	4	3672	3672	Antifreeze
	5	3165	60	Phosphate Solution
			1040	Spent Sodium Hydroxide
			2065	Lead - Acid Battery Electrolyte
	6	1020	1020	Paint Thinner (unspecified)
	7	5647	2587	Paint
			3060	Paint Related Material (unspecified)
	10	54307	6550	Lead - Acid Batteries
			334	Nickel Cadmium Cells
			42635	Scrap Fuel Tanks
			2587	Filters
			170	Empty Cans
			1733	Oily Dirt
			2885	Other
Troop Units	7	851	733	Paint
			118	Paint Related Material
	9	10354	6753	DS - 2
			102	Super Tropical Bleach

Table 27 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Wastes Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
			800	Lindane
			400	Rifle Bore Cleaner
			708	Calcium Hypochlorite
			1000	Shelf Life Chemicals
			591	Insecticide
	10	43143	16080	Magnesium Batteries
			15004	Lithium Batteries
			10405	Mercury Batteries
			48	Nickel Cadmium Batteries
			500	Contaminated Soil
			1106	Other
Hospitals, Clinics, and Labs	8	2400	2400	Photo Solution
	9	7896	1950	Xylene
			498	Formaldehyde
			48	Mercury
			5400	Pharmaceutical
	10	10920	2520	Pathological
			8400	Medical Infectious
Paint Shops	2	190	190	Paint Stripper
	4	506	506	Alcohol
	6	8294	8294	Thinner
	7	1598	830	Paint
			658	Filters
			110	Paint Cans
	10	937	450	Sludges
			487	Other
Printing, Photography, and Arts/Crafts Shops	2	310	300	Blankrola
			10	TCA
	5	160	160	Ammonium Hydroxide
	6	150	150	Thinner
	7	200	200	Paint Wastes

Table 27 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
	8	10191	3246	Developer
			2502	Fixer
			646	Stabilizer
			806	Photo Bleach
			2081	Miscellaneous Photo Chemicals
			910	Bath Dumps
	10	20	20	Empty Caustics
Other Generators	1	80	80	PD 680 - II
	3	3515	600	Fuel Oil
			2475	Used Oil
			440	Hydraulic Fluid
	10		510	Other

WASTE CATEGORIES

1. Spent Cleaning Solvent (Nonhalogenated)
2. Spent Cleaning Solvent (Halogenated)
3. Waste Petroleum Products
4. Waste Alcohols
5. Spent Acids or Bases
6. Spent Paint Thinner
7. Waste PRM
8. Spent Photo or Print Chemicals
9. Miscellaneous Chemicals
10. Miscellaneous Materials

Table 28

Total Waste Generation Rates Sorted By Waste Categories

Generator	Total	1	2	3	4	5	6	7	8	9	10
Motor Pool and Vehicle Maintenance	714848	36302	990	342063	66648	24272	2490	103376		117	231590
Aviation Maintenance Facilities	44410	6350	852	18350	402		786	3774		3978	9738
Industrial Maintenance Small Arms Shops, etc.	130438	13000	2695	46932	3672	3165	1020	5647			54307
Troop	54348							851		10354	43143
Hospitals, Clinics, and Laboratories	21216								2400	7896	10920
Paint Shops	11525		190		506		8294	1598			937
Photography, Printing and Arts/Crafts Shops	11031		310			160	150	200	10191		20
Other	4105	80		3515							510
Total	991921	55732	5037	411040	71228	27597	12740	22446	12591	22345	351165

WASTE CATEGORIES

1. Spent Cleaning Solvent (Nonhalogenated)
2. Spent Cleaning Solvent (Halogenated)
3. Waste Petroleum Products
4. Waste Alcohols
5. Spent Acids or Bases
6. Spent Paint Thinner
7. Waste PRM
8. Spent Photo or Print Chemicals
9. Miscellaneous Chemicals
10. Miscellaneous Materials

5 WASTE MINIMIZATION FOR MOTOR POOLS AND VEHICLE MAINTENANCE FACILITIES AND AVIATION MAINTENANCE FACILITIES

The typical maintenance and repair operations conducted in a vehicle or aviation maintenance facility are: oil and grease removal; engine, parts, and equipment cleaning; and solution replacement. Table 29 lists the operations, the corresponding materials used, and the wastes generated. Table 30 lists the process descriptions and the corresponding waste descriptions according to hazardous waste codes and Department of Transportation (DOT) classifications. These waste descriptions are used when shipping the wastes offsite. Most of the wastes generated at MPVM are: parts cleaning solutions and miscellaneous detergent solutions, oil and grease from engine cleaning, spent automotive fluids, and lead-acid batteries. AMF generated most of the above wastes (except automotive fluids and lead-acid batteries) and nickel-cadmium batteries. Paint removal and painting operations may also occur at both MPVM and AMF. The minimization of wastes from such activities is discussed in Chapter 7.

Some of the equipment used, primarily in parts cleaning operations, are solvent sinks, hot tanks, and jet spray washers. Proper operation of this equipment minimizes material use and waste generation. The solvent in the sinks is recirculated continuously from a tank to the parts wash tray. The solvent (e.g., PD680-II) is replaced periodically. Hot tanks contain aqueous detergent or caustic solutions for immersion cleaning. These tanks are equipped with air or mechanical agitation devices and electrical heating devices to heat the solution to 356 °F. The jet spray washers consist of nozzles that emit rotating water jets to clean parts immersed in an aqueous wash solution. The contaminated liquid and sludge from both the hot tanks and jet sprays are removed periodically.

Most of the minimization options discussed below have been obtained from *Waste Audit Study - Automotive Repairs*,[31] and other references.[32]

Source Reduction

All Wastes - Better Operating Practices

Better housekeeping practices are necessary to minimize the quantity and toxicity of wastes or emissions generated. Some of the methods include: closing the lids of containers (e.g., solvent sinks) containing volatile substances (e.g., Stoddard solvent); conveniently locating cleaning equipment near service bays; increasing employee awareness of proper waste handling and disposal procedures; labeling hazardous waste containers properly; segregating wastes in separate containers; and separating trash/solids before waste collection for recycling or treatment.[33] Draining wastes to a sewer is not a good practice and may be illegal in many states. Inadvertent losses (spills) can also be minimized by using good housekeeping practices.

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[31] W.M. Toy, *Waste Audit Study - Automotive Repairs* (Prepared for the California Department of Health Services, Sacramento, CA, 1987).

[32] *Hazardous Waste Reduction Checklist - Automotive Repair Shops* (California Department of Health Services, Toxic Substances Control Division, 1988); *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops* (California Department of Health Services, Toxic Substances Control Division, 1988).

[33] W.M. Toy, pp 27-28.

All Wastes - Better Operating Practices - Segregation

Segregation of waste streams is a very good practice that minimizes hazardous waste generation and also increases the recyclability of wastes. It is extremely important not to mix solvents and oils. Mixing results in a liquid with very little recycle value and increases the costs of disposal.[34] Minimizing the quantity of contaminants in solvents improves the purity of reclaimed solvent (in onsite recycling) and its market value (in offsite recycling). Used oils, after being drained from engines are known to be contaminated with parts cleaning solvent, carburetor cleaner, fuels, rags, water, trash, etc.[35] These contaminants may make the used oil a hazardous waste due to ignitability, corrosivity, or toxicity, thereby reducing the possibility of energy recovery by burning it in boilers or reducing its market value (for offsite reclamation).

All Wastes - Better Operating Practices - Periodic Maintenance and Cleanup of Equipment

All the equipment, including solvent sinks, hot tanks, and spray washers, must be properly maintained. The tank bottoms must be cleaned frequently to reduce sludge accumulation and contamination of replacement solutions.

Solvent (PD680-I) - Material Substitution - PD680-II

Petroleum distillate Type I (PD680-I) is a flammable substance with a flash point of 102 °F, which is below the USEPA's flammability hazard limit of 140 °F. It must be substituted with petroleum distillate Type II (PD680-II) that has a flash point of 140 °F or above. Changes must be made in the local and centralized procurement processes to prevent users from obtaining PD680-I. When ordering solvent, the user must specify that substitution is not acceptable.

Solvent (PD680-II) - Better Operating Practices

A parts cleaning solvent, such as PD680-II, must not be used to clean floors or hands. It is expensive and must be dedicated to the intended purpose of parts cleaning only. Immersion and removal of parts from the solvent sinks must be done slowly to minimize splashes and rapid evaporation of solvent.

Solvent (PD680-II) - Better Operating Practices - Emissions Minimization

Among the good housekeeping practices, efforts to reduce air emissions are probably the most significant in terms of reducing hazardous wastes released to the environment. Using covers on solvent sinks (or cold cleaning tanks) can result in a 24 to 50 percent reduction in solvent losses.[36] Several standard methods are available for minimizing emissions from immersion cleaning, wipe cleaning, and spray cleaning operations.[37]

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[34] R.H. Salvesan Associates, *Used Oil and Solvent Recycling Guide*, Final Report (Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1985).

[35] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, *Reuse of Waste Oil at Army Installations*, Technical Report N-135/ ADA123097 (USACERL, September 1982).

[36] ICF Associates, Inc., *Guide to Solvent Waste Reduction Alternatives: Final Report* (Prepared for the California Department of Health Services, October 1986), pp 4-11 through 4-13.

[37] ASTM Standard D3640-80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (American Society of Testing and Materials [ASTM], 1988).

Solvent (PD680-II) - Process Change

If dip tanks or dunk buckets full of solvent are used for parts cleaning, the process must be modified. Solvent sinks clean parts more effectively and are easy to use. Spillage and evaporation are less from solvent sinks than from dip tanks or buckets. Equipment leasing services (see Table 31) lease solvent sinks. The equipment, raw materials, maintenance, and waste removal are part of the contract and are included in the service price (see Table 32). Testing of solvents (discussed below) before changing must be included in the contract.

If a leasing service is not desirable economically, a solvent sink must be purchased and the waste solvent recycled. Table 33 lists the sizes and the approximate costs of solvent parts washers. Local vendors must be contacted for exact information.

Solvent (PD680-II) - Process Change - Testing

Solvents are normally replaced periodically, based on the operator's perception of "dirtiness." Simple tests to estimate the "solvation power" of the spent solvent can be used to extend the life of the solvent before disposal. The physicochemical tests most useful for used solvent testing are: absorbence, specific gravity, viscosity, and electrical conductivity [38] Testing instruments (optical probe colorimeter, electronic specific gravity meter, Ostwald viscometer, and electrical conductivity meter) are commercially available. By obtaining a measure of these properties, the usefulness of the solvent can be determined based on Table 34. If the total score (sum of the ratings for all the properties) is less than 6, the solvent is not "spent." If the score is greater than 6, the solvent should be recycled. The criteria provided in Table 34 are only recommendations; they must be revised based on site-specific use and testing. Using solvent testing will reduce raw material and waste disposal costs and minimize the wastes generated.

Solvent (PD680-II) - Process Change - Solvent Sinks (Equipment) Modifications

Solvent losses can be minimized by adding drip trays and lids to existing solvent sinks. About 25 to 40 percent of the solvent is lost because of spillage and about 20 percent because of evaporation.[39] Racks or baskets may be designed and fitted to the solvent sinks to drain parts after cleaning. Minimizing solvent losses results in cost savings for the raw material and waste handling/disposal.

Carburetor Cleaner - Product Substitution

Carburetor cleaners typically contain methylene chloride (< 47 percent), 1,1,1-trichloroethane (< 5 percent), cresylic acid (< 27 percent), and wetting agents. The automobile industry has reformulated them to exclude the use of 1,1,1-trichloroethane.[40] Substitute cleaners must be used.

Used Oil - Better Operating Practices - Selective Segregation

Segregation of used oils and related products is not a source reduction alternative in the strictest sense of the term, yet selective segregation of used oil products may ultimately reduce the large volumes of hazardous wastes[41] that could be produced by mixing used oils with radiator drainings (containing oxylates, phenols, ketones, and acids) and used solvents. Product segregation is cost-

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[38] B.A. Donahue, et al., *Used Solvent Testing and Reclamation, Volume I: Cold-Cleaning Solvents*, Technical Report N-89/03/ADA204731, Vol I (USACERL, December 1988).
[39] W.M. Toy, pp A-1 - A-23.
[40] W.M. Toy, p 20.
[41] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, *Management of Used Lubricating Oil at Department of Defense Installations: A Guide*, NIPER B06711-2 (National Institute for Petroleum and Energy Research, 1986), p 26.

intensive initially, but many factors favor selective segregation of used oils. These factors include but are not limited to: the increasing costs of hazardous waste disposal, particularly for mixed waste disposal; the fact that the British thermal unit (Btu) value of used oil for burning as a fuel is lowered by the presence of solvents; and under USEPA regulations, hazardous wastes cannot be burned except in boilers with air pollution controls and secondary burners. These factors effectively prohibit blending used oil with boiler fuel if the used oil is listed as a hazardous waste.

Used Oil - Process Change - Fast Lube Oil Change System (FLOCS)

The Fast Lube Oil Change System (FLOCS) is a quick and efficient method of draining crankcase oil from vehicles. The model 30A FLOCS oil evacuation unit is designed to evacuate oil from crankcases under a vacuum. The engines must be fitted with quick-connect couplings to provide easy access to the oil drain, eliminating the need for lifts or pits. Because the oil is evacuated under vacuum pressure, sludge buildup in the oil pans is reduced. Spills are virtually eliminated and a substantial savings in time, labor costs, and equipment can be realized. All FLOCS units are designed to accommodate manual draining of the oil pan when necessary.

A single FLOCS unit was tested at Peterson Air Force Base (AFB), CO, from February 1982 to April 1983 to determine if FLOCS afford sufficient advantages over the normal lube oil change methods to warrant its adoption in the Air Force. Savings during 1 year of operation totaled $1,176.00 for 25 vehicles. A total savings of $7,526.40 was expected based on a conservative 8-year life expectancy for the unit. A payback of 1.6 years was projected. The economic success of the FLOCS unit, along with the elimination of spills that could result in accidents to shop personnel, prompted recommendations that the FLOCS evacuation unit be adopted for Air Force use.[42]

Caustic Wastes - Product Substitution

Caustic cleaning compounds are used in hot tanks and jet spray washers. Substitution of detergent compounds minimizes the amount of hazardous (corrosive) wastes produced. Caustic compounds are necessary for cleaning engines made of iron or iron alloys. With the rapid change to manufacturing engine blocks of aluminum, the use of detergent solutions for cleaning is also increasing.

Caustic Wastes - Process Change - Hot Tank (Equipment) Modifications

A major waste from hot tank operations is the tank bottom sludge containing heavy metals, oil, grease, etc. A typical practice is to dislodge the sludge from the bottom of the tank and dump it into a sump. Installing a collection tray with an overflow to the sump will allow for proper capture and disposal of the sludge. Hot tanks must also be equipped with drip trays and pans for collecting solution that drips off the parts after cleaning. The solution in the trays or pans must then be emptied back into the hot tank.

Aqueous or Caustic Wastes - Process Change - Dry Ovens

Hot tanks or spray washers are typically used for engines/parts washing. If the parts are small enough, ovens could be used to burn off the grease, oil, and particles. The dry ash can then be removed from the parts using shot blasters (preferably with plastic beads) and disposed of in a landfill. The ash must be tested for toxicity before assigning a disposal method. Testing the oven stack emissions for air pollutants may be required. However, using a dry oven will eliminate hazardous (corrosive and toxic) wastes that contain caustics, heavy metals, and oily dirt.

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[42] *Management/Equipment Evaluation Program*, Report H82-1B (1st Space Support Group, U.S. Air Force, Peterson Air Force Base, CO, 1983).

Aqueous Wastes - Process Change - Two-stage Cleaning in Jet Spray Operations

Most of the parts covered with oil, grease, and heavy dirt residues are cleaned using jet spray operations. If many parts need to be cleaned, a two-stage cleaning operation might provide cleaner parts in a shorter time. Two washers can be connected in series with the first removing most of the heavier residue and the second providing the final rinse. The cleaning solution from the second tank is transferred to the first tank (countercurrent processing).

Antifreeze Solution - Better Operating Practice - No Draining

Current practice is to dispose of spent antifreeze solution from radiators by emptying it directly into either a municipal or installation sanitary sewer system. Although the solution contains primarily ethylene glycol (which is poisonous), it is biodegradable and is neither carcinogenic nor mutagenic. Therefore, disposal in a sewer system should not present a problem.[43] However, the U.S. Army Mobility Equipment Research and Development Command has documented the presence of phenols, ketones, acids, oxylates, and aldehydes in radiator drainings formed during the use of ethylene glycol as a coolant.[44] Antifreeze wastes are considered hazardous wastes in some states (e.g., California) because ethylene glycol's oral human lethal dose (LD_{50}) is 1400 mg/kg, which is far below the state toxicity limit of 5000 mg/kg. As other state and local regulations lower the levels of phenols permitted in drinking water and sewage treatment plant effluents, antifreeze waste may have to be disposed of as a hazardous waste.

Antifreeze Solution - Product Substitution

Biological treatment of the ethylene glycol waste stream is difficult and the chlorination processes (commonly used in a waste treatment plant) generate other toxic chlorinated hydrocarbons. Substituting propylene glycol for ethylene glycol in antifreeze formulas will reduce the toxicity of the waste stream. Propylene glycol is a nontoxic compound commonly used as a food additive.[45]

Antifreeze Solution - Process Change - Testing

Testing the antifreeze solution, which may currently be drained into the sanitary sewers, before draining and disposal can help minimize the amount of wastes generated. Standard methodologies available for testing engine coolants in cars and light trucks[46] may be adapted for other types of vehicles. Electrochemical tests based on the measurement of galvanic currents have proven useful for measuring the levels of corrosion inhibitors and corrosivity of the antifreeze solution in a radiator (or any other heat tranfer device).[47] Such test methods allow continuous monitoring of the solution to determine the exact time of change (rather than change on a periodic basis, such as 6 months, or when the mechanic thinks it is "dirty").

[43] Union Carbide Corporation, *Ecological Aspects of UCAR Deicing Fluids and Ethylene Gylcol* (Hazardous Materials Technical Center, Rockville, MD, 1984).

[44] J.H. Conley and R.G. Jamison, *Reclaiming Used Antifreeze*, Report 2168/ADA027100 (U.S. Army Mobility Equipment Research and Development Command [USAMERDC], Fort Belvoir, VA, 1976).

[45] F.E. Mark and W. Jetter, "Propylene Glycol, A New Base Fluid for Automotive Coolants," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (American Society of Testing and Materials [ASTM], 1986), pp 61-77.

[46] ASTM Standard D2847-85, "Standard Practice for Testing Engine Coolants in Car and Light Truck Service," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (ASTM, 1988).

[47] R.L. Chance, M.S. Walker, and L.C. Rowe, "Evaluation of Engine Coolants by Electrochemical Methods," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 99-102; C. Fiaud, et al., "Testing of Engine Coolant Inhibitors by an Electrochemical Method in the Laboratory and in Vehicles," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 162-175.

Antifreeze Solution - Process Change - Extend Life

A Military Specification, MIL-A-53009[48], developed by the U.S. Army Research and Development Center, Fort Belvoir, VA, allows the use of antifreeze (MIL-A-46153[49]) whose inhibitor system has reached a marginal condition.[50] The military additive can extend the life of the antifreeze by more than 1 year. It was originally developed for use if new antifreeze was in short supply. During 1987 and 1988, ethylene glycol was in short supply because of the unavailability of ethylene (base stock) and the retail price doubled. In addition to environmental incentives, economic incentives to minimize the quantities of ethylene glycol wastes generated also exist.

Brake Shoes (Asbestos Waste) - Better Operating Practices

Asbestos dust, released when replacing brake shoes, is a hazardous waste. Friable (crushed under hand pressure) asbestos must be carefully collected and handled as a hazardous waste. Some equipment leasing companies may also provide asbestos collection services.

Recycling Onsite/Offsite

Solvent (PD680-II) - Onsite Recycling - Distillation

If large quantities of solvents are used (i.e., over 4000 gal/yr) they can be recycled onsite using distillation stills. These units offer a quick investment payback (i.e., less than 3 years).[51] In the distillation process, the solvent is boiled and the vapors are condensed and collected in a separate container. Substances with a higher boiling point than the solvent (e.g., oils, metal residues, etc.) remain in the bottom of the still. A smaller amount of contaminants will result in a higher purity for the reclaimed solvent. Therefore, it is very important to segregate solvent wastes from oils and other contaminants in the service bays. Table 35 lists some of the major suppliers of solvent distillation equipment. Detailed comparisons of the economics of distillation and solvent management options discussed in this chapter are available elsewhere.[52]

Solvent (PD680-II) - Offsite Recycling - Contract/Leased Recycling

Solvent sinks for parts cleaning can be owned or leased. In a lease arrangement, the contractor (e.g., Safety Kleen) replaces fresh solvent periodically (specified in the contract) and takes the spent solvent for recycling. Wastes can thus be better contained and the solvent recycled rather than disposed of. Contract recycling has been accepted as a good practice by the automobile industry.[53] Table 31 lists some of the equipment leasing and service companies.

[48] Military Specification MIL-A-53009, *Additive, Antifreeze Extender, Liquid Cooling System* (Department of Defense [DOD], 6 August 1982).
[49] Military Specification MIL-A-46153, *Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package* (DOD, 31 July 1979).
[50] J.H. Conley and R.G. Jamison, "Additive Package for Used Antifreeze," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 78-85.
[51] R.H. Salvesan Associates, pp 35-36.
[52] B.A. Donahue and M.B. Carmer, *Solvent "Cradle-To-Grave" Management Guidelines for Use at Army Installations*, Technical Report N-168/ADA137063 (USACERL, December 1983); *Economic Analysis of Solvent Management Options*, Technical Note 86-1 (Department of the Army, May 1986).
[53] W.M. Toy, pp 29-30.

Solvent and Carburetor Cleaner - Offsite Recycling

Solvent and carburetor cleaner wastes can also be sent to a solvent contractor/recycler for offsite recycling. A number of companies (Table 31) provide this service.

Carburetor Cleaner - Offsite Recycling - Contract/Leased Recycling

Some companies distill spent carburetor cleaners and return the cleaner to the user. Equipment similar to solvent sinks are available for lease or purchase. The contract fees include the cost of periodic pickup and disposal of sink bottoms. Companies that provide equipment leasing services for carburetor cleaners are listed in Table 31.

Used Oil - Onsite Recycling - Gravity Separation/Blending

A state-of-the-art RACOR™ oil-to-fuel blending system that will help avoid the problem of disposing of used oils has been developed. The RACOR system is typically used in conjunction with a fuel reservoir or tank. The system blends waste diesel crankcase oil with diesel fuel. It also filters/recycles and transfers diesel fuel from the fuel holding tank. The system comes with a waste holding tank and oil injection system. Used oil from the system's holding tank is blended into diesel fuel (not to exceed 5 percent) and cycled through a three-stage filter to remove water and solid contaminants, resulting in a fuel that is 99.5 percent free of emulsified water and solid particulates. Use of a closed-loop system such as the RACOR system may satisfy all technical requirements and military specifications for oil/fuel blends[54] and should be tested.

Used Oil - Offsite Recycling - Closed-Loop Contract

A closed-loop re-refining contract stipulates that the re-refiner agrees to process the used oil furnished by the generator, returning it to original quality for a contracted price per gallon. The re-refiner does not take ownership of the used oil but merely assumes custody of the oil until it is returned to the generator.

Among the possible disadvantages of a closed-loop contract is that installations may wish to offer used oil, solvents, and synthetic lubricants as a package. Of more immediate and important concern, is that before re-refined oil can be used in government vehicles and engines, it requires approval for the Qualified Products List. Approval is a costly procedure but ensures that the product meets specifications. With estimates of $50,000 for an engine sequence test (1982 dollars) to qualify used oil to meet Army requirements,[55] many re-refiners are reluctant to enter into a contractual agreement unless the cost of such tests can be included in the closed-loop contract.[56] More recent studies have placed the cost of such a qualification procedure at $75,000.[57]

Used Oil - Offsite Recycling - Sale to Recyclers

Sale of used lubricating oils may be the most economical answer for an installation. Although burning and closed-loop recycling agreements offer increased economic rewards, constraints may limit the options available to an installation and make selling used oil the only feasible alternative. The cost of selling or disposing of used oil includes sampling and testing the oil, storage before the sale, 55-

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[54] D.W. Brinkman, W.F. Marshall, and M.L. Whisman, *Waste Minimization Through Enhanced Waste Oil Management*, NIPER B06803-1 (National Institute for Petroleum and Energy Research, 1987); T.C. Bowen, Personal Communication. U.S. Army, Belvoir R&D Center, Materials, Fuels, and Lubricants Laboratory, Fort Belvoir, VA, 1987.

[55] Mil-L-46152, *Lubricating Oil, Internal Combustion Engine, Administrative Service, Metric* (DOD, 1 August 1988).

[56] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, pp 16-19.

[57] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, p S-3.

gal drums for sale/disposal, inventorying expenses, advertising for bid solicitations, bid evaluation, bid letting, and accounting. Draft USEPA regulations, when finalized, could increase the workload of sales personnel slightly by requiring the selling installation (or DRMO/DRMS) to notify the USEPA of the intent to market used lubricating oil and obtain an identification number. Certified analyses on each batch of used oil will also be required, and if the oil is classified as a hazardous waste, it must be manifested and transported by a licensed hazardous waste hauler and may be distributed only to an industrial user.

Antifreeze Solutions - Onsite Recycling

In addition to reducing the quantity of waste produced, there is a major economic incentive for recycling and reusing antifreeze solutions. Because of the shortage of ethylene, the price of antifreeze has more than doubled in the past ? years ($3 to $8/gal) and it is in short supply. A simple recycling method is available.[58] This method includes mechanical filtration that removes large particles before the solution is pumped into a large tank. An antifreeze extender is added to the tank based on the measured pH. The extender neutralizes the acidic byproducts in used antifreeze. The whole recycling system is available as a skid-mounted, 100-gal batch unit.

Lead-Acid Batteries - Offsite Recycling

Because of their weight, lead-acid batteries are the largest quantity of waste generated from vehicle maintenance facilities. Battery recyclers pay between $1.00 and $1.50 per battery (or $0.20 to $0.40 per pound, wet or dry). The batteries are rebuilt or processed to recover lead. Approximately 20 percent of the batteries can be rebuilt. Table 31 lists processors and smelters of lead-acid batteries. Installation logistics personnel can transport "intact" lead-acid batteries to a recycling facility if one is located nearby. A bill of lading is required if more than 10 batteries are transported at any time. Use of a registered hazardous waste hauler is not required and the waste does not have to be manifested. However, cracked or broken batteries must be transported as hazardous waste by registered haulers.

Aqueous or Caustic Wastes - Equipment Leasing

Hot tanks and spray washers are also available from equipment leasing companies (Table 32). The leasing service fee is site-specific and usually includes the raw materials, equipment maintenance, and waste disposal costs.

Dirty Rags/Uniforms - Onsite/Offsite Recycling - Laundry Service

Rags used to wipe up spills or clean off grease must not be disposed of as trash in a solid waste container. They must be collected and sent with dirty uniforms to a laundry for cleaning.

Treatment

Used Oil - Onsite Pretreatment - Filtration

A number of filtration devices are available for removing solids from used oil. Simple screen filters must be used when draining oil into containers to prevent entry of large objects (e.g., rags, cans,

[58] *GLYCLEAN - Anti-freeze Recycling System*, brochure (FPPF Chemical Co., Inc., 117 W. Tupper St., Buffalo, NY 14201, 1988).

trash, etc.). Other filter media ranging from sand to fibrous material are available in filtration units for removing solids and even water. The design of a filtration unit depends on the particles' size and concentration in the oil.

Used Oil - Onsite Pretreatment - Gravity Separation

Gravity separation units are composed of a series of tanks used to contain oil and allow for gradual sedimentation of solids and water because of gravitational force and buoyancy. These units usually include skimmers and pumps to remove the water and solids. Some of the units use heat to enhance separation. Gravity separators are effective on used oils that do not contain emulsions and when a sufficient residence time can be provided for settling to occur.[59]

Used Oil - Onsite Treatment - Blending/Burning

Final rules issued by EPA on burning used oil as fuel in boilers provides a specification for used oil that is substantially excluded from regulation and permits burning without restriction in nonindustrial boilers. Used oil exceeding any of the specification levels for toxic metals, flash point, or total halogen content is termed "off specification used oil" and is subject to regulatory controls. Furthermore, an installation without an industrially classified boiler and whose used oil has hazardous characteristics (heavy metals, halogens, toxics) must blend the oil to meet burning specifications. Regulations regarding used oil for burning can be found in a DOD Memorandum.[60]

Classification as an industrial boiler requires that energy from the boiler be used in manufacturing operations. The manufacture of steam or heat does not satisfy this criteria.[61] The amount of used oil to be blended with the fuel is not likely to have short-term impacts on the combustion efficiency of a boiler, but long-term use will likely present a problem in repeated clogging of pipes and nozzles, accelerated corrosion of pipes and tanks, and a reduction of heat transfer efficiency.[62] Current Navy regulations limit the amount of used oil in fuel oil blends to 1 percent.[63] Mixtures up to 5 percent oil, however, appear to have no appreciable impact on the Btu value of the fuel oil mixture and result in only minor additional maintenance costs, although long-term impacts of blending/mixing on operating parameters of boilers are unknown.

Before blending and burning, used oils must be filtered to remove any large impurities. Other important characteristics of used oils as a boiler fuel are API gravity and viscosity. Viscosity will impact the flow rate of the fuel and the spray pattern from the nozzle as the fuel is introduced to the boiler. The API gravity of an oil is a function of the specific gravity and is related to the heat of the burning oil. Firing temperatures for a given viscosity and discussions of the relationships between specific gravity, API gravity, and heating value can be found in literature.[64]

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[59] R.H. Salvesan Associates, pp 54-57.

[60] DOD Memorandum for Deputy of Environment, Safety and Occupational Health, OASA (I&L); Deputy Director for Environment, OASN (S&L); Deputy for Environment and Safety and Occupational Health (SAF/MIQ); Director, Defense Logistics Agency (DLA-S), 28 January 1986, subject: Regulation of Used Oil for Burning.

[61] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, p 34.

[62] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, pp 33-43.

[63] C.W. Anderson, *Cost-Effectiveness Analysis of Lubricant Reclamation by the Navy*, Technical Note 1481 (Naval Civil Engineering Research Laboratory [NCEL], Port Hueneme, CA, 1977).

[64] T.T. Fu and R.S. Chapler, *Utilization of Navy-Generated Waste Oils as Boiler Fuel - Economic Analysis and Laboratory Tests*, Technical Note N-1570 (U.S. Navy Construction Battalion Center, 1980), pp 14-44.

Aqueous Wastes - Onsite Pretreatment - Filtration

Installing filters on aqueous waste streams to collect grit and heavy residue increases the life of the wash solution. In one case,[65] providing a pump-around loop through a 25-micron filter bag (on a slipstream from jet spray washer) extended the solution life by 2 weeks, thus minimizing the quantity requiring subsequent treatment or disposal.

Aqueous Wastes - Onsite Treatment - Evaporation

Aqueous wastes consist primarily of water with various amounts of contaminants. Evaporating the water minimizes the amount of waste requiring disposal. In an evaporation device, the water is heated away (using an electric or natural gas heating device) leaving behind a semisolid or solid residue requiring disposal. Oil, if present in the waste, could inhibit boiling. Solid residue accumulated on the inner surface of the evaporator could inhibit heat transfer and, therefore, it may have to be cleaned frequently. Table 36 is a list of suppliers of aqueous waste volume reduction equipment.

Aqueous Wastes - Onsite Treatment - Waste Treatment

Onsite batch treatment devices that neutralize and precipitate heavy metals from aqueous wastes are available.[66] A pretreatment system is included to separate oil and grease. Sulfuric acid is added to reduce the pH to between 2 and 3 to reduce any hexavalent chrome to a trivalent state. Adding sulfites leads to precipitation of trivalent chrome. Sodium hydroxide is then added to raise the pH and precipitate the remaining metallic species. The precipitates settle to the bottom as a sludge and the water decanted from the top may be reused in cleaning processes. A filter press is included to reduce the water content of the sludge produced, thus also minimizing the volume to be disposed of.

Carburetor Cleaner - Offsite Treatment

Some solvent recyclers (e.g., Safety Kleen, Safe-Way Chemical) send spent carburetor cleaners to another company (e.g., Solvent Services) for treatment. This treatment process produces a lacquer wash from the spent carburetor cleaner.[67] Lacquer wash can be recycled and used in paint stripping processes.

Antifreeze Solution - Offsite Treatment

If large quantities of spent antifreeze solutions are generated at vehicle maintenance operations, the solutions can be treated at an approved treatment facility (Table 31) for recovery of ethylene glycol that may be used as waste fuel.

Lead-Acid Battery Electrolyte - Treatment

Lead-acid batteries must not be drained. These batteries are not a hazardous waste if they are sold to a recycler. Draining the batteries creates two types of wastes: lead dross, and spent sulfuric acid contaminated with lead. The electrolyte, if drained, must be neutralized and tested for lead and lead salts and neutralized before draining into the sewer.

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[65] W.M. Toy, p 27.
[66] W.M. Toy, pp 25-27.
[67] W.M. Toy, pp 31-32.

NICAD Battery Electrolyte - Treatment

NICAD battery cells contain a caustic potassium hydroxide solution (31 percent by weight). This electrolyte is corrosive. The electrolyte also contains cadmium and cadmium salts that are listed by the USEPA as hazardous wastes. The electrolyte must therefore be tested for cadmium and neutralized before disposal in the sewer.

Table 29

Typical MPVM and AMF Operations With Materials Used and Wastes Generated*

Process/ operation	Materials used	Ingredients	Wastes generated
Oil and grease removal	degreasers - (gunk), carburetor cleaners, engine cleaners, varsol, solvents, acids/alkalis	petroleum distillates, aromatic hydrocarbons, mineral spirits	ignitable wastes, spent solvents, combustible solids, waste acid/alkaline solutions
Engine, parts, and equipment cleaning	degreasers - (gunk), carburetor cleaners, engine cleaners, solvents, acids/alkalis cleaning fluids	petroleum distillates, aromatic hydrocarbons, mineral spirits, benzene, toluene, petroleum naptha	ignitable wastes, spent solvents, combustible solids, waste acid/alkaline solutions
Rust removal	naval jelly, strong acids	phosphoric acid, hydrochloric acid, hydrofluoric acid, sodium hydroxide	waste acids, waste alkalis
Solution replacement	antifreeze solution, petroleum oil	ethylene glycol, petroleum distillates	hazardous liquid, combustible liquid
Lead-acid batteries; recharging, repair, draining	automobile, truck, tracked vehicle, and other equipment batteries	lead dross, less than 3 percent free acids	used lead-acid batteries, strong acid
NICAD batteries; repair, draining	helicopter and airplane batteries	Battery cells containing KOH	used NICAD battery cells strong alkali

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986).

Table 30

Waste Classification for MPVM and AMF*

Process Description		Waste Description			
Typical process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Vehicle oil changes	Used crankcase oil (not manifested)	None	Waste petroleum oil, NOS	Combustible liquid	NA1270
Oil/grease removal and equipment cleaning	Acids	D002	Depends on type of acid	Corrosive material	Varies
	Potash	D002	Waste potassium hydroxide	Corrosive material	UN1814
	Caustic soda	D002	Waste sodium hydroxide solution	Corrosive material	UN1824
	Carburetor cleaners	F002/F004	Waste solvent NOS	ORM-A	UN1591/3
	Chlorinated solvents	F001	Waste (main ingredient)	ORM-A	Varies
	Ignitable (flammable) degreasers	D001	Waste flammable liquid NOS	Flammable liquid	UN1268
	Mineral spirit solvents	D001	Waste naptha	Flammable liquid	UN2553
	Petroleum naptha	D001	Waste naptha	Flammable liquid	UN1255
	Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
	1,1,1-trichloroethane	F001	Waste 1,1,1-trichloroethane	ORM-A	UN2831
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
	"MEK"	F005	Waste Methylethylketone	Flammable liquid	UN1193
Rust removal	Acids	D002	Depends on type of acid	Corrosive material	Varies
	Naval jelly	D002	Waste phosphoric acid	Corrosive material	UN1805
Solution replacement	Ethylene glycol	None	Waste hazardous liquid	ORM-E	UN9189
Used lead-acid batteries	Sulfuric acid	D002	Waste sulfuric acid	Corrosive material	UN1830
	Lead dross/scrap	D008	Hazardous waste solid NOS	ORM-C	NA9189
Used NICAD batteries	Potassium hydroxide	D002	Waste potassium hydroxide	Corrosive material	UN1814
	Battery cells	D002/D006	Hazardous waste solid NOS	ORM-C	NA9189

**Vehicle Maintenance/Equipment Repair*, Hazardous Waste Fact Sheet (Small Quantity Generators Activities Group, Minnesota Technical Assistance Program, 1986).

Table 31

Partial Listing of Waste Recyclers, Haulers, Equipment Leasing Companies, and Equipment Manufacturers*

Company and address	Telephone and services	Solvent waste	Caustic waste	Waste oil	Used antifreeze	Used batteries
Acto-Kleen P.O. Box 278 Pico Rivera, CA 90660	(213) 723-5111 (714) 944-3330 Hauler, seller	X				
American Labs 5701 Compton Avenue Los Angeles, CA 90011	(213) 588-7161 Hauler, transfer facility, and recycler	X	X			
Antifreeze Environmental Svc. Corp. 2081 Bay Rd., P.O. Box 50757 Palo Alto, CA 94303	(415) 325-2666 Recycler					X
Antifreeze Environmental Svc. Corp. 16031 E. Arrow Hwy, Unit H Irwindale, CA 91706	(818) 337-3877 Recycler				X	
Appropriate Technologies II 1700 Maxwell Road Chula Vista, CA 92011	(619) 421-1175 Processor	X	X			
Baron Blakeslee, Inc. 3596 California Street San Diego, CA 92101	(619) 295-0041 Hauler, processor, seller	X				
Baron Blakeslee, Inc. 8333 Enterprise Drive Newark, CA 94560	(415) 794-6511 Hauler, processor, seller	X				
Battery Exchange 2195 Story Road San Jose, CA 95122	(408) 251-3493 Lead-acid battery processor, 7,000 lb/month processed					X
Bayday Chemical 2096-B Walsh Avenue Santa Clara, CA 95050	(408) 727-8634 Hauler, processor	X				
Bud's Oil Service, Inc. 1340 West Lincoln Street Phoenix, AZ 85007	(602) 258-6155 Processor			X		
California Oil Recyclers, Inc. 977 Bransten Road San Carlos, CA 94070	(415) 795-4410 Processor			X	X	
Chem-Tech Systems 3650 East 26th Street Los Angeles, CA 90023	(213) 268-5056 Processor			X		

*Source: *Hazardous Waste Reduction Checklist - Automotive Repair Shops*, pp 17-20.

Note: Names of other companies specific to each area can be obtained from trade publications, associations, and local telephone directories.

Table 31 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
Chem-Tak 1719-B Marshall Court Los Altos, CA 94022	(415) 968-1861 Equipment leasing and service company		X			
Demenno/Kerdoon 2000 North Alameda Street Compton, CA 90222	(213) 537-7100 Processor			X		
Detrex Chemical Industries 3027 Fruitland Avenue Los Angeles, CA 90058	(213) 588-9214 Hauler, processor	X				
Environmental Pacific Corp. 5258 SW Meadows Rd, Suite 120 Lake Oswego, OR 97035	(916) 989-5130, (503) 226-7331 Processor, recycler All lead batteries					X
Equipment Manufacturing Corp. 1433 Lidcombe Avenue South El Monte, CA 91733	(818) 575-1644 Hot tank and jet spray washer manufacture.		X			
Evergreen Oil 6880 Smith Avenue Newark, CA 94560	(415) 795-4400 Recycler			X		
EKOTEC 27833 Industrial Pk, Bldg 1, Unit 1 Valencia, CA 91355	(805) 257-9390 Processor, recycler			X		
Fuel Processors, Inc. P.O. Box 1407 Woodland, WA 98674	(503) 286-8352 Rerefiner			X		
Gibson Oil & Refining Co. 3121 Standard Street Bakersfield, CA 93308	(805) 327-0413 Processor			X		
GNB, Inc. - Metals Division 2700 South Indiana Street Los Angeles, CA 90023	(213) 262-1101, Lead-acid battery processor, 9,000 lbs. min, non-metallic cases					X
Hedrick Distributors, Inc. 210 Encinal Street Santa Cruz, CA 95060	(408) 427-3773 Hauler, storage			X		
Holchem/Service Chemical 1341 East Maywood Santa Ana, CA 92706	(714) 546-5890 (714) 538-4554 Processor	X				
Hot Tank Supply 3733 E. Clinton Avenue Fresno, CA 93703	(209) 229-0565 Equipment leasing and service		X			
Industrial Oils, Inc. P.O. Box 1221 Klamath Falls, OR 97601	(503) 884-4685 Rerefiner			X		
IT Corp/Vine Hill Facility 4575 Pacheco Blvd. Martinez, CA 94553	(415) 372-9100 Hauler, Processor	X	X			

Table 31 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
JJS Warehouse, Inc. 1076 Park Avenue San Jose, CA	(408) 294-9717 Solvent parts washer manufacturer	X				
Kinsbursky Bros. Supply North Lemon Street Anaheim, CA 92801	(714) 738-8516 Recycler, Spent batteries					X
Lubrication Co. of America 4212 East Pacific Way Los Angeles, CA 90223	(213) 264-1091 Hauler, processor			X		
McKesson Chemical Co. 5353 Jillson Street Commerce, CA 90040	(213) 269-9531 Hauler, Seller	X				
Nelco Oil Refining Corp. 600 West 12th Street National City, CA 92050	(619) 474-7511 Processor					
Oil and Solvent Process Co. 1704 West First Street Azusa, CA 91702	(818) 334-5117 Hauler, processor, seller	X				
Omega Chemical Company 12504 W. Whittier Blvd. Whittier, CA 90602	(213) 698-0991 Hauler, processor, seller	X				
Orange County Chemical Co. 425 Ancleason Drive Escondido, CA 92025	(619) 489-0798 Hauler, seller	X				
Orange County Chemical Co. 1230 E. Saint Gertrude Place Santa Ana, CA 92707	(714) 546-9901 Hauler, seller, processor	X				
Pacific Treatment Corp. 2190 Main Street San Diego, CA 92113	(619) 233-0863 Processor		X	X		
Pepper Oil Company, Inc. 2300 Tidelands Avenue National City, CA 92050	(619) 477-9336 Processor			X	X	
Petroleum Recycling Corp. 1835 East 29th Street Signal Hill, CA 90806	(213) 595-4731 Processor			X		
Plastic Materials, Inc. 3033 West Mission Road Alhambra, CA 91083	(818) 289-7979 Hauler, seller, processor	X				
Rho-Chem Corporation 425 Iris Avenue Inglewood, CA 90301	(213) 776-6233 Hauler, processor	X				
Romic Chemical Corp. 2081 Bay Road East Palo Alto, CA 94303	(415) 324-1638 Hauler, processor	X				

Table 31 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
RSR Quemetco, Inc. 720 South 7th Avenue City of Industry, CA 91746	(800) 527-9452 Lead acid battery processor					X
Safety Kleen Corporation 777 Big Timber Rd Elgin, IL 60120	(800) 323-5740 Equipment leasing & service from locations throughout CA	X				
Safe-Way Chemical 909 Stockton Avenue San Jose, CA 95110	(408) 292-9289 Equipment leasing and service company	X	X			
SDI Company P.O. Box 835 Upland, CA 91785	(714) 982-0553 Solvent parts washer manufacturer	X				
Solvent Services 1021 Berryessa Road San Jose, CA 95113	(408) 286-6446 Hauler, processor	X				
Tanks-A-Lot 220 W. Santa Ana Anaheim, CA 92805	(714) 778-5155 Radiator flush booth manufacturer				X	
Triad Marine & Industrial Cleaning 1668 National Avenue San Diego, CA 92113	(619) 239-2024 Processor			X	X	
Van Waters and Rogers 2256 Junction Avenue San Jose, CA 95131	(408) 435-8700 Hauler, seller	X				
Van Waters and Rogers 1363 S. Bonny Beach Place Los Angeles, CA 90023	(213) 265-8123 Hauler, seller	X				

Table 32

Equipment Leasing Costs*

Equipment	Size	Approximate cost (November 1986 prices)
Solvent Sink Includes monthly leasing of solvent sink with recirculation pump, monthly maintenance service, removal of spent solvent, and replacement with fresh solvent.	11 gal of solvent with 22-gal barrel	$38/mon
	10 gal of solvent with 16-gal barrel	$33.75/mon
	10 gal of solvent with 16-gal barrel	$36.75/mon
Hot Tank Includes monthly hot tank leasing, monthly maintenance service, removal of 10 gal of solution and sludge, and recharge of solution with caustic detergent and water.	60 gal	$93/mon
Jet Spray Washer Includes monthly jet spray washer leasing, monthly maintenance service, removal of 10 gal of solution and sludge, and recharge with caustic detergent and water.	90 gal	$242/mon

*Source: *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops*, p 20.

Table 33

Parts Cleaning Equipment Purchase Costs*

Equipment	Size	Approximate cost (November 1986 prices)
Solvents parts washer	Small: fill/capacity = 11/22 gal or 10/16 gal	$200 - $300
	Large: fill/capacity = 15/30 gal or 20/30 gal	$250 - $400
Jet spray washer	45 gal	$3,400
	85 gal	$3,800
	100 gal	$4,500
Hot tank	60 gal	$300

*Source: *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops,* p 20.

Table 34

Test Criteria for Used Cleaning Solvent (PD680-II)

Rating	Absorbence (500 nm)	Specific Gravity (17°C)	Viscosity cp (18°C)	Conductivity nmho (23°C)
0	< 0.6	< 0.773	< 1.35	< 22.5
1	0.6 - 0.8	0.773 - 0.779	1.35 - 1.85	> 22.5
2	0.8 - 1.0	0.779 - 0.785	> 1.85	
3	1.0 - 1.2	> 0.785		
4	> 1.2			

Table 35

Solvent Recovery Equipment

Supplier	Model	Capacity	Temperature limits	Approximate cost*
Acra Electric Corp 3801 N. 25th Avenue Schiller Park, IL 60176 (solvent: TCE, 1,1,1-TCE,PCE,etc.)	SD-15	5 gal	--	$750
Artisan Industries 73 Pond Street Waltham, MA 02154	--	5-1440 gal/h	--	$4,000 to $1.4 million
Baron Blakesless, Inc. 2001 N. Janice Avenue Melrose Park, IL 60160 (solvents: TCE, 1,1,1-TCE, PCE)	NRS-60 HRS-60	45-60 gal/h 45-60 gal/h	-- --	-- --
Branson Cleaning Equipment Co. Parrot Drive, P.O. Box 768 Shelton, CT 06484 *(solvents: 1,1,1-TCE, Freon TF)*	S111W S121W	9-15 gal/h 21-31 gal/h	-- --	-- --
Crest Ultrasonics Corporation Scotch Road Mercer County Airport Trenton, NJ 08628 (solvents: TCE, 1,1,1-TCE, PCE)	CRS-10H CRS-10U CRS-20H CRS-20U	10 gal/h 10 gal/h 20 gal/h 20 gal/h	-- -- -- --	-- -- -- --
DCI Corporation 5752 W. 79th Street Indianapolis, IN 46268 (solvents: chlorinated, aliphatic, aromatic fluorocarbons)	D1-DG-15	15 gal/hs	--	--
Detrex Chemical Industries, Inc. P.O. Box 501 Detroit, MI 48232 (solvents: TCE, 1,1,1-TCE, Freon TF)	FC-6-EW FC-6-ER	7-25 gal/h 7-25 gal/h	-- --	-- --

Table 35 (Cont'd)

Supplier	Model	Capacity	Temperature limits	Approximate cost
Finish Engineering Company				
921 Greengarden Road	LS-Jr.	3-5 gal/8h	<320 °F	$2,995
Erie, PA 16501	LS-15	15 gal/8h	<320 °F	$5,895
(814)455-4478, (415)821-4154	LS-15V	15 gal/8h	<320 °F	$9,390
(Hazardous waste solvents)				
Garden Machinery Corp.				
700 N. Summit Avenue	#50	50-60 gal/h	--	$4,950
Charlotte, NC 28233				
(Petroleum solvents and oils)				
Hoyt Corporation				
Westport, MA 02790	EP8	4-8 gal/h	<330 °F	$14,500
Hazardous waste solvents)	EP20	<20 gal/h	<330 °F	$26,945
Interel Corporation	--	7.5 gal/h	--	$8,950
P.O. Box 4676	--	15 gal/h	--	$11,850
Englewood, CO 80155				
(solvents: chlorinated,				
Petroleum)				
Kontes Scientific	K-547100	0.8 gallons	--	$1,961
Glassware/Instruments	K-547700	2.5 gallons	--	$2,723
Spruce Street, P.O. Box 729				
Vineland, NJ 08360				
O-I/Shott Process Systems, Inc.	--	13.2 gallons	--	--
1640 SW Blvd., P.O. Box T	--	26.4 gallons	--	--
Vineland, NJ 08360				
Phillips Manufacturing Co.	RS-1	2-5 gal/h	--	--
7343 N. Clark Street	RS-3	4-10 gal/h	--	--
Chicago, IL 60626	RS-5	6-12 gal/h	--	--
	RS-15	13-28 gal/h	--	--
	RS-20	17-37 gal/h	--	--
Progressive Recovery, Inc.	SC-Jr.	1-2 gal/h	<400 °F	$4,795
P.O. Box 521	SC-25	2-4 gal/h	--	$6,495
Trumbull, CT 06611				
(solvents: MEK, toluene,				
xylene, TCE, Freon, etc.)				
Recyclene Product, Inc.	R-2	5 gal/4h	<375 °F	$2,495
405 Eccles Ave.	RS-20	5-7 gal/h (1)	<375 °F	$11,000
South San Francisco, CA 94080	RS-35AF	6-8 gal/h (2)	<375 °F	$21,000
(415)589-9600	RX-35AF	12-16 gal/h (2)	<375 °F	$25,850
Unique Industries, Inc.	1100-10W	12 gal/h	--	
11544 Sheldon Street	1100-10RW	12 gal/h	--	$5,270
Sun Valley, CA 91353	1100-10RA	12 gal/h	--	$8,250
(solvents: chlorinated and				$8,600
fluorinated)				

Table 36

Aqueous Waste Volume Reduction Equipment Suppliers*

Supplier	Model	Capacity	Approximate Cost
EMC Manufacturing 1433 Lidcombe Ave. El Monte, CA 91733 (818) 575-1644	EVAP-85E	85 gal	$ 1995
Nordale Fluid Eliminator 990 Xylite Ave., N.E. Minneapolis, MN 55434 (603) 668-7111 (714) 885-0691	FE-150	150 gal	$ 8000 - $13,000
Wastewater Treatment Systems 440 N. Central Ave. Campbell, CA 95008 (408) 374-3030	BM-50	50 gal	$15,000 - $18,000

*Source: *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops*, p 22.

6 WASTE MINIMIZATION FOR INDUSTRIAL MAINTENANCE, SMALL ARMS SHOPS

Most of the hazardous wastes generated from IMSS operations can be categorized as corrosive wastes (acids and alkalis), spent solvents, paint stripping wastes, and wastes containing toxic metals. The operations that generate these wastes include: equipment and vehicle repair, metal cleaning, surface preparation, and metal finishing. A summary of processes, wastes generated, and DOT classifications are listed in Table 37. The minimization options for vehicle maintenance repair wastes are discussed in Chapter 5.

Chlorinated or nonchlorinated solvents are commonly used to clean or degrease parts before repair, rebuilding, or finishing. Nonchlorinated solvents (e.g., petroleum distillates) are normally used in cold cleaning operations using solvent sinks or dip tanks. Chlorinated solvents such as TCE, 1,1,1-trichloroethane, methylene chloride (MC), and perchloroethane (PC), are used in vapor degreasers where condensing solvent vapors remove the grease, oil, or wax from the dirty parts. 1,1,1-trichloroethane is the safest of these four solvents and is the most commonly used. Of the several different vapor degreasers commercially available, the open top vapor degreasers are the most common at Army installations. In such a vapor degreaser, the heater coils at the bottom of a tank boil nonflammable solvent. The solvent vapors that are denser than air, displace the air and form a vapor zone. A condensing coil at the top of the tank prevents the vapors from escaping from the open top. The parts are lowered into the vapor zone and pure solvent vapors condense on them and solubilize the soil and grease. The solvent drips off or evaporates as the parts are removed after they are cleaned. The soil accumulates at the bottom of the tank. This contaminates the solvent which has to be changed periodically. Also, because the solvent evaporates, fresh solvent must be added frequently.

Cleaning with caustic compounds or detergents also occurs at IMSS operations. Cleaning is usually followed by surface preparation such as painting or scale stripping. Sand, glass, or shot blasting are common methods of removing paint or scale. In some cases, paint stripping is accomplished with solvent (MC) or caustic strippers.

Metal finishing operations, such as surface finishing of small arms, and metalworking, such as cutting and threading are also common at IMSS. A small arms shop conducts weapons rebuilding on many types of small arms. Chemicals such as chromic acid, phosphoric acid, etc., are used. Manganese phosphate coatings are the most common surface finishing treatments used on small arms components. The phosphate coating is dull black and provides wear resistance to the cast iron/steel surfaces. The first step in the process is to clean the parts. The methods include: vapor degreasing or alkali cleaning, blasting with sand/walnut shells, self-emulsified solvent treatment, and phosphoric acid-solvent-detergent cleaning. The parts are then rinsed in water and coated with phosphate. The parts are rinsed in water immediately after the phosphate coating. The next step is to use a hot oil conditioning rinse and then dry the coated and rinsed surfaces. Any supplementary coatings are then applied.[68] The typical coating time is 15 to 40 minutes. The phosphate immersion coating bath is maintained between 200 and 210 °F. The phosphate tank and heating elements are usually made of acid-resistant material. Some of the equipment used in the immersion coating process include: conveying equipment, if necessary; work-supporting equipment such as hooks, racks, baskets, and tumbling barrels; tanks associated with water and heat (steam or electricity); a drain to the sewer line; ventilation equipment; and drying equipment such as ovens, air heaters, fans, and compressors.[69] The operator of the small arms shop must account for all materials used in the process. The potential for severe environmental hazards exists in the operation of a small arms shop.

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[68] A. Douty and E.A. Stockbower, "Surface Protection and Finishing Treatments A. Phosphate Coating Processes," revised by W. C. Jones, in *Electroplating Engineering Handbook*, Fourth Edition, L. J. Durney, Ed. (Van Nostrand Reinhold Co., 1984), pp 366-390.

[69] A. Douty and E.A. Stockbower.

The metalworking operations in IMSS use petroleum and synthetic oils and small quantities of solvents in cleaning, cutting, and threading metallic pipes and other surfaces. Used oil and waste solvents are commonly generated. Painting vehicles, equipment, and parts is also conducted by IMSS. The minimization options for painting and surface coating are discussed in Chapter 7.

The five major categories of processes relevant to Fort Ord and discussed in this chapter are: solvent cleaning, alkaline cleaning, dry media blasting, and cutting and threading.

Source Reduction - Solvent Cleaning

PC/MC/TCE - Product Substitution

1,1,1-trichloroethane should be substituted for PC, MC, or TCE if they are still being used in vapor degreasing. The hazards associated with 1,1,1-trichloroethane are much less than those of the other solvents. It has a higher threshold limit value (TLV, 350 parts per million [ppm]), in terms of worker safety, than PC (100 ppm) and TCE (100 ppm). Although MC has a higher TLV (= 500 ppm), it is a known carcinogen.[70]

TCE/PC/1,1,1-Trichloroethane - Better Operating Practices - Testing

Solvents are replaced in a vapor degreasing tank based on the operator's perception of the solvent's contamination or "dirtiness." A better and a more scientific method must be applied to determine a solvent's "solvation power" and cleaning efficiency. Chlorinated solvents have physico-chemical and electrical properties that can be used to determine if the solvent is "spent."[71] Tests for these properties include: visible absorbence, viscosity, conductivity, and acid acceptance value. Recommended scores for these tests are listed in Tables 38, 39, and 40. (Continued use of the testing procedures will result in more accurate scores that can be substituted for those suggested in the tables.) If the solvent has a score greater than 6, it should be replaced. The acid acceptance value is the most important test because it determines the concentration of amine and alpha epoxide inhibitors left in the solvent. A standard titration procedure,[72] reacting the solution with excess hydrochloric acid which in turn is neutralized with sodium hydroxide, is used to measure this value. Direct measurement instruments (UV/visible spectrophotometer, Ostwald viscometer, and conductivity meter) are available for the other tests. Eventually, solvent test kits will be available for use at Army installations.[73]

1,1,1-Trichloroethane - Better Operating Practices - Aluminum Scratch Test

A standard method[74] is available to qualitatively determine the amount of inhibitor present in 1,1,1-trichloroethane to prevent its degradation in the presence of aluminum or aluminum alloys. This test is used to determine the stability of both the solvent being used and that of recycled solvent. In this test, a cleaned/degreased aluminum coupon is immersed in inhibited 1,1,1-trichloroethane and scratched. After allowing sufficient time to elapse for a reaction to occur, a dark resinous ("blood"-like) material may form and bubbling and discoloration may be noted. If the solvent is sufficiently

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[70] *Solvent Minimization and Substitution Guidelines*, DAEN-ZCF-U, Technical Note 86-2 (Facilities Engineering Division, U.S. Army, Office of the Chief of Engineers, Washington, D.C., 1986), 18 pp.

[71] B.A. Donahue, et al., Used Solvent Testing and Reclamation, Volume II: Vapor Degreasing and Precision Cleaning Solvents, Technical Report N-89/03 (USACERL, December 1988).

[72] ASTM Standard D2942-86, "Standard Test Method for Total Acid Acceptance for Halogenated Organic Solvents (Nonreflux Methods)," *Annual Book of American Society of Testing and Materials Standards*, Vol. 15.05 (1988).

[73] A.R. Tarrer, Personal Communication (Auburn University Department of Chemical Engineering, Auburn, Alabama).

[74] ASTM Standard D2943-86, "Standard Method of Aluminum Scratch Test for 1,1,1-Trichloroethane," *Annual Book of American Society of Testing and Materials Standards*, Vol. 15.05 (1988).

inhibited, no reaction occurs. Possible results are: (1) no reaction, (2) bleeds but heals, no solvent discoloration, (3) bleeds but heals, solvent discoloration, and (4) bleeds with no healing. Continued use of this test over a period of time will result in a site-specific, semi-qualitative procedure to determine when the solvent is spent and should be recycled or disposed of.

1,1,1-Trichloroethane - Better Operating Practices - Emissions Minimization

Reducing air emissions is probably the most significant good operating practice in terms of reducing hazardous wastes released to the environment. Covers should be installed and used for both cold cleaning and vapor degreasing operations. Using covers on vapor degreasing vats can result in a 24 to 50 percent reduction in solvent losses.[75] For open-top vapor degreasers with no cover, boiling of solvent increases emissions by 81 percent compared to covered-top vapor degreasers.[76] Standard guidelines[77] must be established to reduce the hazards to workers, optimize system performance, and conserve material.

Other methods of reducing emissions from vapor degreasers include: increasing freeboard height (0.75 times or greater than the degreaser width); limiting hoist system speed to less than 11 ft/min; limiting the load's cross-sectional area to less than 0.5 times that of the degreaser width; installing a freeboard chiller with a minimum capacity of 100 Btu/h/ft of perimeter coil; removing the load only when the liquid runoff has stopped; and protecting the degreaser from drafts, air currents, and excessively high velocity exhaust ducts.[78]

1,1,1-Trichloroethane - Better Operating Practices - Material Conservation

Empty containers that contain residual 1,1,1-trichloroethane must be triple rinsed before disposal or use. However, rinsing generates a large quantity waste stream that requires proper treatment before drainage to a treatment plant. Purchasing the solvent in minibulk (e.g., 55-gal drums) rather than large containers (e.g., tankers) is a good practice. After purchase, the solvent must be stored in containers of 230 gal or less. Material transfer carts specifically designed for transferring solvent from storage tanks to vapor degreasers must be dedicated for that use only. Cross-contamination may thus be prevented.

1,1,1-Trichloroethane - Better Operating Practices - Material Transfer and Storage

Storing new products in a storage area in drums may lead to cross-contamination. This contamination is caused by using transfer equipment, such as solvent pumps, on drums containing several different products.

Degradable hazardous materials must not be stored in areas that are overheated. Also, contamination from the other materials present must be avoided. Material handlers must be trained in proper handling and storage of hazardous materials.

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[75] ICF Consulting Associates, Inc., *Guide to Solvent Waste Reduction Alternatives*, Final Report (Prepared for the California Department of Health Services, Sacramento, CA, 1986), pp 4-8 - 4-9.

[76] *Solvent Minimization and Substitution Guidelines.*

[77] ASTM Standard D3640-80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol. 15.05 (1988).

[78] ASTM Standard D3640-80.

1,1,1-Trichloroethane - Better Operating Practices - Chemical Purchase

New solvent purchases must be controlled by proper inventory management. Overstocking must be avoided. The material safety data sheets that accompany new products must be reviewed to ensure worker safety and minimize environmental pollution.

1,1,1-Trichloroethane - Better Operating Practices - Operator Handling

Operators must be trained in the proper use of degreasers. The training must include not only the health and safety aspects, but also efficient use and proper waste handling/disposal. Training the operators in process control, proper equipment use, and handling, increases the performance efficiency and minimizes waste generation. Standing operating procedures must be written to include these considerations.

1,1,1-Trichloroethane - Product Substitution - Aqueous Cleaners

Aqueous cleaners that are practical substitutes for chlorinated solvents are commercially available.[79] The advantages of substituting aqueous cleaners for solvents include minimizing the exposure of workers to solvent vapors and reduced liability and disposal costs. Since aqueous cleaners are usually biodegradable, the wastewater produced can be discharged directly to a wastewater treatment plant for further treatment; no disposal of used solvents is required. Substituting aqueous cleaners for solvents requires additional cleaning steps and equipment to achieve the same cleaning performance. Some of the aqueous solvents, that are possible substitutes for chlorinated solvents, are listed in Table 41.

One disadvantage of aqueous cleaners is that they are generally more corrosive to a tank's construction. Tank liners must be installed to prevent excessive corrosion. This may present a particular problem for open-top vapor degreasers with baffles and heating coils. Another disadvantge is that noncorrosive cleaners typically do not clean as well. Aqueous cleaners also require agitation to work properly, so a circulating pump or ultrasonic agitator must often be installed. Furthermore, aqueous cleaners leave metals wet after cleaning. Parts must be blow dried to guard against rust. Corrosion problems have been noted when cleaning galvanized metal with aqueous cleaning solutions. Finally, oil removed from parts during cleaning will typically float on aqueous cleaning solutions and must be skimmed by an internally floating oil skimming pump or by a small external pump and hydrocyclone which continuously cleans the aqueous cleaner and returns it to the tank.[80]

1,1,1-Trichloroethane - Process Change - Ultrasonic Cleaning

Using ultrasonic cleaning processes instead of vapor degreaser cleaning will eliminate the problems associated with 1,1,1-trichloroethane wastes management. Ultrasonic cleaners use high frequency sound to dislodge fine particles attached to surfaces. Further treatment of the aqueous waste stream may be required, depending on the concentration of toxic contaminants in solution. Additional information about ultrasonic equipment must be obtained from manufacturers.

1,1,1-Trichloroethane - Process Change - Process Controls

Unnecessary changes of solvents from degreaser tanks must be avoided. A method of determining the requirement for changing the solvent is to measure the vapor boiling temperature of the contaminated solvent. Solvent suppliers provide information about the boiling temperature range

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[79] J.M. Beller, et al., *Biodegradable Solvent Substitution - A Quick Look Report* (U.S. Air Force Logistics Commands, 1988).
[80] ICF Consulting Associates, Inc.

for all solvents. When the optimum point is reached, the cleaning efficiency of the solvent is minimum and a change is recommended.

Controlling the speed of parts moving in and out of the vapor degreaser to less than 11 ft/min can also be viewed as a process control technique that minimizes solvent dragout and emissions.[81] Speed control equipment (governors) must be used to control the handling speed to allow for adequate draining time, and cooling and condensing of the solvent in the chilling zone.

Vapor degreasers must not be used as drying chambers for parts that have been cleaned and rinsed with water. The wet parts introduce water into the solvent and decrease its useful life. The water may also react with the solvent to form hydrochloric acid that corrodes equipment and contaminates the solvent. Using water separators can extend the life of the solvent.

Recycling Onsite/Offsite - Solvent Cleaning

1,1,1-Trichloroethane - Onsite Recycling - Closed-Loop Distillation

A closed-loop distillation system must be designed and used to recover 1,1,1-trichloroethane from vapor degreasers. Solution from the vapor degreasing tank is pumped into a distillation still and the pure 1,1,1-trichloroethane is pumped back into the tank after the recovery process. This process also segregates 1,1,1-trichloroethane from other wastes, thus preventing cross-contamination. Inhibitors will have to be added. The still bottoms have to be disposed of as a hazardous waste. A list of manufacturers of distillation equipment is provided in Table 35.

1,1,1-Trichloroethane - Onsite Recycling - Degreaser

In small degreasing operations, the vapor degreaser can be used for distillation on a part-time basis. This is accomplished by diverting the vapor-return-to-sump line to a separate holding tank. The "spent" solvent must cover the heating coils. Usually this operation is undertaken during periods of slow workload or during off-hours.

Treatment - Solvent Cleaning

1,1,1-Trichloroethane - Onsite Treatment - Filtration

When used in a vapor degreasing operation, filtration devices can remove particles and thus extend the life of the solvent and reduce cleaning frequency. Equipment suppliers must be contacted to obtain additional information about filtration equipment.

1,1,1-Trichloroethane - Onsite Treatment - Freeze Crystallization

Freeze crystallization is a treatment process that selectively crystallizes certain components from waste solvent. The crystals can then be filtered and disposed of separately. A flow rate of 0.25 gal/min is required for continuous operation of freeze crystallization equipment.[82] Dissimilar metals may thus be removed from waste solvent. Design of the treatment process has to be done on a case-by-case basis.

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[81] ASTM Standard D3640-80.

[82] Fred C. Hart Associates, Aerospace Waste Minimization Report (Prepared for the California Department of Health Services and Northrop Corporation, CA, 1987).

1,1,1-Trichloroethane - Offsite Treatment

Solvent recyclers use many methods to recover solvents, including: distillation, solvent extraction, and ultrafiltration. A list of solvent recyclers is provided in Table 31. Thermal destruction of contaminated solvent in a hazardous waste incinerator for energy recovery is also a common treatment technique.

Treatment - Alkaline Cleaning

Caustic Wastes - Onsite Treatment

Cleaning metal substrate using alkaline cleaners generates a corrosive waste that must be neutralized. In addition to neutralization, removal of grease and heavy metals may be required. Batch treatment units are commercially available. A precipitation/neutralization system can also be designed onsite. The sludge collected on the bottom of the tank which must also be tested for hazard characteristics and disposed of properly.

Source Reduction - Dry-Media Blasting

Dry Wastes - Product Substitution - Plastic Media

Plastic media blasting (PMB) is a relatively new method of removing paint and rust from a variety of metallic and alloy substrates such as aluminum, steel, titanium, copper, and zinc. It is a good substitute for organic chemical stripping (using mixtures of methylene chloride and other toxic compounds) and abrasive blasting with sand, glass beads, or agricultural media (walnut shells, rice hull, corn cobs, etc.).

Agricultural media blasting has several drawbacks such as high explosion potential, poor paint/rust removal, high contamination, and it generates large quantities of waste. Comparatively, sand and glass beads are better because of good performance and low explosion potential. However, they have a very low recycle rate. PMB is aggressive and requires less operating time (compared to agricultural media only). The plastic beads maintain their size and hardness and since it does not break up, it can be recycled 10 to 20 times[83] resulting in lower replacement and disposal costs. Overall, PMB is economically favorable.

Although PMB is slower than sand or glass bead blasting, it produces a better quality finish. Also, the amount of waste produced using PMB is greatly reduced because most of the media can be recycled many times. Assuming a labor rate of $15/h and a media recycle rate of 90 percent, the costs of sand blasting and PMB are $0.62 and $0.36/sq ft, respectively.[84]

Suppliers of plastic media include: Aerolyte Systems, 1657 Rollins Rd., Burlingame, CA 94010, (415) 570-6000; E.I. du Pont de Nemours and Co., Inc., Fabricated Products Dept., Wilmington, DE 19898, (800) 441-7515; and U.S. Blast Cleaning Media, 328 Kennedy Drive, Putnam, CT 06260. The price of plastic media (available on a GSA contract, 1988 prices) ranges from $1.75 to $2.50/lb.

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[83] J. Gardner, *Dry Paint Stripping Utilizing Plastic Media: A New Solution to an Old Problem*, Technical Bulletin (Clemco Industries, 1987).

[84] C.H. Darvin and R.C. Wilmoth, *Technical, Environmental, and Economic Evaluation of Plastic Media Blasting for Paint Stripping*, EPA/600/D-87/028 (Prepared for the U.S. Army Toxic and Hazardous Materials Agency, and the U.S. Environmental Protection Agency, Water Engineering Research Laboratory, 1987); J.B. Mount, et al., *Economic Analysis of Hazardous Waste Minimization Alternatives*, Draft Technical Report (USACERL, 1989), pp 59-60.

Dry Wastes - Process Change - Plastic Media Blasting

Existing abrasive blasting machines can be replaced with more efficient PMB machines. A number of companies manufacture PMB machines; however, design consultants must be retained to design specific applications. PMB machines are available as cabinets or open blast systems. Cabinet systems are very similar to the conventional abrasive blasting machines. The most commonly used cabinet measures about 5 ft by 4 ft. Small open blast systems are portable and self-contained.

Source Reduction - Cutting and Threading

Cooling/Cutting Oils - Better Operating Practices - Material Conservation

The application of cooling/cutting oils in metal working must be limited to the area that has to be cooled without using it in excess. Efficient applicators or directional delivery systems, if used, can reduce the amount of coolant delivered to a surface. This efficient use extends the life of oils and minimizes the quantities purchased and wastes generated.

Cooling/Cutting Oils - Better Operating Practices - Proper Concentration Maintenance

Performance of a coolant depends on maintaining the proper coolant to water ratio. Accurate measurements of the concentrations can be obtained by using refractometers. Also, coolant proportioning devices are available to ensure accurate mixing. Specific information on coolant maintenance must be obtained from the manufacturer; the recommendations must be followed.

Cooling/Cutting Oils - Better Operating Practices - Proper Storage

Water soluble oils can be stored easily. Proper storage avoids deterioration by biodegradation. The manufacturer's storage recommendations must be followed.

Cooling/Cutting Oils - Better Operating Practices - Operator Handling/Segregation

The operators of metalworking equipment must be cautioned about minimal use of coolant. They should be trained about the hazards of mixing oils and chlorinated/nonchlorinated solvents and associated disposal problems.

Cooling/Cutting Oils - Better Operating Practices - Chemical Purchase

When purchasing oils, they must be screened for undesirable hazardous components. If such information is not available in the manufacturers' Material Safety Data Sheets (MSDSs), testing may be required.

Cooling/Cutting Oils - Better Operating Practices - Metal Chips Removal

Metal chips that accumulate in a coolant must be removed frequently. They interfere with the machine's performance and serve as a site for bacterial growth. Filter screens, when placed at the entrance to sump and over the exit from the holding trays, can prevent chips from entering the sump. The chips can then be vacuumed from the screens.

Cooling/Cutting Oils - Product Substitution

Several different brands of water soluble oils are available. Some of them contain small amounts of hazardous materials such as cresol (< 1 percent). Only those oils that do not contain hazardous materials can be purchased.

Cooling/Cutting Oils - Process Change - Equipment Modifications

Worn equipment must be repaired or replaced to optimize performance and minimize waste generation (e.g., leaks). Older models should be replaced with automated equipment.

Adding skimmers (belt or disc) to remove "tramp" petroleum oil from the cooling/cutting oils can minimize the quantities of mixed wastes produced. These skimmers must be placed near the sump containing the coolant. Timers are also available to control equipment operation and to ensure that the quantities of coolant removed with the oil are minimal.[85]

Cooling/Cutting Oils - Process Change - Process Controls

The loss of cooling/cutting oils during metalworking operations must be minimized. Adding splash guards or drip trays allows the excess oils to be collected and possibly recycled/reused. Splash guards and drip trays can also be used to contain spills in the machining areas, thus reducing the use of adsorbent material (e.g., DRY-SWEEP) and wastes generated.

Cooling/Cutting Oils - Process Change - Control Bacterial Growth

Bacterial growth in coolants can be controlled by:[86] cleaning the sump whenever the coolant is replaced; using biocides; adjusting the pH; and adequately circulating the coolant. The sump must be cleaned with steam or chemicals. In some cases, its design may have to be modified to provide sufficient access for cleaning tools.

When using biocides to control bacterial growth, it is important to realize the "ultimate" treatment or fate of the coolant. Bacterial test kits must be used to determine the exact amount of biocide to be added. The use of biocides can be minimized by proper pH control. Bacterial growth decreases the pH of the coolant. By measuring pH (with a pH meter or litmus paper) and adjusting it (with caustic soda) to the manufacturer's recommended level can control bacterial growth. It is also necessary to maintain proper circulation of the coolant to ensure an oxygen enriched environment in the sump. A mixer or an agitator can be used for this.

Treatment - Cutting and Threading

Cooling/Cutting Oils - Onsite Treatment

Fine particles in oils, such as metal cuttings, can be removed in a pretreatment step by using a centrifuge. Batch centrifuges are available for small metalworking equipment. Large continuous centrifuges are available for removing particles from oils generated continuously in large volumes.

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[85] *Prolonging Machine Coolant Life*, Fact Sheet (Minnesota Technical Assistance Program [MnTAP], Minneapolis, MN, 1988).
[86] *Prolonging Machine Coolant Life*.

Mobile treatment services are provided by some companies to generators that produce large quantities of water soluble oils. The cost for such a service depends on the volume of oil and the concentration of contaminants.

Another physical treatment technique is ultrafiltration to remove fine particles. About 90 percent of the water fraction can be extracted and directly discharged into the sewer system.[87] The oil recovered is high quality and can be recycled.

Epsom salts (magnesium sulfate) can be used to reduce volume by precipitation and separation before disposal. However, this method is less efficient than other volume reduction techniques available.

To reuse water soluble oils, it is necessary to treat them by pasteurization followed by filtration. The biological contamination during usage can thus be removed. The blend ratio of recycled oil to new oil is determined with a refractometer.

Cooling/Cutting Oils - Offsite Treatment

Several offsite treatment and recovery techniques available for cutting/cooling oils, including ultrafiltration, evaporation, and thermal destruction by incineration. The choice of a method depends on the volume of wastes, and their physical/chemical state.

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[87] Fred C. Hart Associates.

Table 37

Waste Classification for IMSS*

Process Description		Waste Description			
Process/operation	Materials used wastes produced	HW code	DOT shipping name	Hazard class	Number
Degreasing metal surfaces/parts and other metal surface preparation	Caustic soda	D002	Waste sodium Hydroxide solution	Corrosive material	UN1824
	Chlorinated solvents	F001	Waste (main ingredient)	ORM-A	Varies
	Freon	F001	Hazardous waste liquid, NOS	ORM-A	UN9189
	Ignitable (flammable) degreasers	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	MEK	F005	Waste methylethylketone	Flammable liquid	UN1193
	Methylene chloride	F001	Waste methylene chloride	ORM-A	UN1593
	Mineral spirits solvents	D001	Waste naptha	Flammable liquid	UN2553
	Petroleum naptha	D001	Waste naptha	Flammable liquid	UN1255
	Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
	1,1,1-trichloroethane	F001	Waste 1,1,1-trichloroethane	ORM-A	UN2831
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
Metal finishing (including etching)	Spent acid solutions	D002	Waste chromic acid solution	Corrosive material	UN1755
	Chromic solutions	D002	Waste hydrochloric acid	Corrosive material	NA1789
	Hydrochloric solutions	D002	Waste nitric acid > 40%	Oxidizer	UN2031
	Nitric stripping solutions	D002	Waste nitric acid < 40%	Corrosive material	NA1760
	Phosphoric solutions	D002	Waste phosphoric acid	Corrosive material	UN1805
	Sulfuric solutions	D002	Waste sulfuric acid	Corrosive material	UN1832
Surface preparation	Acetone	F003	Waste acetone	Flammable liquid	UN1090
	Alcohols	D001	Waste alcohol, NOS	Flammable liquid	UN1987
	Caustic paint stripper	D002	Waste paint related material	Corrosive material	NA1760
	Methylene chloride stripper	F002	Waste methylene chloride	ORM-A	UN1593
	Mineral spirits	D001	Waste naptha	Flammable liquid	UN2553
				Flammable liquid	UN1263
Metalworking	Used oils (not manifested)	None	Waste petroleum oil, NOS	Combustible liquid	NA1270
	Spent solvents		Varies	Varies	Varies

* Source: *Metal Manufacturing and Finishing*, Hazardous Waste Fact Sheet (Small Quantity Generators Activity Group, Minnesota Technical Assistance Program, Minneapolis, MN, 1987).

Table 38

Test Criteria for Trichloroethylene

Rating	Acid Acceptance Value (AAV) (wt percent NaOH)	Absorbence (450 nm)	Viscosity (cp)	Conductivity (nanomho/cm)
0	>0.06	<0.50	0.57	> 27.0
1	--	0.50-0.67	0.571-0.590	27.0-24.0
2	--	0.68-0.84	0.591-0.600	23.9-20.0
3	--	0.85-1.00	>0.600	<20.0
4	0.06-0.03	>1.00	--	--
6	<0.03	--	--	--

Table 39

Test Criteria for Perchloroethylene

Rating	Acid Acceptance Value (AAV) (wt percent NaOH)	Absorbence (500 nm)	Viscosity (cp)	Conductivity (nanomho/cm)
0	>0.06	<0.18	0.75	>29.4
1	--	0.18-0.42	0.76-0.77	29.4-26.7
2	--	0.43-0.66	0.78-0.80	26.6-24.0
3	--	0.67-0.90	>0.80	<24.0
4	0.06-0.03	>0.90	--	--
6	<0.03	--	--	--

Table 40

Test Criteria for 1,1,1-Trichloroethane

Rating	Acid Acceptance Value (AAV) (wt percent NaOH)	Absorbence (400 nm)	Conductivity (nanomho/cm)
0	>0.06	<0.98	>22.7
1	--	0.980-0.986	22.7-21.1
2	--	0.987-0.994	21.0-19.5
3	--	0.995-1.00	<19.5
4	0.06-0.03	>1.00	--
6	<0.03	--	--

Table 41

Biodegradable Solvents and Their Suppliers

Solvent	Supplier
Safety Solvent Degreaser	Bio-Tek Inc.
Exxate 1000, Exxate 1300, Exxate 600, Exxate 700, Exxate 800, Exxate 900	Exxon Chemical Co.
Desolve-It	Orange-Sol Inc.

7 WASTE MINIMIZATION FOR PAINT SHOPS

Paints are applied to metal or other surfaces (e.g., wood) for waterproofing, flameproofing, rustproofing, insulating, etc. There are three different categories of paints: architectural, original equipment manufacture (OEM), and special purpose. Architectural paints are used on buildings. OEM paints are used in industries that manufacture automobiles, appliances, and furniture.[88] Special purpose paints such as chemical agent resistant coating are used in maintenance operations in some industries, the armed services, and highways' maintenance. Forty-four percent of the special purpose coatings are used on automobiles, 18 percent in industrial maintenance, and the remaining distributed between aerosols, traffic paints, and other categories.[89]

The painting process involves: paint stripping and surface preparation, application of the paint, and curing. Paint stripping (using wet or dry techniques) and surface preparation are necessary to clean the substrate and prepare it for adhesion of the paint. Paint is then applied to the surface. The method used depends on the size, shape, complexity, and number of items. After painting, the items are placed in a curing oven to remove excess solvent and make the coating uniform. Some of the common painting techniques are: dip painting, flow painting, roll painting, curtain painting, spray painting, and bulk painting.[90] Spray painting is the most commonly used technique and can be manual or automatic. Spray painting techniques (including conventional pressure/air atomized, and electrostatic centrifugal/air atomized) have transfer efficiencies that range from 30 to 95 percent. The overspray from the paint application process can be as high as 50 to 70 percent, and is in most cases collected and disposed of. The method of painting may sometimes be dictated by the type of paint formulation (e.g., water-based enamels cannot be sprayed).

Most paint formulations use solvents as carriers for binders such as pigments, powders, and adhesives. The solvent content can vary from 1 to 85 percent. Typical solvents include: acetone, n-butanol, o-dichlorobenzene, diethyl ether, ethyl acetate, butanol, MEK, methyl isobutyl ketone, MC, 1,1,1-trichloroethane, trichlorofluoro-methane, tetrahydrofuran, cyclohexanone, and petroleum derivatives such as naptha, xylene, toluene, or hexane. Powder or water-based paints do not contain solvents. Solvent-based paints (e.g., acrylic lacquers) have the advantage of durability, fast drying time, low corrosivity to substrate, and high gloss finish.[91] Some of the disadvantages include: emission control problems; worker exposure hazards; fire hazards; and waste management, disposal, and liability problems. The criteria used in choosing a solvent depends on the type of paint required, drying speed, the nature of the substrate, and the properties of the solvent.

In addition to the wastes from the painting process, a large quantity of solvent wastes are generated during equipment cleaning. Table 42 describes the wastes generated from the painting process and lists the corresponding DOT classifications.

Source Reduction

Solvent-Based Paints - Product Substitution - Powder Coatings

Powder coating is an effective alternative to solvent-based paints. In a powder coating process, the paint powder is applied to a substrate with an electrostatic spray gun. The carrier is pressurized air, rather than solvents. The powder coating adheres to the surface because of electrostatic forces.

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[88] ICF Associates, Inc.
[89] P.L. Layman, "Paints and Coatings: the Global Challenge," *Chemical and Engineering News* (September 30, 1985), pp 27-68.
[90] ICF Associates, Inc.
[91] ICF Associates, Inc.

Excess powder that does not cling to the surface can be recycled. Heating in the curing oven ensures that the powder fuses to the surface. Powder coatings can also be applied using a fluidized bed process where the heated objects are immersed in the fluidized bed.

Because powder coatings contain no solvents, emissions of volatile organic compounds and the related air pollution problems are eliminated. Fire hazard and insurance rates are reduced and better neighborhood relations develop as the odor associated with solvent-based application are eliminated. Preliminary toxicological studies indicate that many of the commercial powder formulations are nontoxic. Since the overspray powder can be recycled, material use is high and solid waste generation is minimal. Waste disposal and liability problems are reduced. The process also has a high transfer efficiency, resulting in a lower reject ratio of parts. Coating quality is claimed to be better than with solvent-based coating. The messy cleanup operations associated with liquid-based paints are avoided. Powder coating is easier to apply and it is easier to train people to use it. The operators' attitudes improve. The operation is less labor intensive. Maintenance is easier and the overall operating costs are lower. Powder costs are minimally affected by petroleum prices and the operation is more flexible to changing coating requirements.

However, powder application equipment is more expensive to install than solvent-based or high solids coating equipment. Another disadvantage is that powder coating must be done at elevated temperatures. It is not usable on heat sensitive substrates such as plastics, wood, and assemblies containing nonmetal parts. Formulations with lower cure temperatures (275 °F) are being developed.[92]

Solvent-Based Paints - Product Substitution - Water-Based Formulations

Water-based formulations reduce the amount of solvents used and emitted in the coating process. Solvent-based paint equipment can easily be modified to apply water-based paints/coatings. The paint overspray can easily be collected with water in the spray booth and recycled. Though this can also be done in a solvent-based process, a difficult-to-treat aqueous waste stream may result due to direct contact with the solvent. Disposal and liability issues associated with wastes from the solvent-based formulation are reduced and the fire and explosion hazards present with the solvent-based process are eliminated. Concerns about worker exposure to solvents are also eliminated. Energy savings can be achieved by recirculating hot air in the ovens used to cure the paint. Similar recirculation is not possible in a solvent-based operation as the solvent levels in the recirculated air may reach explosive levels. The installed capital cost of water-based units is lower than that for high solids or powder coating.[93]

A number of private companies and a naval installation (Naval Air Rework Facility, Pensacola, Florida) have successfully converted from solvent-based painting to a water-based painting operation.[94] Based on their experience, the annual cost to coat using water-based coating was higher compared to conventional solvent, high solids, or powder coating. The applied coating cost per square foot for a water-based unit is also higher and the coating may be inferior. The quality of water-based coatings varies with ambient conditions such as room temperature and humidity. The drying time is longer and could be a bottleneck in the production line. It may necessitate installing a drying unit. Surface treatment procedures may need extensive modification to convert to a water-based coating method.[95]

One company that unsuccessfully tried to convert to water-based painting reported that the increased drying time led to production scheduling problems. The new system took several hours for drying, compared to the 30 minutes required for the solvent based process. It required an increased

[92]ICF Associates, Inc.
[93]ICF Associates, Inc.
[94]ICF Associates, Inc.
[95]ICF Associates, Inc.

amount of surface cleaning before the water-based coating could be applied. The time and cost involved in the extra cleaning were prohibitive. The water coating did not have the same hardness, durability, or gloss and the quality of the water-based paint varied with room temperature and humidity. The company also reported that the water environment was corrosive to galvanized steel. The existing equipment made of galvanized steel needed to be replaced with stainless steel, which involved considerable expense.[96]

Solvent-Based Paints - Product Substitution - Two-Component Catalyzed Coatings

Two-component catalyzed coatings are comprised of isocyanates (highly toxic compounds) and hydroxyl compounds. These compounds polymerize on a surface to form a polyurethane coating. Their use has been extensively investigated by the automobile industry.[97] Substituting two-component catalyzed coatings for solvent-based formulations is not justified because of the toxicity of the components.

Solvent-Based Paints - Product Substitution - Radiation-Curable Coatings

Radiation-curable coatings do not contain solvents and therefore could be good substitutes. A liquid prepolymer is allowed to react with a thinner under ultraviolet light to form a coating. These coatings have been found to be effective on a number of surfaces.[98]

Paint Wastes - Better Operating Practices - Segregation

The current practice for disposing of residual paint left in cans is to pour it into drums containing thinner wastes. However, segregating paints from thinner wastes maintains the purity of the thinner and improves its recyclability. Thinners can be recycled onsite or offsite and reused in painting and cleaning processes.

Excess paints should be given to customers for touchup use, thus reducing the improper disposal of cans containing liquid paint with other nonhazardous wastes. (Cans containing dried paint residue can be thrown out.)

Solvent Wastes - Better Operating Practices - Adopt Good Manual Spraying Techniques

When manual spraying practices are used, the amount of waste produced can be reduced by: using a 50 percent overlap in the spray pattern, maintaining a 6- to 8-in. distance between the spray gun and the surface, maintaining a gun speed of 250 ft/min, holding the gun perpendicular to the surface, and triggering at the beginning and end of each pass.[99] In addition to reducing the amount of waste produced, an increase in the production rate and a decrease in rejection rate can be realized.

Solvent Wastes - Better Operating Practices - Avoid Adding Excess Thinner

The tendency to use excess thinners should be avoided. If the paint is difficult to apply, adding thinner may make it easy. However, adding excess thinner affects the film thickness, density, and durability.[100]

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[96] ICF Associates, Inc.
[97] M.E. Campbell and W.M. Glenn, *Profit from Pollution Prevention - A Guide to Industrial Waste Reduction and Recycling* (The Pollution Probe Foundation, Toronto, Canada, 1982).
[98] M.E. Campbell and W.M. Glenn.
[99] J. Kohl, P. Moses, and B. Triplett, *Managing and Recycling Solvents: North Carolina Practices, Facilities, and Regulations* (North Carolina State University, Raleigh, NC, 1984).
[100] L.J. Durney, "How to Improve Your Paint Stripping," *Product Finishing* (1982), pp 52-53.

Solvent Wastes - Better Operating Practices - Avoid Excessive Air Pressures for Atomization

Using excessive air pressure to atomize paint particles leads to increased emissions and overspray, and must be avoided. By adjusting the air pressure, a 30 percent decrease in overspray and therefore a savings in raw material costs could be realized.[101]

Solvent Wastes - Better Operating Practices - Maintain Equipment Properly

Proper equipment maintenance is critical to reducing the number of reject products and improving productivity.[102] Proper maintenance also reduces the quantity of waste produced from paint stripping and repainting operations.

Solvent Wastes - Better Operating Practices - Lay Out Equipment Properly

Proper layout of equipment in a work area can also reduce emissions and improve the quality of the finished products. Solvent tanks must be kept away from heat sources such as curing ovens. This will help minimize evaporation of the solvents and will also prevent the solvent vapors from entering the curing oven and affecting the curing rate or decreasing the quality of the finish.[103]

Solvent Wastes - Better Operating Practices - Isolate Solvent-Based Spray Units From Water-Based Spray Units

Isolation of solvent-based spray units from water-based spray units is a good segregation practice. The oversprays from these operations should not be allowed to mix; the mixture could be classified as a hazardous waste. If the units are segregated, the filters from the water-based paint spray booths are not classified as hazardous waste.

Solvent Wastes - Better Operating Practices - Close Floor Drains in Production Area

Closing the floor drains will reduce the amount of water used to clean up spills. This practice promotes the use of rags that must be drycleaned. Thus the generation of large quantities of rinse water containing solvents can be minimized.[104]

Solvent Wastes - Better Operating Practices - Purchase Proper Quantities of Paints

Buying paint in large containers is preferable to buying the same quantity in smaller containers. The amount of residual materials can thus be reduced. Large containers can be returned to manufacturers for cleaning and reuse. Ordering extra paint for any given job should also be avoided. The exact amount of paint required must be calculated to reduce the number of small cans containing residues for disposal.

Solvent Wastes - Better Operating Practices - Segregate Wastes

Segregating wastes is extremely important to reducing the amount of hazardous wastes generated and to improve the recyclability of solvents. If many solvents are used, they should be segregated. Some solvents can be directly reused in equipment cleaning operations.

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[101] ICF Associates, Inc.
[102] ICF Associates, Inc.
[103] ICF Associates, Inc.
[104] L.J. Durney.

Proper labels must be attached to containers. Hazardous wastes must be segregated from nonhazardous wastes and handled and disposed of properly. Labeling a container containing nonhazardous waste as "hazardous" can result in an unnecessary increase in disposal costs.

Solvent Wastes - Better Operating Practices - Standardize Solvent Use

Standardizing solvent use will reduce the numbers of different types of thinners and solvents used in coating formulations. If fewer solvents are stocked, the possibility of mixing of the wastes is reduced. Only one type of thinner or solvent corresponding to each type of paint should be purchased.

Solvent Wastes - Product Substitution - Use High-Solids Formulations

High-solids formulations contain a reduced quantity of solvent. Using high-solids formulations will therefore reduce the amounts of wastes and emissions generated from the painting operations.

Solvent Wastes - Process Change - Choose Proper Coating Equipment

The proper choice of coating equipment can reduce the quantity of wastes produced and result in raw material savings. Overspray from painting operations generates the most waste. Equipment with high transfer efficiencies must be chosen.

Solvent Wastes - Process Change - Replace Conventional Spray Units With Electrostatic Units

Electrostatic units (either centrifugally- or air-atomized spray) have high transfer efficiencies. Converting from conventional equipment to electrostatic equipment may lead to a 40 percent reduction in overspray and considerable savings.[105] The overspray collects on the spray booth walls that are electrically grounded. Thus, the amount of residues in the rest of the work area is reduced. However, the complete conversion requires a lot of time and work in testing, visiting other plants, engineering, and maintenance.

Solvent Wastes - Process Change - Replace Air-Spray Guns With Pressure Atomized Spray Guns

Replacing air-spray guns with air-less spray guns increases the transfer efficiencies. A 23 percent reduction in raw material costs has been reported.[106] Also, the cleaning frequency is increased from once every 3 weeks to once a week.

Aqueous Wastes - Process Change - Dry Paint Booths

Large volumes of wastewater are generated from "water curtain" paint booths. The water curtain is used to remove the paint overspray particulates from the exhaust system. A significant concentration of paint, solvents, and flocculating/coagulating agents accumulates in the wastewater. This wastewater must be treated to remove hazardous contaminants and the sludge must be disposed of as a hazardous waste.

Converting from a wet to a dry paint booth eliminates the problem of wastewater generation. In a dry booth, the contaminated air (laden with paint particles) is drawn through fibrous filters which must then be disposed of as hazardous waste. A much smaller volume of waste is generated. Results

[105] L.J. Durney.
[106] J. Kohl, P. Moses, and B. Triplett.

of a Navy study[107] indicate that converting to dry operation is technically feasible and cost effective (payback 8 months to 2 years) for small, medium, and large painting facilities.

Recycling Onsite/Offsite

Paint Wastes - Onsite Recycling - Recycle Paint Overspray/Sludge

In water curtain spray booths, the overspray impinges on a water curtain. The paint/water mixture is then pumped to a separator. If the paints used are immiscible in water, they can be separated out and recycled. Also, the water can be recycled back into the water curtain. Recycling of the water and paint reduces the amount of wastes produced and results in a savings in raw materials costs.

Solvent Wastes - Onsite Recycling - Ultrafiltration, Distillation, or Evaporation

In ultrafiltration, the sludge containing solvents is filtered using membranes with pore sizes of 0.01 microns. Paint particles, usually larger than 1 micron, collect on the membranes and are removed continuously. A series of membranes filter the waste to produce a pure solvent that can be recycled.[108]

Distillation stills can be used to recover solvents. The solvent is indirectly heated and the vapors are condensed and collected. Purities of 90 to 99 percent can be obtained by this process. Table 35 lists manufacturers of distillation stills and associated costs. The concentrated still bottoms containing paint sludge must be shipped for proper disposal as a hazardous waste. Another possibility is to ship the still bottoms to a cement kiln for use as a supplemental fuel through a waste exchange program.

Evaporation, using drum-dryers or thin-film evaporators, is effective on solvents that are heat-sensitive. Large scale equipment is necessary for evaporation and, therefore, is cost effective only for large quantities of solvents. Many commercial solvent recyclers use agitated thin-film evaporators.

Solvent Wastes - Offsite Recycling - Closed-Loop Contract

Wastes consisting primarily of thinners, paint sludge, and paint can be reclaimed at an offsite facility. This closed-loop service is provided by many paint and thinner suppliers. Usually the purchase price includes delivery, waste hauling, recycling, and disposal. Such a service removes the wastes when it delivers the new product. The waste is processed at a licensed treatment, storage, and disposal (TSD) facility. Processes used for recycling thinners are well-established and widely used.[109] Commerical recyclers have the versatility and have developed technologies for recycling large varieties of waste solvents. Between 70 and 80 percent of spent thinners can be recycled into a useful product.

Treatment

Solvent Waste - Onsite Pretreatment - Gravity Separation

Gravity separation is a relatively inexpensive option that is easy to implement. In this treatment process, the thinner and paint sludge mixture is allowed to separate by the force of gravity without

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[107] Acurex Corporation, *Navy Paint Booth Conversion Feasibility Study*, CR 89.004 (Prepared for the Naval Civil Engineering Laboratory [NCEL], Port Hueneme, CA, 1989).
[108] Y. Isooka, Y. Imamura, and Y. Sakamoto, "Recovery and Reuse of Organic Solvent Solutions," *Metal Finishing* (June 1984), pp 113-118; W.H. Reay, "Solvent Recovery in the Paint Industry," *Paints & Resins* (March/April 1982), pp 41-44.
[109] SCS Engineers, Inc., *Waste Audit Study - Automotive Paint Shops* (California Department of Health Services, January, 1987).

external disturbance or agitation. The heavier paint sludge particles settle to the bottom of the container and the supernatant can be decanted off. The decanted thinner can be used as a "wash thinner" for cleaning equipment or for thinning primer and base coatings.[110]

Paint/Solvent/Aqueous Wastes - Offsite Treatment

Although most waste associated with paint can be treated using a number of different physical, chemical, and biological techniques, these techniques are not feasible for most Army installations that generate small quantities. However, licensed TSD facilities can use a number of processes such as activated carbon adsorption, chemical oxidation, solvent extraction, solid/liquid separation, stabilization/solidification, thermal destruction, volume reduction, and biological treatment. The applicability of each technique will not be discussed here.

Table 42

Waste Classification for Paint Removal, Painting, and Brush Cleaning

		Waste Description		
Materials used/ wastes produced	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Acetone	F003	Waste acetone	Flammable liquid	UN1090
Alcohols	D001	Waste alcohol, NOS	Flammable liquid	UN1987
Caustic paint stripper	D002	Waste paint related material	Corrosive material	NA1760
Chlorobenzene	F002	Waste chlorobenzene	Flammable liquid	UN1134
Enamel liquids	D001	Waste enamel	Combustible liquid	UN1263
Ethylene dichloride		Waste ethylene dichloride	Flammable liquid	UN1184
MEK	F005	Waste methylethylketone	Flammable liquid	UN1193
Methylene chloride stripper	F002	Waste methylene chloride	ORM-A	UN1593
Mineral spirits	D001	Waste naptha	Flammable liquid	UN2553
Paint dryer	None	Waste paint dryer, liquid	Combustible liquid	UN1263
Paint liquids	D001	Waste paint	Flammable liquid	UN1263
Paint solids (toxic)	Varies	Hazardous waste (solid), NOS	ORM-E (if solid)	UN9189
Paint thinners, lacquers	D001	Waste paint related material	Flammable liquid	NA1263
Paint waste with heavy metals	Varies	Hazardous waste liquid, NOS	ORM-E	NA9189
		Hazardous waste solid, NOS	ORM-E	NA9189
Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
Toluene (Toluol)	F005	Waste toluene	Flammable liquid	UN1294
VM&P naphtha	D001	Compound, paint removing liquid	Flammable liquid	NA1142
Xylene (Xylol)	F003	Waste xylene	Flammable liquid	UN1307

[110] SCS Engineers, Inc.

8 WASTE MINIMIZATION FOR PHOTOGRAPHY, PRINTING, AND ARTS/CRAFTS SHOPS

Photography and photoprocessing are common operations at Army installations. Among the source types that use photography are: training and audiovisual centers, hospitals, dental clinics, and research laboratories (as discussed in Chapter 4). Printing operations are limited to training and audiovisual centers. The materials used in producing a photograph are paper, plastic film, or a sheet of glass containing light-sensitive photographic emulsion. The emulsion is a gelatineous substance containing silver halides (chloride, bromide, and iodide). Some photographic films may be made of cellulose acetate. However, most are made of polyester. In photography, a negative containing different shadings is produced. The dark portions on a negative contain heavy deposits of silver. The processing that follows the exposure of a film or emulsion consists of developing, fixing, and washing. Wastewater containing photoprocessing chemicals and silver is the primary wastestream of concern.

A printing process usually follows image processing, including typesetting and the photographic processing step discussed above. However, an intermediate step to prepare plates to carry the image to paper is necessary. A roller transfers ink onto a plate or a cylinder. The image on the plate or cylinder is transferred to a rubber blanket which in turn transfers it to paper. There are four different types of image carriers: manual - in screen printing; mechanical - for relief printing; electrostatic - in offset duplicating; and photomechanical - most common method of platemaking.[111] Preparation of plates is followed by the actual printing. Two common types of printing presses used are: sheet-fed presses that can print up to 3 impressions per second and web presses that operate at the rate of 1000 to 1600 feet per minute.[112]

In the printing process, the plate (a thin aluminum sheet) is first attached to the plate cylinder of the press. Each unit of a printing press then prints a single color. Four units (red, blue, yellow, and black) are required for a full color illustration. The raw materials typically used in a printing operation are ink, paper or other print substrate, and fountain solution. Wastes generated from a printing process include waste inks, used ink containers, used plates, damaged or worn rubber image transfer blankets, waste press oils, cleanup solvents, rags, and trash.[113]

The arts and crafts shops are educational and vocational shops that provide training in automobile maintenance/repair, metalworking, graphic arts, and woodworking. Only the minimization of wastes from the photography and printing section of arts and crafts shops is considered in this chapter. Minimization of wastes from automobile maintenance/repair and metalworking are discussed in Chapters 5 and 6, respectively. A summary of processes, corresponding waste streams, and DOT classifications is provided in Tables 43 and 44.

Most of the waste minimization options discussed in this chapter have been extracted from *Waste Audit Study - Commercial Printing Industry*.[114]

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[111] Jacobs Engineering Group, Inc., *Waste Audit Study - Commercial Printing Industry* (California Department of Health Services, Sacramento, CA, May 1988).
[112] Jacobs Engineering Group, Inc.
[113] Jacobs Engineering Group, Inc.
[114] Jacobs Engineering Group, Inc.

Source Reduction - Photography and Printing Operations

All Wastes - Better Operating Practices - Proper Material Handling and Storage

Raw materials may become obsolete and get spoiled due to improper storage and handling. Therefore, proper storage and handling is a good operating practice that will reduce the amount of waste generated and result in savings in raw materials costs.

Photographic and printing chemicals require proper storage, which is usually indicated on the containers. They are sensitive to light and temperature. Proper storage under recommended conditions increases their shelf life and results in savings in raw materials costs and disposal costs.

The storage area must be kept clean. One way to keep the storage area clean is to prohibit through traffic and restrict entry to only a few persons. Traffic increases the amount of dirt and the possibility of contamination. It is easier to contain spills if the entry is restricted to only a few persons.

Proper inventory control is necessary to decrease the possibility of the material's shelf life expiring before the materials are used. The materials should be arranged and labeled on shelves so that those that were purchased first must be used first. Computerized inventory control and materials tracking will help manage the inventory.

Material with an expired shelf life should not be discarded. Tests must be used to determine the effectiveness and usability. Waste disposal may thus be minimized. Excess material should be recycled through a manufacturer or a waste exchange.

Ordering excess material should be avoided. Material ordering should be based on use. Small printing operations should purchase inks in small containers to limit the possibility of the ink spoiling in large containers that may not be properly sealed. Large printing operations should order materials in large containers that can be returned to manufacturers for cleaning and reuse.

Raw materials should be inspected when they arrive and before use. Unacceptable and/or damaged items must be returned to manufacturers to avoid disposal problems and to avoid creating defective products.

Source Reduction - Photographic Operations

Photographic Chemicals - Better Operating Practices - Proper Chemical Storage

Many of the photographic chemicals degrade in the presence of air. Small photographic operations store chemicals in plastic containers. Adding glass beads to the containers to bring the liquid level up to the brim has been found to be useful.[115] The life of the chemicals can thus be extended.

Photographic Films - Material Substitution - Nonsilver Films

Substituting films containing silver with those containing nonhazardous chemicals reduces hazardous waste generation. The silver from silver films makes the photographic wastes (e.g., fixing

[115]Jacobs Engineering Group, Inc.

bath solutions, rinse water, etc.) hazardous. Only very low silver concentrations are allowed in wastewaters treated at wastewater treatment plants operated by county sanitation districts.

Some substitutes to silver-halide films include vesicular (diazo), photopolymeric, and electrostatic films.[116] However the disadvantage of these films is that they are slower than silver films. Vesicular films consist of a honeycomb structure and are constructed from a polyester base coated with a thermoplastic resin. These films are also coated with a light-sensitive diazonium salt. Photopolymeric films use carbon black instead of silver. A weak alkaline solution is used to process these films. The spent bath solution is a nonhazardous waste that can be neutralized before disposal. An electrostatic charge makes electrostatic film light sensitive. The speed of this nonsilver film is comparable to silver films and it has a high resolution.

Other Photographic Wastes - Material Substitution

Other photographic wastes such as intensifiers and reducers also contain hazardous compounds (e.g., mercury, cyanide salts, etc.). Use of available nonhazardous substitutes will reduce the amount of hazardous wastes generated.

Fixing Bath Solutions - Process Change - Extend Bath Life

The life of fixing baths can be extended to reduce the quantities of wastes generated from photographic operations. Some of techniques that could be used include:[117]

1. Adding ammonium thiosulfate which increases the bath life by doubling the allowable silver concentration,

2. Using an acidic stop-bath before the fixing bath,

3. Adding acetic acid to the fixing bath to keep the pH low.

Photographic Wastewater - Process Change - Reduction in Water Use

Parallel rinsing is commonly used in photographic processing operations. Converting to countercurrent rinsing reduces the amount of wastewater generated. In countercurrent rinsing, the water flows in a direction that is opposite to the film movement. Thus, fresh water in the final tank is used in the final film washing stage after most of the contamination has been rinsed off. The most contaminated water is in the very first washing stage. A countercurrent system, however, requires more equipment and space.

Sponges or squeegees must be used in nonautomated operations to remove excess water from the films. Thus the dragout of chemicals from one tank to another can be reduced by almost 50 percent.[118] Minimizing contamination of processing baths has many advantages including: increasing the recyclability of solutions, extending solution life, and reducing the quantities of raw materials (replenishments) required.

Another method of reducing waste chemicals is to add accurate amounts of replenishment chemicals and properly monitor the chemical concentrations of baths. Exposing the process baths to air must be minimized to prevent oxidation reactions.

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[116]Jacobs Engineering Group, Inc.
[117]Jacobs Engineering Group, Inc.
[118]Jacobs Engineering Group, Inc.

All Photographic Wastes - Process Change

With the recent advances in desk top publishing systems and the use of personal computers, "electronic prepress photographic systems" are gaining widespread popularity. In such a system, the graphics, photographs, and layouts are scanned into the computer. Editing is accomplished on the monitor rather than on paper. Only the final version is printed on paper. Use of electronic sytems will greatly reduce the quantities of wastes generated from photographic operations conducted at printing facilities.

Source Reduction - Printing Operations

Metal Etching/Plating Wastes - Process Change

If printing operations still include metal etching and plating, alternative processes (e.g., lithographic plate, hot metal, flexographic, etc.) must be examined as substitutes. These alternative processes do not present the problems associated with treatment and disposal of hazardous wastes.

Metal Etching and Plating Wastewater - Process Change - Reducing Water Use

The wastewater produced from metal etching and plating is a hazardous waste. Efforts must be made to reduce the toxicity of wastewater by reducing the dragout from process tanks and by using countercurrent rinsing. Dragout reduction can be achieved by: (1) positioning parts on racks so they drain properly, (2) using drip bars and drain boards to collect the dragged-out chemicals and returning them to the process tanks, and (3) increasing the process tank temperature to reduce surface tension of the solution thereby minimizing its tendency to cling to parts.

Countercurrent rinsing reduces the amount of wastewater leaving an operation. However, it does not reduce the hazardous material content in wastewater.

Lithographic Plate Processing Chemicals - Better Operating Practices - Reduced Chemical Use

The use of plate processing chemicals must be reduced. One way to reduce chemical consumption is to frequently monitor the pH, temperature, and chemical concentration of the bath. Bath life can thus be extended and changing of solutions can be reduced to only a few times a year. Using automatic plate processors facilitates precise monitoring of bath conditions.

Lithographic Plate Processing Plates - Better Operating Practices - Proper Storage/Recycling

Proper storing of plates reduces the possibility of them getting spoiled and maintains their effectiveness. Used plates are not a hazardous waste and must be collected and sold to an aluminum recycler.

Lithographic Plate Processing Plates - Material Substitution

Alternative "presensitized plates" are available that can be processed with water. Other plates available include "Hydrolith" plates manufactured by 3M Corporation.[119] 3M has also developed a platemaking system that eliminates the need for photoprocessing, and has been found to be economical for large plating operations.[120]

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[119] M.E. Campbell and W.M. Glenn.
[120] M.E. Campbell and W.M. Glenn.

Web Press Wastes - Process Change - Break Detectors

Using break detectors in web presses prevents severe damage to the presses and also reduces the quantities of wastes from spillage of inks, fountain solutions, and lubricating oil. Web break detectors detect tears in a web as it passes through a high speed press. Broken webs tend to wrap around rollers and force them out of their bearings.

Waste Inks/Cleaning Solvents/Rags - Better Operating Practices

Rags dampened with cleaning solvents are used to clean presses. The amount of solvent and number of rags used can be minimized by reducing the cleaning frequency and by properly scheduling cleaning. Ink fountains must be cleaned only when a different color ink is used or if the ink has dried out. Overnight drying of ink may be reduced by using compounds that are dispensed as aerosol sprays.[121] Thus, the amount of waste ink, solvents, and rags is reduced.

Waste Inks - Better Operating Practices

The amount of waste ink generated can be reduced by implementing better operating practices. Only the required amount of ink must be put in an ink fountain before starting a print job. Resealing the ink containers after use is a good practice that prevents contamination by dust/dirt, formation of a "skin" on the ink surface, loss of solvents, and hardening. As much of the ink as possible must be scraped from the container for use.

Automatic ink levelers, when used in large presses, improve the print quality and reduce the amount of trash and the likelihood of accidental spills.

Waste (Flexographic) Inks - Product Substitution - Water-Based Inks

Substituting water-based inks for solvent-based inks in flexographic printing reduces the quantity of hazardous wastes generated. Use of water-based inks also eliminates the problems encountered with volatilization of solvents. Some of the disadvantages of water-based inks include: limited range of colors, higher energy requirement for drying because of high heat of vaporization, higher equipment operating costs, lower capacity, lower speed, and difficult cleaning requirements.[122] Water-based inks are not available for lithographic printing operations.

Waste Inks - Product Substitution - UV Inks

Ultraviolet (UV) inks are those that dry when exposed to UV light. UV inks contain: monomers, photosynthesizers, and pigments rather than solvents. Because they do not dry in fountains, the need for cleaning is reduced. The advantages of UV inks include:[123]

1. UV inks eliminate "set-off" -- the unintentional transfer of ink from one sheet to the back of the preceding sheet after the sheets have been stacked, which occurs when the ink has not completely dried.

2. UV inks eliminate the need for anti-offset sprays that prevent set-off.

3. UV inks eliminate the need for ventilated storage of sheets when using oxidative drying processes.

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[121]Jacobs Engineering Group, Inc.
[122]Jacobs Engineering Group, Inc.
[123]Jacobs Engineering Group, Inc.

Disadvantages of UV inks include:[124]

1. The cost is 75 to 100 percent higher than conventional heat-set inks.

2. UV light is a hazard to plant personnel.

3. The interaction of UV light and atmospheric oxygen forms ozone.

4. Conventional paper recycling procedures will not deink paper printed by this process. This creates a waste source from an otherwise recyclable material.

5. Some of the chemicals in the inks are toxic.

Waste Inks - Product Substitution - EB Inks

Electron beam (EB) inks are those that are dried by electron beams and are similar to UV inks in operational concept. They have the same advantages as UV inks. However, operator protection from X-rays is necessary and these inks degrade the paper.

Waste Inks - Product Substitution - Heat Reactive Inks (Web Presses)

Heat reactive inks contain a prepolymer, a cross-linking resin, and a catalyst. At 350 °F, the inks are activated to polymerize and set. These inks contain much less solvent than the conventional heat-set inks.

Cleaning Solvents - Good Operating Practices - Pour Cleaning

Whenever possible "pour" cleaning with solvent followed by "wipe" cleaning with a rag could be used to clean presses. The drained solvent must be collected and recycled. Although more solvent is used in this process, less ink ends up on the rags. Cross-contamination of inks must be avoided. The used solvent can be used to clean rollers and blankets, thus reducing the amount of fresh solvent used.

Use of wipe cleaning with rags may be preferable to pour cleaning in some cases because the quantity of solvent wastes is considerably reduced.

Cleaning Solvents - Good Operating Practices

Detergents or soap solutions rather than solvents should be used for general cleaning. Use of solvents should be limited to removing inks and oils.

Cleaning Solvents - Product Substitution - Nonhazardous Formulations

Hazardous materials such as benzene, carbon tetrachloride, TCE, and methanol were previously used as cleaning solvents. Several "blanket washes" containing glycol ethers and other heavy hydrocarbons that are less toxic and flammable are now available. Using nonhazardous blanket washes is recommended for all cleaning requirements in a printing operation.

[124]Jacobs Engineering Group, Inc.

Fountain Solutions - Product Substitution

Conventional fountain solutions contain water, isopropyl alcohol, gum arabic, and phosphoric acid. These compounds are transferred to the printing paper or they evaporate causing volatile organic compounds to be released. Substitute formulations must be used to reduce the emissions.

Waste Paper - Good Operating Practices - Reduce Use

Printing operations generate a large quantity of waste paper. Although paper is not a hazardous waste, reducing paper consumption and thus the purchase of new paper is a good operating practice.

Recycling Onsite/Offsite - Photographic Operations

Spent Fixing Bath Solution - Onsite Recycling - Silver Recovery

Spent fixing bath solutions contain silver that can be recovered. Following recovery, the bath can be reused or discharged to a sewer. Some of the reasons for recovering silver from the solution include:[125] reducing the amount of hazardous silver compounds in wastewaters, extending the useful life of fixing baths, and redeeming the precious metal value of silver.

Electrolytic deposition is the most common method of recovering silver. The electrolytic recovery units have carbon anodes and steel cathodes. Applying a low voltage results in the plating of metallic silver on the cathode. The fixing bath solution, after silver removal, can be mixed with fresh solution and reused in the photographic development process.

A second method of silver recovery is the use of steel wool cartridges to replace silver in an oxidation-reduction reaction. In this process, the spent fixing bath solution is pumped through the steel wool cartridge and iron replaces silver in the solution. Silver sludge settles to the bottom of the cartridge.

A detailed discussion of methods and procedures for silver recovery including: general procedures for hypo collection and recovery, procedures for removing silver from recovery units, recommended recovery procedures for use with automatic film processors, and procedures for using the metallic replacement recovery cartridges are outlined in the Defense Logistics Agency's *Defense Utilization and Disposal Manual.*[126]

Photographic Films - Offsite Recycling - Silver Recovery

Photographic laboratories and many other facilities that use X-ray films generate used photographic films that contain 1 percent (0.15 troy ounces) of silver.[127] These films must be sold to recyclers for silver recovery.

[125] Jacobs Engineering Group, Inc.

[126] *Defense Utilization and Disposal Manual*, DOD 41620.21-M (Defense Logistics Agency, Office of the Assistant Secretary of Defense, Alexandria, VA, September 1982), pp VI-42 and XVII-A-5 through XVII-A-10.

[127] *Defense Utilization and Disposal Manual*.

Recycling Onsite/Offsite - Printing Operations

Metal Etching and Plating Wastewater/Sludge - Onsite/Offsite Recycling - Material Recovery

The wastewater from metal etching and plating operations contains heavy metals and various quantities of process chemicals. Material recovery processes can be implemented to recover some of the process chemicals and thus reduce raw material costs.

Used Metal Wastes - Offsite Recycling

Linotype operations used for letterpress printing generate used metal wastes. The process uses an alloy with a low melting point to create the letters in lines of text. The metal must be melted in the linotype machines and/or recycled. The manufacturer or metal supplier may be willing to buy the used metal and recycle it.

Waste Inks - Onsite Recycling

A simple recycling technique is to blend all the waste inks together to form black ink. It may be necessary to add small amounts of color and toner to obtain an acceptable black color. The reformulated black ink is similar in quality to new newspaper ink. Most newspaper printing presses use recycled black ink.[128]

Waste Inks - Offsite Recycling

Contract recycling of waste inks can be used to produce black ink. This black ink can be used to print newspapers or flyers. In such a contract, waste inks are bottled and shipped to the recycler (or manufacturer) and the reformulated black ink is shipped back. The costs of buying new black inks and disposing of waste inks can thus be reduced.

Cleaning Solvents - Onsite Recycling - Distillation

Small distillation units are available for recycling solvent used in pour cleaning. Proper segregation of solvents and trash is necessary. Still bottoms have to be disposed of as hazardous waste.

Waste Paper - Offsite Recycling

Waste paper must be collected and recycled. Manufacturers or paper recyclers remove the ink and repulp the paper. Pulp from recycled paper adds strength and durability to many other paper products.

Treatment - Printing Operations

Wastewater from metal etching and plating operations is classified as hazardous and must be treated before discharge to a municipal sewer. If not treated, it must be put in drums and disposed of as hazardous waste. Packaged treatment units that neutralize and precipitate the heavy metals are available. The sludge generated from treatment is also a hazardous waste and is banned from land disposal.

[128] C. Woodhouse, *Waste Ink Reclamation Project* (California Department of Health Services, Toxic Substances Control Division, August 1984).

Table 43

Typical PPAS Operations With Materials Used and Wastes Generated*

Process/ Operation	Materials Used	Ingredients on Labels	Wastes Generated
Apply light sensitive coating	resins, binders, emulsion, photosensitizers, gelatin, photoinitiators	PVA/ammonium dichromate, polyvinyl cinnamate, fish glue/albumin, silver halide/gelatin emulsion, gum arabic/ammonium dichromate	photographic waste
Develop plates	developer	lactic acid, zinc chloride, magnesium chloride	photographic waste
Wash/clean plates	alcohols, solvents	ethyl alcohol, isopropyl alcohol, methyl ethyl ketone, trichloroethylene, perchloroethylene	spent solvents
Apply lacquer	resins, solvents, vinyl lacquer	PVC, PVA, maleic acid, methyl ethyl ketone	spent solvents
Counter-etch to remove oxide	phosphoric acid	phosphoric acid	acid/alkaline wastes
Deep-etch coating of plates	deep etch bath	ammonium dichromate, ammonium hydroxide	acid/alkaline waste, heavy metal solutions, waste etch bath
Etch baths	etch bath for plates	ferric chloride (copper), aluminum chloride/zinc chloride/hydrochloric acid (chromium), nitric acid (zinc, magnesium)	waste etch bath, acid/alkaline waste, heavy metal solutions
Printing (Ink)	pigments, dyes, varnish, drier, extender, modifier	titanium oxide, iron blues, molybdated chrome orange, phthalocyanine pigments, oils, hydrocarbon solvents, waxes, cobalt/zinc, magneze oleates, plasticizers	waste ink with solvents/heavy metal, ink sludge with chromium/lead
Making gravure cylinders	acid plating bath	copper hydrochloric acid	spent plating waste

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), pp 146-147.

Table 44

Waste Classification for PPAS

Process Description		Waste Description			
Process/ operation	**Materials used/ wastes produced**	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Photographic processing	Carbon tetrachloride	F001	Waste carbon tetrachloride	ORM-A	UN1846
	Waste solutions with heavy metals (Cd, Cr, Pb, etc.)	Varies	Hazardous waste solution, NOS	ORM-E	NA9189
Washing, cleaning plates; press cleanup	Ethyl alcohol	D001	Waste ethyl alcohol	Flammable liquid	UN1170
	Isopropyl alcohol	D001	Waste isopropyl alcohol	Flammable liquid	UN1219
	Methylethylketone	F005	Waste methylethylketone	Flammable liquid	UN1193
	Naptha	D001	Waste naptha	Flammable liquid	UN2553
	Perchloroethylene	F002	Waste perchloroethylene	ORM-A	UN1897
	Petroleum distillates	D001	Waste petroleum distillates	Flammable liquid	UN1268
	Press wash	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
	Xylene	D001	Waste xylene	Flammable liquid	UN1307
Etching, plating	Ammonium hydroxide	D002	Waste ammonium hydroxide	Corrosive material	NA2672
	Hydrochloric acid (Cr)	D002	Waste hydrochloric acid	Corrosive material	NA1789
	Nitric acid (Zn, Mg)	D002	Waste nitric acid	Corrosive material	NA1760
	Phosphoric acid	D002	Waste phosphoric acid	Corrosive material	UN1805
Printing	Waste ink (containing various solvents and heavy metals)	D002	Waste ink	Combustible liquid Flammable liquid	UN2867 UN1210
	Ink sludge (heavy metals - Cr or Pb)	D002	Hazardous waste liquid, NOS Hazardous waste solid, NOS	ORM-E ORM-E	NA9189 NA9189

9 WASTE MINIMIZATION FOR HOSPITALS, CLINICS, AND LABORATORIES

Army hospitals, veterinary clinics, dental clinics, and other laboratories are usually tenants located on an installation. The types of wastes generated by these activities can be divided into infectious wastes (IW), pathological wastes (PW), sharps, pharmaceutical wastes (PhW), radioactive wastes (RW), laboratory wastes (LW), chemotherapy wastes (CW), infectious linen (IL), and general wastes (GW). Only the LW and CW are hazardous wastes by the RCRA and HSWA definition.

For this discussion, some of the definitions for hospital wastes are extracted from Army Regulation (AR) 40-5.[129] Detailed definitions and classifications of infectious wastes can be obtained from USEPA's *Guide to Infectious Waste Management*.[130]

IW is from patients in strict or respiratory isolation, or with wound and skin precautions; wastes from microbiological laboratories; and surgical waste (at the discretion of the operating room supervisor). PW includes anatomical parts, excluding human corpses and animal carcasses. Sharps include discarded hypodermic needles, syringes, pipettes, broken glass, and scalpel blades that pose infection and physical injury hazards through cuts or puncture wounds. GW is all the waste not classified as infectious, pathological, or hazardous, for example: refuse generated from general patient units, emergency rooms, dental areas, surgical suites, administrative areas, and supply areas. PhW consists primarily of outdated medicines (drugs, vaccines, and physiological solutions). RW wastes emit ionizing radiation (such as alpha, beta, gamma, or X-rays).

The activities that generate most of the highly infectious wastes are: general surgery/recovery, vascular surgery, plastic surgery, pathology, blood bank, microbiology laboratory, labor and delivery rooms, obstetrics, emergency room isolation, and the morgue. Among the wastes generated are: (1) significant laboratory waste, including all tissue or blood elements, excreta, and secretions obtained from patients or laboratory animals and disposable fomites (items that may harbor or transmit pathogenic organisms); (2) surgical specimens and attendant disposable fomites; (3) disposable materials from outpatient areas and emergency departments; (4) equipment, instruments, utensils, and fomites of a disposable nature from isolation rooms; (5) animal feces, animal bedding, supplies, and fomites resulting from and/or exposed to infectious animal care and laboratory procedures; and (6) all disposable needles and syringes.[131]

Radioactive wastes are usually generated by the radiology ward, nuclear medicine, clinical pathology, and laboratories that use radionuclides. Some of the radionuclides administered to patients during treatment include: $^{99\text{-}M}$Technetium, ^{51}Chromium, ^{32}Phosphorus, and ^{131}Iodine.[132] Most of the radioactive wastes that require special handling and disposal are generated by the use of radionuclides such as ^{14}Carbon, ^{4}Hydrogen, and ^{131}Iodine, in clinical laboratories.

A number of different types of hazardous wastes are generated in HCL, although in small quantities. Table 45 lists processes and operations that generate wastes, and the corresponding DOT classifications. LW is mostly chemical wastes, including ignitable/chlorinated solvents and miscellaneous used chemicals (e.g., xylene, formalin, mercury, etc.) generated in analytical and clinical laboratories. These wastes may also be generated in maintenance, pharmacy, and nursing areas. Photographic films and chemicals are used in radiology. Other toxics and corrosives are used throughout the hospitals.

[129] Army Regulation (AR) 40-5, *Preventive Medicine* (HQDA, 30 August 1986).
[130] *Guide to Infectious Waste Management*, EPA/530-SW-86-014 (USEPA, Washington, D.C., 1986).
[131] D. Kraybill, T. Mullen, and B.A. Donahue, *Hazardous Waste Surveys of Two Army Installations and an Army Hospital*, Technical Report N-90/ADA088260 (USACERL, August 1980), pp 46-48.
[132] D. Kraybill, T. Mullen, and B.A. Donahue.

CW is a large quantity HW generated by the use of antineoplastic, or cytotoxic agents in chemotherapy solutions administered to patients. The chemicals themselves are only a small volume of the waste; most of it consists of protective clothing and gauze pads that are lightly contaminated.

Most of the guidance on proper management and minimization of wastes discussed in this chapter has been obtained from *Protocol Health Care Facility Waste Management Surveys*,[133] and *Waste Audit Study - General Medical and Surgical Hospitals*.[134] The minimization of photographic wastes is discussed in Chapter 8.

Regulations

On October 21, 1988, the U.S. Congress passed the Medical Waste Sanctions Act (MWSA) which requires strict control on generation and disposal of medical wastes, and prohibits anyone from dumping the wastes in oceans and large water bodies (such as the Great Lakes).[135] MWSA was initiated as an amendment to the original Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972. MPRSA and MWSA define "medical waste" to include "isolation wastes; infectious agents; human blood and blood products; pathological wastes; sharps; body parts; contaminated bedding; surgical wastes and potentially contaminated laboratory wastes; dialysis wastes; and other equipment and material that the Administrator of the USEPA determines may pose a risk to public health, welfare, or the marine or Great Lakes environment." Of the 160 million tons of waste generated in the United States each year, 3.2 million tons of them are medical wastes from hospitals.[136] These medical wastes do not include refuse from doctors' offices, laboratories, home health care, veterinary clinics, and blood banks. Of the 3.2 million tons of medical wastes, USEPA estimates that 10 to 15 percent are infectious.

MWSA was passed because medical wastes could be regulated under the RCRA and HSWA but are not under the USEPA rules. MWSA requires USEPA to develop rules and regulations for a cradle-to-grave manifest system to track the medical wastes from generation to disposal, and for record-keeping, reporting, and proper segregation (from ordinary refuse) and disposal requirements. The States have been given the authority to enforce MSWA more stringently than the USEPA requirements. Therefore, States such as Delaware, Louisiana, Maryland, Minnesota, New York, and Pennsylvania, have passed stricter laws for tracking and disposing of medical wastes.

In the private sector, research and testing laboratories such as those located in Army hospitals and associated research facilities would be regulated as small quantity generators of hazardous laboratory waste. All the rules of RCRA and HSWA would apply and cradle-to-grave management and development of minimization strategies would be necessary.

Source Reduction - All Wastes

IW/PW/GW/Sharps - Better Operating Practices - Segregation

IW and PW must be segregated from GW and sharps. GW such as surgical glove wrappers should not be placed in IW containers (e.g., red bags in rigid containers). Sharps must be placed in

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[133] *Protocol Health Care Facility Waste Management Surveys* (USAEHA, 1987).

[134] Ecology and Environment, Inc., *Waste Audit Study - General Medical and Surgical Hospitals* (California Department of Health Services, Sacramento, CA, 1988).

[135] *Medical Waste Sanctions Act of 1988*, Report 100-1102 (House of Representatives, 100th Congress, October 1988).

[136] *Medical Waste Sanctions Act of 1988*.

separate containers (e.g., rigid plastic boxes) in every room where they are used. Separate containers (e.g., yellow or white bags) must be used for general wastes including paper and trash.

Source Reduction - Infectious and Pathological Wastes

IW/PW - Better Operating Practices - Segregation/Labeling

All the containers must be rigid and must be lined with impervious, tear resistant, and distinctively colored bags (e.g., red bags for infectious wastes only). The same type and color bags must be used at all waste generation points and marked/labeled with the universal biohazard symbol. Standardized procedures (labeling, color, etc.) reduce confusion among personnel and improve waste management, thus, minimizing quantities of wastes generated.

IW/PW - Better Operating Practices - Collection/Transportation

IW/PW must be collected frequently from all the generation points by trained personnel only. The transport containers must have tight-fitting lids and should be used exclusively for IW/PW. The interior of the transport containers must be cleaned and disinfected regularly.

IW/PW - Better Operating Practices - Storage

All IW/PW storage areas (including access doors, containers, freezers, refrigerators, etc.) must be labeled and marked with the universal biohazard symbol.

Treatment - Infectious and Pathological Wastes

IW/PW - Treatment/Better Operating Practices - Incineration

Incineration is one of the options used to treat infectious wastes. The manufacturer's operating instructions and standard operating procedures must be posted on the incinerator. A State or local air quality permit must be obtained and the incinerator must be operated in compliance by following the manufacturer's recommended temperature to reduce emissions and opacity problems.

The incinerator ash could be a hazardous waste. It should be tested annually for hazardous characteristics. Testing of incinerator ash at Army installations[137] has revealed that it is Extraction Procedure (EP) toxic for heavy metals.

The red bags used to contain IW/PW burned in incinerators are made of chlorinated plastics (PVC). Burning these red bag wastes generates a number of air pollutants of concern including: hydrochloric acid, dioxins, furans, and particles. These toxic stack emissions are a significant hazard to the community. As public concern increases (and regulations change) proper flue-gas cleanup will be required. Some of the air emission control devices that could be installed include: dry impingement separators, dry cyclonic separators, venturi scrubbers, electrostatic precipitators, fabric filters, wet acid gas scrubbing devices, and dry scrubbing systems.

[137]*Protocol Health Care Facility Waste Management Surveys.*

IW/PW - Treatment/Better Operating Practices - Autoclaves/Retorts

Autoclaves or retorts are used in several hospitals to disinfect IW/PW before landfill disposal. All the operators should be trained in proper equipment use. The bags used in autoclaves should allow sufficient steam penetration and yet contain the wastes. Compaction of wastes must always follow the autoclaving process. Spore strips should be used to check the effectiveness of the operation.

Source Reduction - Sharps

Clipping needles after use is prohibited by AR 40-5 to prevent generation of pathogen-containing aerosols. Used syringes must be placed only in rigid impervious containers marked with the universal biohazard symbol. Adequate containers must be provided and managed by trained personnel.

Source Reduction - Hazardous Wastes

HW - Better Operating Practices - Inventory

A current and comprehensive inventory must be developed for all the hazardous materials used and hazardous wastes generated. The inventory must contain the following for each HW: a description; hazard code; USEPA (or State) number; physical form; rate of generation; method of treatment, storage, and disposal; and an indication if the waste is infectious. All HW on the inventory must be reviewed annually and reported to the installation environmental office.

Infectious hazardous wastes could be generated at the histology (waste xylene), parasitology (hazardous fluids), and radiology (waste barium) laboratories. A proper inventory must be developed for these wastes. The procedures for handling these wastes are outlined in *Infectious Hazardous Waste Handling and Disposal.*[138]

HW - Better Operating Practices - Proper Storage

Proper containers must be used to store hazardous wastes; they must be properly labeled. They must contain liners compatible with the wastes. Upon exceeding the 55-gal (or 1 qt for acute HW) storage limit in the satellite accumulation areas, the 90-day temporary storage requirements[139] have to be complied with and the wastes must be turned in to the installation's hazardous wastes storage building.

HW (solvents) - Better Operating Practices - Segregation

Solvent wastes must be segregated according to the recycling or treatment processes used for their recovery or disposal. Some of the criteria useful for segregation are:[140] flash point, Btu value, viscosity, halogen content (e.g., chlorine), and water content. Segregating wastes as individual chemicals (with minimal contamination) simplifies waste management.

HW (solvents) - Product Substitution

Nonhalogenated solvents must be substituted for halogenated solvents (e.g., TCE, 1,1,1-trichloroethane, MC, etc.). Simple alcohols and ketones are good substitutes for petroleum

[138]*Infectious Hazardous Waste Handling and Disposal*, Technical Guide Number 147 (USAEHA, 1986).
[139]40 CFR 262.34, *Onsite Accumulation Requirements*.
[140]Ecology and Environment, Inc., pp 5-1 -- 5-3.

hydrocarbons (e.g., toluene, xylene, etc.). Aqueous reagents must be used whenever possible. The feasible substitutions have to be determined by laboratory managers on a case-by-case basis.

Xylene is commonly used as a tissue clearing agent at hospitals. Use of a nonhazardous substitute (such as Histoclear™) must be examined to determine its effectiveness.

HW (solvents) - Process Change

Cleaning processes that use alcohol-based disinfectants must be modified to use ultrasonic or steam cleaning methods. Premixed containerized test kits must be used for solvent fixation (making slides). Calibrated solvent dispensers must be used for routine tests. Minimizing the sizes of cultures or specimens in the pathology, histology, and other laboratories, minimizes the quantities of solvent wastes produced.

Modifying laboratory methodologies to use modern technologies (e.g., monoclonal antibodies, radioisotope labeled immunoassays, and ultrasensitive analytical devices) minimizes or even eliminates the need for extractions and fixation with solvents. Sensitive analytical equipment can reduce analyte volume requirements.

LW - Better Operating Practices - Disposal

All the laboratory hazardous wastes that may be discharged into the sanitary sewer must be identified. Approval must also be obtained from local authorities. According to USEPA requirements [40 CFR 261.3(a)(2)(iv)(E)] the following conditions must be met:

1. Only low toxic hazard, and biodegradable wastes may be discharged,

2. The annualized average flow rate of laboratory wastewater must not exceed 1 percent of the total wastewater flow into the inflow of the wastewater treatment plant,

3. The combined annualized average concentration must not exceed one part per million (ppm) of the inflow to the wastewater treatment plant.

Proper standard operating procedures must be developed and used for disposal of chemicals in the sanitary sewer system.[141] Disposal actions must be coordinated with the installation's environmental office. Sewer disposal is an environmentally unsound practice and must be avoided. However, controlled disposal is allowed by law.

HW (mercury) - Better Operating Practices

Waste mercury can be recycled and must be recovered from spills and from crevices of broken devices. All the residual mercury contained in broken thermometers, blood pressure reservoirs, or other devices should be drained. However, proper spill cleanup and handling operations have to be designed to protect the employees. Special mercury vacuums and spill absorbing kits are available.

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[141] National Research Council, *Prudent Practices for Disposal of Chemicals from Laboratories* (National Academy Press, Washington, DC, 1983).

HW (mercury) - Process Change

Many hospitals in the United States are using electronic piezometric sensing devices instead of mercury-based thermometers and blood pressure instruments. Such a substitution eliminates both the hazards and cleanup costs associated with broken glass and spilled mercury.

HW (formaldehyde) - Better Operating Practices

Reducing both the cleaning frequency of hemodialysis and reverse osmosis (RO) water supply equipment and the solution strength will minimize the quantities of waste formaldehyde generated. The membranes used in RO units have to occasionally be flushed with formalin. A laboratory standard for formalin solutions should be developed based on microbial culture studies that compare microbial residue with variations in strength, cleaning frequency, and water supply systems.[142]

HW (formaldehyde) - Process Change

The dialysis equipment used in the hospital can be used to capture and concentrate waste formalin (containing 4 percent formaldehyde, 1 percent methanol, and 95 percent water).[143] Formaldehyde extracted and concentrated with the used dialysis membranes can then be sent for proper disposal (e.g., incineration) thus minimizing the waste and associated costs.

CW - Better Operating Practices - Collection/Disposal

Special dedicated containers must be used to collect antineoplastics, cytotoxins (cancer treatment agents), and other controlled drugs. Many of these drugs are listed hazardous wastes and must be managed using proper turn-in procedures.

CW - Better Operating Practices

Segregation of CW from other wastes is an effective minimization practice. Personnel must be properly trained and separate containers (with distinct labels) must be placed in all the drug handling areas.

The cleaning frequency for hoods used for compounding drugs should be reduced. According to OSHA recommendations, hoods should be wiped down daily with 70 percent alcohol and decontaminated weekly with an alkaline solution.[144] However, the actual cleaning frequency must be determined based on the use and amount of spillage in the hood.

Spill cleanup kits, for small and large spills, must be readily available in the drug compounding and use areas. The garments, except gloves, worn by employees should be disposed of with non-hazardous refuse if no spills occurred.

The location of compounding and administration areas should be centralized to minimize spillage and exposure hazards. Drug purchases must be controlled such that only the appropriate container sizes are procured and no residue is left for disposal. Outdated drugs should be returned to the manufacturer.

[142]Ecology and Environment, Inc.
[143]Ecology and Environment, Inc.
[144]Ecology and Environment, Inc.

CW - Product Substitution

Antineoplastics and cytotoxic agents are highly toxic and environmentally persistent. They must be substituted with biodegradable drugs. In some cases, the shelf life can be used as an indicator of environmental persistence. Doctors and pharmacists must be encouraged to choose less environmentally hazardous drugs of equal effectiveness.

RW - Product Substitution

A knowledge of the properties of radionuclides is required for the minimization of RW. A stable radionuclide with a short half-life, low energy, nontoxic decay product, and minimal extraneous radiation emissions must be chosen. Extraneous radiation is the radiation generated that is not required in a test or procedure. If a beta emitter is required, a radionuclide with minimal gamma emissions must be chosen. Containment of gamma rays is difficult.

A radiation safety committee should be established to advise researchers about alternative isotopes that are less environmentally hazardous than those currently in use.

RW (^{226}Radium) - Product Substitution

^{226}Radium is the most hazardous radionuclide used for cancer treatment in hospitals. It has a very long half-life and its decay products are unstable. ^{192}Iridium or ^{137}Cesium needles have been found to be good substitutes for ^{226}Radium needles.[145]

Recycling Onsite/Offsite - Hazardous Wastes

HW (xylene, other solvents) - Recycle Onsite - Distillation

All the spent solvents generated in the laboratories must be accumulated in proper segregated containers. The recyclability of solvents is greater if contamination is minimal. Small distillation stills can be used to recover solvents for reuse.

Table 35 lists manufacturers of industrial distillation equipment. For laboratories, stills made of glassware (process-spinning band distillation[146]) may be more suitable. Appropriate manufacturers (e.g., B/R Instrument Corporation, P.O. Box 7, Pasadena, MD 21122; (301) 647-2894) must be contacted for information on technical feasibility and costs.

Xylene wastes generated at the hospitals are contaminated with paraffin and tissue samples, and their recyclability depends on the content of the contaminants. Small stills can be used to distill out pure xylene for reuse. The still bottoms must be properly disposed of as HW. The still can be used to recycle other solvents (e.g., ethanol).

HW (solvents) - Offsite Recycling

A number of commercial recyclers process solvents for reuse. Table 31 lists some of them.

[145] Ecology and Environment, Inc.

[146] L.M. Gibbs, "Recovery of Waste Organic Solvents in a Health Care Institution," *American Clinical Products Review* (November/December 1983).

HW (mercury) - Offsite Recycling

If more than 10 lb of liquid mercury is accumulated, it can be sold to a commercial reprocessor.[147] Large quantities can be sent in standard (76-lb) flasks supplied by the reprocessor. These reprocessors are willing to purchase from institutions rather than individuals. Therefore, DRMO must pursue this option for Army installation generators such as hospitals, laboratories, etc.

HW (formaldehyde) - Onsite Recycling - Reuse

Direct reuse of formaldehyde solutions in autopsy and pathology laboratories is possible, depending on the type of specimen. Reuse is possible because the specimen holding times are short and formalin solutions retain their properties for a long time. Additionally, the desired preservative properties may be more effective at lower concentrations than the 10 percent formaldehyde solutions commonly used in pathology laboratories.[148] Minimum effective strength of formalin solutions should be determined based on microbial culture studies.

HW (photographic chemicals) - Recycle Onsite/Offsite - Silver Recovery

Silver recovery methods such as those described in Chapter 7 must be used.

Treatment - Hazardous Wastes

HW (solvents) - Onsite Treatment - Incineration

If recovery by distillation is not a feasible option, onsite incineration should be considered. A permit is needed to operate an incinerator to burn solvents. Therefore, onsite incineration may not be a practical option for most Army hospitals. However, with the increase in offsite incineration costs and the ban on land disposal of liquid wastes and long-term liabilities, onsite incineration may become a feasible treatment method in the future.

Waste designated for incineration must have a high Btu content, a high flash point, low specific gravity, and a low solids content. The incinerator must be designed to achieve complete destruction while generating negligible quantities of air pollutants. Both technical and institutional problems have to be addressed before acquiring an incinerator to burn small amounts of a wide variety of chemical wastes.[149]

HW (solvents) - Offsite Treatment - Incineration

Use of offsite facilities to incinerate solvent wastes may be a feasible option for most laboratories. Commercial incineration facilities require generators to segregate wastes and arrange for transportation.

LW (acids/alkalis) - Treatment - Neutralization

Elementary neutralization of corrosive liquids is exempt from treatment permit requirements. Acids ($pH < 2$) and alkalis ($pH > 12.5$) must be neutralized before they are allowed to flow into the drain.

[147]National Research Council, pp 44-55.
[148]National Research Council, Chapter 4.
[149]National Research Council, Chapter 9, pp 111-125.

Table 45

Waste Classification for HCL

Process Description		Waste Description			
Typical process/ operation	**Materials used/ wastes produced**	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Analytical/clinical laboratories, Pathology, Histology, Embalming, Sterile processing, Facilities maintenance, Laundry	Nonhalogenated solvents:	F003	Waste acetone	Flammable liquid	UN1090
	Acetone	D001	Waste acetonitrile	Flammable liquid	UN1648
	Acetonitrile	F003	Waste ethyl alcohol	Flammable liquid	UN1170
	Ethanol	F003	Waste ethyl acetate	Flammable liquid	UN1173
	Ethyl acetate	D001	Waste isopropyl acohol	Flammable liquid	UN1219
	Isopropanol	F003	Waste methanol	Flammable liquid	UN1230
	Methanol	F005	Waste toluene	Flammable liquid	UN1294
	Toluene	F003	Waste xylene	Flammable liquid	UN1307
	Xylene				
	Halogenated solvents:		Waste chloroform	ORM-A	UN1888
	Chloroform	F001	Hazardous waste liquid, NOS	ORM-A	UN9189
	Freon	F001	Waste methylene chloride	ORM-A	UN1593
	Methylene chloride	F001	Waste 1,1,1-trichloroethane	ORM-A	UN2831
	1,1,1-trichloroethane	F001	Waste trichloroethylene	ORM-A	UN1710
	Trichloroethylene				
	Acids/bases:	D002	Waste acetic acid (solution)	Corrosive material	UN2790
	Acetic acid	D002	Waste hydrochloric acid	Corrosive material	UN1789
	Hydrochloric acid	D002	Waste nitric acid, > 40%	Oxidizer	UN2031
	Nitric acid	D002	Waste Nitric Acid, ≤ 40%	Corrosive material	NA1760
		D002	Waste sulfuric acid	Corrosive material	UN1830
	Sulfuric acid	D002	Waste sulfuric acid, spent	Corrosive material	NA1831
		D002	Waste ammonium hydroxide, < 12%	ORM-A	NA2672
	Ammonium hydroxide	D002	Waste ammonium hydroxide, ≥ 12% < 44%	Corrosive material	NA2672
		D002	Waste potassium hydroxide, solid	Corrosive material	UN1813
	Potassium hydroxide	D002	Waste potassium hydroxide, liquid	Corrosive material	UN1814
		D002	Waste sodium hydroxide, solid	Corrosive material	UN1823
	Sodium hydroxide	D002	Waste sodium hydroxide, liquid	Corrosive material	UN1824
	Others:	D009	Waste mercury	ORM-A	UN2809
	Mercury		Waste oxidizer, NOS	Oxidizer	UN1479
	Oxidizers		Waste oxidizer, corrosive, liquid, NOS	Oxidizer	NA9193
			Waste oxidizer, corrosive, solid, NOS	Oxidizer	NA9194
	Poisons		Waste poison B, liquid, NOS	Poison B	UN2810
			Waste poison B, solid, NOS	Poison B	UN2811
			Waste corrosive liquid, poisonous, NOS	Corrosive material	UN2922
	Poisonous, oxidizers		Waste poisonous solid, corrosive, NOS	Poison B	UN2928
	Nonspecific hazardous Wastes		Waste oxidizer, poisonous, liquid, NOS	Oxidizer	NA9199
			Waste oxidizer, poisonous, solid, NOS	Oxidizer	NA9200
			Hazardous waste liquid, NOS	ORM-E	NA9189
				ORM-E	NA9189

Table 45 (Cont'd)

Process Description		Waste Description			
Typical process/ operation	**Materials used/ wastes produced**	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Chemotherapy, pharmacy, clinics	Antineoplastics Cytotoxic drugs		Hazardous waste solid, NOS		UN2209 UN1198
Radiology	Photographic chemicals: Fixer Developer			ORM-A ORM-A	
Hemodialysis, Pathology, Autopsy, Embalming, Nursing	Formaldehyde		Waste formaldehyde solution, flash point > 141 °F Waste formaldehyde solution, flash point ≤ 141 °F		
Clinical Testing	Radioisotopes				

10 WASTE MINIMIZATION FOR OTHER SOURCE TYPES

Heating and Cooling Plants

Army installations have a number of heating and cooling plants that generate power and steam. Hazardous wastes are generated by using various combustible (e.g., cyclohexylamine) and corrosive (e.g., caustic soda, caustic potash, hydrochloric acid) chemicals to adjust pH, prevent scaling or corrosion, clean the interior of the boiler, and to test feedwater. In addition, boiler blowdown liquid mixed with water is a hazardous waste generated periodically. Waste oil blended with virgin fuel oil is burned in boilers at some installations. The waste oil may be a hazardous waste, depending on the content, and should be burned only in permitted facilities.

A number of efficiency related boiler maintenance procedures can be used to minimize environmental pollution, while correcting malfunctions in boiler operation and preventing performance degradation. Component malfunction or performance degradation can cause increases in: stack gas temperature; excess air requirements; carbon monoxide, smoke, or unburned carbon in ash; convection or radiation losses from the boiler exterior, ductwork, and piping; blowdown above that required to maintain permissible water concentrations; and auxiliary power consumption by fans, pumps, or pulverizers. In addition to the normal maintenance recommended by manufacturers, efficiency-related maintenance procedures must be performed to extend equipment life and for personnel safety. These procedures include:[150] efficiency spotchecks of combustion conditions, establishing best achievable performance goals, monitoring performance (boiler log) to document deviations, periodic equipment inspection, and troubleshooting. Boiler tuneups also improve efficiency and fuel conservation.

Some modifications to the boiler operating practices improve boiler efficiency, save fuel, and reduce continuous blowdowns. These practices include: reducing boiler steam pressures, controlling the water quality by continuous blowdowns instead of infrequent blowdowns, and proper load management. Efficient boiler operation also minimizes the amounts of air pollutants (particulates, carbon monoxide, nitrogen oxides, sulfur dioxide, hydrocarbons, and oxidants) released to the atmosphere.

Inventory management of chemicals and reducing their use in water treatment and scale removal minimizes the amounts of wastes produced. Nonhazardous substitutes must be developed and used instead of the combustible and corrosive chemicals normally found at heating and cooling plants.

Used Oil Burning

Used lubricating oil generated by vehicle maintenance activities can be recycled as a fuel and blended and burned in boilers. Before burning, however, it is necessary to determine if the oil meets fuel specifications (Table 46). Used oil that meets the specifications can be burned in any burner

[150] *Efficient Boiler Operations Sourcebook*, F.W. Payne, Ed. (The Fairmont Press, Inc., Atlanta, GA, 1986), pp 79-106.

(space heater, nonindustrial boiler, industrial boiler, utility boilers, and industrial furnaces),[151] whereas other waste oils can only be burned in high-efficiency industrial boilers, industrial process furnaces, or boilers that have demonstrated compliance with performance standards set for hazardous waste incinerators. Nonspecification used oils can be blended with virgin oil to meet specifications and burned in an industrial or nonindustrial boiler.

It is necessary to test the used oil for halogen and heavy metal content before burning. Other treatment techniques such as filtration, oil-water separation, etc. (discussed in Chapter 5), must be used to improve the quality of the oil and its heating value.

Laundry and Drycleaning Facilities

Laundry and drycleaning facilities on a Army installation are the responsibility of the DOL. Caustic soda and other corrosive chemicals are used in the laundry. Perchloroethylene (PERC) is the most common drycleaning solvent used. The two other solvents used are Valclene™ (fluorocarbon 113 or tetrachloroethylene), and petroleum solvent (Stoddard). Use of solvents and corrosive chemicals in these processes results in the generation of contaminated wastewater and dry wastes (Table 47). Table 48 lists the wastes generated and the corresponding DOT classifications.

PERC drycleaning plants generate: (1) still residues from solvent distillation (entire weight), (2) spent filter cartridges (total weight of cartridge and solvent remaining after draining), and (3) cooked filter residue (the total weight of drained powder residue from diatomaceous or other powder filter systems after heating to remove excess solvent). Valclene plants generate still residues and spent filter cartridges. Petroleum solvent plants generate still residues only. Proper disposal is required for all the hazardous wastes generated at laundry and drycleaning facilities. Among the acceptable options are recycling, incineration, or disposal in an authorized hazardous waste landfill. However, source reduction by material substitution seems to be the most effective minimization technique for drycleaning operations. The possibility of replacing PERC or Valclene with Stoddard (PD680-II) or petroleum naphtha must be explored. As is obvious from Table 47, using Stoddard produces the smallest amount of hazardous waste. If the petroleum solvent has a flash point greater than 140 °F, the wastes are not considered hazardous and are exempt from reporting requirements. Drycleaning plants generally have stills for continuous distillation of solvents, which are constantly recycled. However, the still bottoms must be disposed of properly.

Woodworking and Preserving

Table 49 lists the woodworking and preserving operations and corresponding waste classifications. Some of the wastes are generated by carpentry shops that manufacture or refinish wooden cabinets, softwood and hardwood veneer and plywood, household or office furniture, and other furniture (including reupholstery and repair). Typical wood preserving operations used to condition wood

[151] Industrial boilers are defined as utility or power boilers used to supply heated or cooled air or steam for a manufacturing process, and are usually rated at greater than 25 x 10^6 Btu/hour. In addition to being located at a manufacturing facility, it must be a device using controlled flame combustion and have the following characteristics: (1) a combustion chamber and primary energy recovery section of integral design, (2) thermal energy recovery efficiency of at least 60 percent, and (3) at least 75 percent of recovered energy must be exported.
Utility boilers are boilers not located at a manufacturing facility and have the above listed characteristics. They must be used to generate electric power, steam, heated or cooled air, or other gases or fluids for sale.
Nonindustrial boilers are those that do not fall in the above two categories. They are subject to prohibition.

include: steaming, boultonizing, kiln or air drying (under pressure or vacuum), and applying agents such as creasote, pentachlorophenol (PCP), and other arsenical compounds.

Inventory control and management is an effective technique for minimizing hazardous wastes associated with woodworking and preserving. Proper disposal practices must also be used.

Pesticide Users

Army installations have a number of pesticide users including the entomology shop (pest control services), the garden shop (lawn, garden, and tree services), and the golf courses. Table 50 lists a variety of pesticides used and their waste classifications. Use of pesticides in activities ranging from protecting food and structures to pest and disease control, results in generation of hazardous rinsewater, empty containers with pesticide residue, unused pesticides, and possibly contaminated soil.

Very dilute rinsewaters or soil contaminated with very low concentrations may not be hazardous. However, chemical analysis is necessary to verify the concentrations. Pesticide containers are not a hazardous waste if they are triple rinsed. The rinsewater, however, is a hazardous waste. Some pesticides that contain flammable solvents or ignitable material are also hazardous wastes when discarded. A number of pesticides exhibit acute toxicity characteristics. Therefore, all the discarded and off-specification products, containers, and spill residues containing acute toxic species are listed as "P" hazardous wastes [40 CFR 261.33(e)]. All the hazardous material/wastes related to pesticides must be managed carefully to prevent environmental problems and to protect the health and safety of personnel.

The amounts of pesticide rinsewaters generated can be minimized by using multiple rinse tanks, installing drain boards and drip tanks, and recycling and reusing the water for rinsing.[152] Treatment methods include destruction with chlorine or lime, incineration, and carbon adsorption.[153] Minimization of empty containers and contaminated soil wastes is discussed in Chapter 11.

Open Burning/Open Detonation

Open burning/open detonation (OB/OD) is one option used to demilitarize ordnance containing propellants, explosives, and pyrotechnics (PEP). Other methods are washout/steamout/meltout and deactivation in a furnace. Ingredients of some common explosive compounds are listed in Table 51. OB/OD is the simplest and has been the primary method of demilitarization used at Army installations.[154] Active and inactive sites of OB/OD are commonly found. The environmental contaminants generated from OB/OD activity include gases and particles (carbon, soot, etc.) released into the atmosphere and as residues in soils. The soil residues are comprised mainly of undetonated PEP materials and combustion/detonation products. Table 52 lists the elements found in soils, including some that are regulated under RCRA and HSWA. Soils at all the active and inactive sites must be analyzed to determine the chemical content and proper disposal.

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[152] Ventura County Environmental Health, *Hazardous Waste Reduction Guidelines for Environmental Health Programs* (California Department of Health Services, Sacramento, CA, 1987).

[153] *Standard Handbook of Hazardous Waste Treatment and Disposal*, H.M. Freeman, Ed. (McGraw Hill, New York, NY, 1989).

[154] D.W. Layton, et al., *Demilitarization of Conventional Ordnance: Priorities of Data-Base Assessments of Environmental Contaminants*, UCRL-15902 (U.S. Army Medical Research and Development Command [USAMRDC], Fort Detrick, MD, 1986).

Some of the materials in the demilitarization inventories at installations may have a recovery value in excess of the cost of the original item because of the increase in material and manufacturing costs.[155] Recovery and reuse of such materials before burning will reduce raw material costs and production requirements, and, thereby, minimize wastes generated. A number of processes (e.g., resolvation of ground propellants, selective solvent extraction, disposal of scrap propellant, solution-pelletization, etc.) are available for recovery and reuse of propellants or their ingredients. Processing propellants by such reclamation techniques[156] minimizes environmental discharges, conserves strategic materials, and provides cost savings.

Under USEPA and State regulations, OB/OD is considered a treatment technique for hazardous wastes (ordnance). Therefore, installations are required to obtain a Part B permit. The generation of contaminated soil residues from OB/OD activity can be minimized by conducting the activity on steel "burn-pans" instead of on open ground. Incineration must also be explored as a possible minimization alternative. Controlled incineration allows for better control of air pollutants. However, proper disposal is required for residues generated in any of the operations.

Firefighting and Training

Aqueous film forming foam (AFFF) is considered a hazardous material in a number of states. Firefighting operations that use AFFF must be replaced with nonhazardous substitutes. All other wastes generated by maintenance of fire trucks and other equipment can be minimized by methods discussed in Chapters 5 and 6.

Another waste generated from fire training activities is contaminated soils in the training pits. Typically, contaminated fuel (e.g., JP-4, gasoline) is used to generate a fire in the pits for training exercises. The soil from the pits must be analyzed for chemical contaminants and properly disposed of.

Underground Storage Tanks (USTs)

Discovery of a number of leaking USTs throughout the United States prompted Congress to add Subtitle I to RCRA in 1984. Subtitle I requires the USEPA to develop regulations for leaking USTs to safeguard human health and environment. In September 1988, USEPA finalized the UST rules and regulations[157] that cover the technical requirements for designing, installing, testing, and monitoring USTs, and the requirements for cleanup following releases from leaking USTs. Many USTs are located on each Army installation. They must all be tested for leaks and any leaking tanks must be managed according to the rules. Proper management of USTs will minimize the quantities of vapor emissions, soil contamination, and potential groundwater contamination.

A data base of information of Army-owned USTs was developed at USACERL.[158] Many of the Army's USTs are more than 30 years old, greater than 10,000 gal, may contain hazardous substances, are made of steel, and have a high potential for leakage. A leak potential index (LPI)

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[155] D.W. Layton, et al.

[156] F.W. Nester and L.L. Smith, *Propellant Reuse Technology Assessment*, AMXTH-TE-CR-86076 (USATHAMA, Aberdeen Proving Ground, MD, 1986).

[157] 40 CFR Parts 280-281, *Underground Storage Tanks: Technical Requirements and State Program Approval; Final Rule*, pp 37081 - 37247.

[158] B.A. Donahue, T.J. Hoctor, and K. Piskin, *Managing Underground Storage Tank Data Using dBase III Plus*, Technical Report N-87/21/ADA182452 (USACERL, June 1987).

associated with the data base has been devised to indicate the likelihood of individual tank leakage.[159] The LPI is a tool that enables tank managers to group tanks based on the likelihood of leaks. This information indicates which tanks should be monitored more closely, which should be tested, and which should be considered for replacement.

The HAZMIN technique of inventory control is very effective in detecting tank leaks. This method requires regular measurement of the level of substances in the tanks. Records must also be maintained concerning addition and withdrawl of products. Comparison of inflow, outflow, and the inventory indicates product loss. Other leak detection methods can be grouped into volumetric methods, nonvolumetric methods, and leak effects monitoring.[160] Volumetric methods measure the change in volume with time and are the most fully developed and popular. Site-specific decisions have to be made regarding the use of the most appropriate leak detection method. Nonvolumetric methods measure changes in a variable, such as a tracer gas or acoustic signal, to determine changes in the level of the tank contents. Leak effects monitoring refers to methods used to determine leaks in the surrounding environment (e.g., soil vapor analysis).

Table 46

Used Oil Fuel Specifications*

Constituent or Property	Allowable Level
Arsenic	5 mg/kg maximum
Cadmium	2 mg/kg maximum
Chromium	10 mg/kg maximum
Lead	100 mg/kg maximum
Total Halogens	4000 mg/kg maximum**
Flashpoint	37.7 °C (100 °F) minimum

*Source: Federal Register, Vol 50, No. 23, pp 49,164 - 49,249.
**Used oil containing more than 1000 mg/kg total halogens must be shown not to have been mixed with hazardous waste. This is called the "rebuttable presumption."

[159] S. Dharmavaram, et al., "A Profile and Management of the U.S. Army's Underground Storage Tanks," *Environmental Management*, Vol 13 (1989), pp 333-338.
[160] J. Makwinski and P.N. Cheremisinoff, "Special Report: Underground Storage Tanks," *Pollution Engineering*, Vol 20 (1988), pp 60-69.

Table 47

Amounts of Typical Hazardous Wastes Generated from Drycleaning Operations*

	Cleaning Solvent**		
Waste Type	PERC	Valclene	Stoddard
Still Residues	25	10	20
Spent Cartridge Filters			
Standard (carbon core)	20	15	***
Adsorptive (split)	30	20	***
Cooked Powder Residue	40	n/a	n/a
Drained Filter Muck	n/a	n/a	***

* Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), p 144.
** In pounds per 1000 pounds of clothes cleaned.
*** Well-drained filter cartridges and filter muck are solids that do not meet the criteria for classification as an ignitable solid, and are therefore not considered hazardous wastes.

Table 48

Drycleaning and Laundry Operations and Wastes Classification*

Process/ operation	Materials used	HW code	Waste Description: DOT shipping name	Hazard class	Number
Drycleaning	PERC	F002	Waste perchloroethylene or waste tetrachloroethylene	ORM-A	UN1897
	Valclene	F002	Hazardous waste liquid or solid, NOS	ORM-E	UN9189
	Petroleum solvents	D001	Waste petroleum distillate	Combustible liquid	UN1268
			Waste petroleum naptha	Combustible liquid	UN1255
Laundering	Caustic soda	D002	Waste sodium hydroxide	Corrosive material	UN1824
	Cleaning compound	D001	Hazardous waste liquid, NOS	Flammable liquid	UN9189

*Source: *Drycleaning and Laundry Plants*, Hazardous Waste Fact Sheet (Small Quantity Generators Activity Group, Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Table 49

Wastes Classification: Woodworking and Preserving Operations*

		Waste Description			
Process/ operation	**Materials used**	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Wood cleaning and wax removal	Petroleum distillates	D001	Waste flammable liquid	Flammable liquid	UN1993
	White spirits	D001	Waste naptha	Combustible liquid	UN2553
			Waste naptha solvent	Flammable liquid	UN2553
			Waste naptha solvent	Combustible liquid	UN1256
				Flammable liquid	UN1256
Refinishing/ stripping; brush cleaning and spray gun cleaning	Paint strippers (containing methylene chloride)	F002	Hazardous waste liquid or waste methylene chloride	ORM-E ORM-A	UN2553 UN1593
	Paint removers (containing distillates, acetone, toluene)	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Paint removers (containing caustic)	D002	Corrosive liquid	Corrosive material	NA1760
Staining	Stains (mineral spirits, alcohols, pigments)	D001	Waste flammable liquid	Flammable liquid	UN1993
Painting	Paints (enamels, lacquers, epoxy, alkyds, acrylics)	D001	Waste paint or enamel liquid	Flammable liquid	UN1263
Finishing	Varnish, shellac, lacquer	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
Preserving	Creosote	K001	Hazardous waste liquid or solid, NOS	ORM-E	NA9189
	Pentachlorophenol	K001	Waste pentachlorophenol, liquid or solid	ORM-E	NA2020
	Chromated copper arsenate	D004/ D007	Waste arsenical compounds, liquids	Poison B	UN1557
	Ammoniacal copper arsenate	D004	Waste arsenical compounds, solids	Poison B	UN1556
			Waste arsenical compounds, liquids	Poison B	UN1557
			Waste arsenical compounds, solids	Poison B	UN1556
	Other wood preservatives	Varies	Hazardous waste liquid or solid, NOS	ORM-E	NA9189

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), pp 146-147.

Table 50

Waste Classification: Pesticides*

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Pesticides Containing Arsenic:				
Arsenic pentoxide	Arsenic acid anhydride Arsenic (V) oxide	Waste arsenic pentoxide, solid	Poison B	UN1559
Arsenic trioxide	Arsenic sesquioxide Arsenic (III) oxide Arsenous acid (anhydride) White arsenic	Waste arsenic trioxide, solid	Poison B	UN1561
Cacodylic acid	Hydroxydimethylarsine oxide Dimethylarsinic acid Phytar	Waste arsenical pesticide, solid, NOS[3] Waste arsenical pesticide, liquid, NOS Waste arsenical pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2759 UN2759 UN2760
Monosodium Methanearsonate	MSMA Ansar 170 H.C. and 529 H.C. Arsanote liquid Bueno 6 Daconate 6 Dal-E-Rad Herb-All Merge 823 Mesamate Monate Trans-Vert Weed-E-Rad Weed-Hoe	Waste arsenical pesticide, solid, NOS Waste arsenical pesticide, liquid, NOS Waste arsenical pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2759 UN2759 UN2760
Disodium Monomethanearsonate	DSMA Ansar 8100 Arrhenal Arsinyl Dinate Di-Tac DMA Methar 30 Sodar Versar DSMA-LQ Weed-E-Rad	Waste arsenical pesticide, solid, NOS Waste arsenical pesticide, liquid, NOS Waste arsenical pesticide, liquid, NOS	Poison B Poison B Poison B	UN2759 UN2759 UN2759

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL 1986), pp 150-161.

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Pesticides Containing Carbomates:				
Temik	Aldicarb	Waste carbamate pesticide, solid, NOS	Poison B	UN2757
	OMS 771	Waste carbamate pesticide, liquid, NOS	Poison B	UN2757
	UC 21149	Waste carbamate pesticide, liquid, NOS	Flammable liquid	UN2758
Pesticides Containing Mercury				
2-Methoxyethyl-mercuric Chloride	MEMC	Waste mercury based pesticide, solid, NOS	Poison B	UN2777
	Agallol			
	Cekusil Universal-C	Waste mercury based pesticide, liquid, NOS	Poison B	UN2777
	Ceresan-Universal-Nassbeize			
	Emisan 6	Waste mercury based pesticide, liquid, NOS	Flammable liquid	UN2778
Phenylmercurie acetate	PMA	Waste mercury based pesticide, solid, NOS	Poison B	UN2777
	PMAS			
	Agrosan	Waste mercury based pesticide, liquid, NOS	Poison B	UN2777
	Cekusil			
	Celmer	Waste mercury based pesticide, liquid, NOS	Flammable liquid	
	Gallotox			
	Hong Nien			
	Liquidphene			
	Mersolite			
	Pamisan			
	Phix			
	Seedtox			
	Shimmer-ex			
	Tag HL 331			
Pesticides Containing Substituted Nitrophenols:				
Dinitrocresol	DNC	Waste substituted nitrophenol pesticide, solid, NOS	Poison B	UN2779
	DNOC			
	Chemset	Waste substituted nitrophenol pesticide, liquid, NOS	Poison B	UN2779
	Detal			
	Elgetol 30	Waste substituted nitrophenol pesticide, liquid, NOS	Flammable liquid	UN2780
	Nitrador			
	Selinon			
	Sinox			
	Trifocide			
	Trifrina			
Dinoseb	DNBP	Waste substituted nitrophenol pesticide, solid, NOS	Poison B	UN2779
	Basanite			
	Caldon	Waste substituted nitrophenol pesticide, liquid, NOS	Poison B	UN7890
	Chemox general			
	Chemox PE	Waste substituted nitrophenol pesticide, liquid, NOS	Flammable liquid	UN2780
	Dinitro			
	Dinitro general			
	Dynamite			
	Elgetol 318			
	Gebutox			

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Dinoseb (Cont'd)	Hel-Fire Nitropone C Premerge 3 Sinox general Subitex Vertac general weed killer Vertac selective weed killer			
Organophosphate pesticides:				
Dimetboate	AC-12880 Bi 58 EC Cekuthoate Cygon Daphene De-Fend Demos-L40 Devigon Dimet Dimethogen Perfekthion Rebelate Rogdial Rogor Roxion Trimetion	Waste organophosphorous pesticide, solid, NOS Waste organophosphorous pesticide, liquid, NOS Waste organophosphorous pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2783 UN2783 UN2784
Disulfoton	Bay 19639 and S276 Dithiodemeton Dithiosystox Di-Syston Ethylthiodemeton Frumin AL M-74 Solvirex Thiodemeton	Waste disolfoton Waste disulfoton mixture, dry Waste disulfoton mixture, liquid Waste organophosphorous pesticide, liquid, NOS	Poison B Poison B Poison B Flammable liquid	NA2783 NA2783 NA2783 UN2784
Famphur	Bash Bo-Ana Dovip Famfos Warbex	Waste organophosphorous pesticide, solid, NOS Waste organophosphorous pesticide, liquid, NOS Waste organophosphorous pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2783 UN2783 UN2784
Methylparathion	Cekumethion E-601 Devithion Folidon M Fosferno M50 Gearphos Methacide Metaphos Nitrox 80 Parataf Paratox Partron M	Waste methyl parathion, liquid Waste methyl parathion mixture, dry Waste methyl parathion mixture, liquid, (containing 25% or less methylparathion) Waste methyl parathion mixture, liquid, (containing more than 25% methylparation) Waste organophosphorous pesticide, liquid, NOS	Poison B Poison B Poison B Poison B Flammable liquid	NA2783 NA2783 NA2783 NA2783 UN2784

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Methylparathion (Cont'd)	Penncap-M Wofatox			
Parathion	AC-3422 Alkron Alleron Aphamite Bladan Corothion E-605 ENT 15108 Ethyl parathion Etilon Folidol E-605 Fosterno 50 Niran Orthophos Panthion Paramar Paraphos Parathene Parawet Phoskil Rhodiatox Soprathion Stathion Thiophos	Waste parathion, liquid Waste parathion mixture, dry Waste parathion mixture, liquid Waste organophosphorous pesticide, liquid, NOS	Poison B Poison B Poison B Flammable liquid	NA2783 NA2783 NA2783 UN2784
Strychnine Pesticides:				
Strychnine	Strychnine salts	Waste strychnine, solid Waste strychnine salt, solid	Poison B Poison B	UN1692 UN1692
Thallium Sulfate Pesticides:				
Thallium sulfate	Thallous sulfate Ratox Zelio	Waste thallium sulfate, solid Waste flammable liquid, poisonous, NOS	Poison B Flammable liquid	NA1707 UN1992
Triazine Pesticides:				
Amitrole	Amerol Amino triazol weedkiller 90 Amizol AT-90 AT liquid Azolan Azole Cytrol Diurol Farmco Herbizole Simazol Weedazol Weedazol TL	Waste triazine pesticide, solid, NOS Waste triazine pesticide, liquid, NOS Waste triazine pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2763 UN2763 UN2764

Table 50 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
Flammable Solvents Used in Pesticides:				
Methyl alcohol	Methanol	Waste methyl alcohol	Flammable liquid	UN1230
Ethyl alcohol	Ethanol Alcohol	Waste ethyl alcohol	Flammable liquid	UN1170
Isopropyl alcohol	Isopropanol	Waste isopropanol	Flammable liquid	UN1219
Toluene	Methyl benzene Toluol	Waste toluene (tuluol)	Flammable liquid	UN1294
Xylene	Dimethyl benzene Xylol	Waste xylene (xylol)	Flammable liquid	UN1307
Solvent mixtures		Waste combustible liquid, NOS Waste flammable liquid, NOS	Combustible liquid Flammable liquid	NA1993 UN1993
Phenoxy Pesticides:				
2,4-D	Amoxone Brush Killer Brush-Rhap Chloroxone Crop Rider D50 DMA 4 Dacamine Ded-Weed Desormone Dinoxol Emulsamine BK and E3 Envert DT and 171 Hedonal Miracle Pennamine D Rhodia Salvo Super-D Weedone Verton Visko-Rhap Weed Tox Weed-B-Gone Weed-Rhap Weedar Weedone Weedtrol	Waste 2,4-dichlorophenoxyacetic acid Waste 2,4-dichlorophenoxyacetic acid ester Waste phenoxy pesticide, liquid, NOS	ORM-A ORM-E Flammable liquid	NA2765 NA2765 UN2766
2.4,5-T	Brush-Rhap Dacamine Ded-Weedon Esteron Farmco Fence Rider Forron Inverton 245 Line Rider	Waste 2.4,5-trichlorophenoxyacetic acid Waste 2.4,5-trichlorophenoxyacetic acid (amine, ester, or salt) Waste phenoxy pesticide, liquid, NOS	ORM-A ORM-E Flammable liquid	NA2765 NA2765 UN2766

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
2.4,5-T (Cont'd)	Super D Weedone Tormona Transamine U 46 Veon 245 Weedar Weedone			
Silvex	2.4,5-TP Fenoprop	Waste 2-(2.4.5-trichlorophenoxy) propionic acid	ORMA-A	NA2765
	AquaVex Double Strength	Waste 2-(2.4.5-trichlorophenoxy) propionic acid ester	ORM-E	NA2765
	Fruitone T Kuron Kurosal Silver-Rhap Weed-B-Gone	Waste phenoxy pesticide, liquid, NOS	Flammable liquid	UN2766
Organochlorine Pesticides:				
Aldrin	HHDN Aldrex 30	Waste aldrin	Poison B	NA2761
	Aldrite Aldrosol	Waste aldrin mixture, dry (with more than 65% aldrin)	Poison B	NA2761
	Altox Drinox	Waste aldrin mixture, liquid (with or less aldrin)	ORM-A	NA2761
	Octalene Seedrin liquid	Waste aldrin mixture, liquid (with more than 60% aldrin)	Poison B	NA2762
		Waste aldrin mixture, liquid (with 60% or less aldrin)	ORM-A	NA2762
		Waste organchlorine pesticide, liquid, NOS	Flammable liquid	UN2762
Chlordan	Belt Chlordan	Waste chlordane, liquid	Flammable liquid	NA2762
	ChlorKil Chlortox Corodane Gold Crest C-100 Kypchlor Vesicol 1068 Topiclor 20 Niran Octachlor Octa-Klor Ortho-Klor Synklor Termi-Ded	Waste chlordane, liquid	Combustible liquid	NA2762
DDT	Dedelo Didimac	Waste DDT	ORM-A	NA2761
	Digmar Genitox Gyron Gildit Kopsol Neocid	Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
DDT (Cont'd)	Pentachlorin Rukseam Zerdand			
Dichloropropene	1.3-dichloropropene Telone II Soil Fumigant	Waste dichloropropene	Flammable liquid	UN2047
Dieldrin	Dieldrex Dieldrite Octalox Panoram D-31	Waste dieldrin Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable Liquid	NA2761 UN2762
Endrin	Endrex Hexadrin	Waste Endrin Waste Endrin mixture, liquid Waste organochlorine pesticide, liquid, NOS	Poison B Poison B Flammable liquid	NA2761 NA2761 UN2762
Endosulfan	Beosit Chlorthiepin Crisulfan Cyclodan Endocel EnSure FMC 5462 Hildan Hoc 2671 Malix Thifor Thimul Thiodan Thiofor Thionex Tiovel	Waste Endosulfan Waste Endosulfan mixture, liquid Waste organochlorine pesticide, liquid, NOS	Poison B Poison B Flammable liquid	NA2761 NA2761 UN2762
Heptachlor	Gold Crest H-60 Drinox H-34 Heptamul Heptox Chlordecone	Waste Heptachlor Waste organochlorine pesticide, liquid NOS	ORM-E Flammable liquid	NA2761 UN2762
Kepone	Exagama Forlin	Waste Kepone Waste organochlorine pesticide, liquid, NOS	ORM-E Flammable liquid	NA2761 UN2762
Lindane	Gallogama Gamaphex Gammex Inexn Isotox Lindafor Lindagam Lindagrain Lindagranox Lindalo Lindamul Lindapoudre	Waste Lindane Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable liquid	NA2761 UN2762

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Lindane (Cont'd)	Lindaterra Novigam Silvanol			
Methoxychlor	Flo Pro McSeed Protectant Marlate	Waste Methoxychlor Waste organochlorine pesticide, solid, NOS Waste organochlorine pesticide, liquid, NOS Waste organochlorine pesticide, liquid, NOS	ORM-E Poison B Poison B Flammable liquid	NA2761 UN2761 UN2761 UN2762
Propylene Dichloride	1.2-dichloropropane	Waste propylene dichloride	Flammable liquid	UN1279
Toxaphene	Attac 4-2, 4-4, 6, 6-3, 8 Camphochior Motox Phenacide Phenatox Strobane T-90 Toxakil Toxon	Waste toxaphene Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable liquid	NA2761 UN2762
Other Pesticides:				
Thiram	TMTD AAtack Arasan Aules Evershield T Seed Protectant Fermide 850 Fernasan Flo Pro T Seed Protectant Hexathir Mercuram Nomersan Pomarsolforte Polyram-Ultra Spotrete-F Tetrapom Thimer Thionock Thiotex Thiramad Thiuramin Tirampa Trametan Tripomol Thylate Tudas Vancide TM	Waste Thiram Waste flammable liquid, poisonous, NOS	ORM-A Flammable liquid	NA2771 UN1992
Warfarin	Co-Rax Cov-R-Tox Kypfarin Liqua-Tox	Hazardous waste solid, NOS Hazardous waste liquid, NOS	ORM-E ORM-E	NA9189 NA9189

Table 50 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
	RAX	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Rodex			
	Rodex Blax	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Tox Hid			
Pentachlorophenol	PCP	Waste pentachlorophenol	ORM-E	NA2020
	Penta			
	Penchlorol	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Pentacon			
	Penwar	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Sinitudo			
	Santophen			
Pentachloronitrobenzene	PNCB	Hazardous waste, solid	ORM-E	NA9189
	Avicol			
	Botrilex	Hazardous waste, liquid	ORM-E	NA9189
	Brassicol			
	Earthcide	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Folosan			
	Kobu	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Pentagen			
	Saniclor 30			
	Terraclor			
	Tilcarex			
	Tritesan			
Hexachlorobenzene	Perchlorobenzene	Hazardous waste, solid	ORM-E	NA9189
	Anticarie			
	Ceku C.B.	Hazardous waste, liquid	ORM-E	NA9189
	HCB			
	No Bunt	Waste flammable liquid, NOS	Flammable liquid	UN1993
	DBCP	Waste combustible liquid, NOS	Combustible liquid	NA1993
1,2-Dibromo 3-Chloropropane	Nemafume	Hazardous waste, solid, NOS	ORM-E	NA9189
	Nemanox	Hazardous waste, liquid, NOS	ORM-E	NA9189
	Nemaset	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Nematocide	Waste combustible liquid, NOS	Combustible liquid	NA1993

Table 51

Ingredients Contained in Propellants, Explosives, and Pyrotechnics

Compound	Type
2,4,6-Trinitrotoluene (TNT)	EX*
Cyclotrimethylenetrinitramine (RDX)	EX
Pentaerythritol Tetranitrate (PETN)	EX
2,4,6-Trinitrophenylmethylnitramine (Tetryl)	EX
Ammonium Picrate (Explosive D)	EX
Cyclotetramethylenetetranitramine (HMX)	EX
2,4-Dinitrotoluene (DNT)	PP
Nitroglycerin (NG)	PP
Nitroguanidine (NQ)	PP
Dibutyl phthalate	PP
Diethyl phthalate	PP
Diphenylamine	PP
Benzene	EX
Toluene	EX
Sodium Nitrate	PY
Barium Nitrate	PY
Magnesium Nitrate	PY
Strontium Peroxide	PY
Strontium Oxalate	PY
Calcium Resinate	PY

*EX = explosives; PP = propellants; PY = pyrotechnics.

Table 52

Common Elements Found in PEP and OB/OD Soil Residue

Element	OB	OD
	% of samples greater than EP toxic limits	
Strontium		
Cadmium	2.5	1.3
Arsenic	0.3	0.0
Antimony		
Lead	6.0	0.7
Mercury	0.6	0.0
Barium		

*Source: D.W. Layton, p 29.

11 WASTE MINIMIZATION FOR MISCELLANEOUS WASTES

Polychlorinated Biphenyls

PCBs are chlorinated organic compounds with a wide range of physical properties. There are 209 possible PCBs of which tri-, tetra-, penta-, and hexachloro biphenyls are the most important. They were commonly used in coolants and insulation fluids in transformers. Some of the older products that may contain PCBs or oils with PCBs include: heat-transfer fluids, lubricants, paints, plastics, air conditioners, fluorescent lights, and televisions. PCBs were most widely used in capacitors and transformers because of their low conductivity and thermal stability.

In several cases of poisoning in Japan and Taiwan, PCBs and their secondary products such as polychlorinated dibenzofurans were found to be the major contaminants in bran oil used to cook rice. Since then, PCBs have been linked to severe health problems (e.g., gastric disorders, skin lesions, swollen limbs, cancers, tumors, eye problems, liver disorders, menstrual irregularities, etc.) and birth defects (e.g., reproductive failures, mutations, etc.). Compounding the problem of PCBs' toxicity is their bioaccumulation in cells and fatty tissues of micro-organisms and animals, which are then consumed by other animals higher in the food chain.

PCBs are regulated by the Toxic Substances Control Act (TSCA) passed in 1976. Manufacture of PCBs was banned under TSCA and deadlines were provided for removing capacitors and transformers containing PCBs. One year was allowed for storage before disposal. If regulatory agencies determine that the use of PCB transformers poses no risk, the use will be allowed to continue. All capacitors were to have been removed by October 1988, and transformers of certain size in or near commercial buildings should be removed by October 1990.

If the concentration of PCBs in a product is greater than 50 parts per million (ppm), the product is regulated as hazardous under TSCA. Some States have set limits that are stricter than Federal limits (e.g., California, 5 ppm).

PCBs in Transformers

In the United States, there are 150,000 askarel (nonflammable electrical fluid) transformers, each of which contains thousands of pounds of PCBs with a wide range of concentrations.[161] Many of these tranformers develop leaks.

The transformers are generally classified as: PCB transformers (greater than 500 ppm), PCB-contaminated transformers (50 to 500 ppm), and Non-PCB transformers (less than 50 ppm). PCB transformers must be inspected quarterly for leaks; detailed records must be kept. No maintenance work involving removal of the coil or casing is allowed. PCB-contaminated transformers must be inspected annually. Their requirements for maintenance and recordkeeping are less restrictive than for PCB transformers. Non-PCB transformers are exempt from regulation.

The importance of analyzing all transformers for PCBs must be stressed. All the transformers on an installation must be inventoried and tested for PCBs. If the PCB levels are greater than 50 ppm (greater than 5 ppm in California), appropriate actions must be taken.

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[161]P.N. Cheremisihoff, "High Hazard Pollutants: Asbestos, PCBs, Dioxins, Biomedical Wastes," *Pollution Engineering*, Vol 21 (1989), pp 58-65.

PCB Wastes Management

There are no minimization options available for PCB wastes. Recycling of PCBs is illegal. Nevertheless, containers and oils contaminated with PCBs may be recycled if the PCBs are removed.

Federal regulations require that PCBs be destroyed in approved high-temperature incinerators. Oils containing 50 to 500 ppm PCBs can be burned in high-efficiency boilers. Alternate technologies capable of operating at the high incinerator efficiencies, such as the molten salt processes or UV/Ozonation may also be considered for "ultimate" treatment/disposal. In addition to incineration, which is the most common, chemical dechlorination technologies have also been successful. Table 53 lists the names and addresses of incineration facilities and available chemical dechlorination services.

The most common practice at Army installations is to retain PCB transformers in service until the end of their useful life or they leak. They are then replaced with non-PCB transformers. The other possible options that may be available are decontaminating and/or retrofilling the transformers. Table 54 lists the names and addresses of companies that provide retrofilling services.

USACERL's PCB Transformer System

A computer-aided, fate-decision analysis tool was developed at USACERL to help users make decisions about transformers containing PCB levels greater than 50 ppm. The computer model is available to Army users through the Environmental Technical Information System (ETIS) on the mainframe computer at USACERL. A PC-based model is also available.*

The model provides users with information about PCBs and appropriate regulations, and allows them to input information for risk assessment, fate-decision analysis, and life cycle cost analysis. The options considered in the final economic analysis are: retaining, retrofilling, decontaminating, and replacing transformers.

Onsite Mobile Treatment Units

Mobile incineration and chemical dechlorination units can decontaminate insulating oils from transformers. One dechlorination process, the "PCBX" process developed by ENSR, is a self-contained continuous-flow unit. It is designed and equipped to destroy PCBs (up to 2600 ppm) from transformer oil without moving the transformer. The operating capacity of the unit is up to 600 gallons per hour. Exceltech, Inc., based in California, also markets mobile dechlorination units for removing PCBs from transformers.

Lithium Batteries

Discarded lithium batteries come from equipment (carried by Troops) that use batteries as a reserve power source. The following six types of primary lithium batteries are commonly used in the U.S. military services: Li-CuO, Li-nnO2, Li-(CFx)n, Lithium Sulfur dioxide (Li-SO2), Li-SO2Cl2, and Lithium thionyl chloride (Li-SOCl2).

The U.S. Navy has proposed the development of a center of excellence to develop a fully permitted state-of-the-art, portable disposal technology for world-wide utilization.[162]

* For information, contact Bernard Donahue or Keturah Reinbold at USACERL-EN, P.O. Box 9005, Champaign, IL 61826-9005, or telephone 800-USACERL (outside Illinois) 800-252-7122 (within Illinois).

[162] Comarco, Inc., *U.S. Navy Lithium Battery Disposal*, Report No. CESD-88-179 (Prepared for the Naval Weapons Support Center, High Energy Battery Systems Branch, Crane, IN, January 1989).

A study was conducted by USAEHA to evaluate the disposal of lithium batteries under RCRA regulations.[163] Fully charged and duty-cycle discharge batteries were hazardous because of reactivity and/or ignitability characteristics and must be discharged through the DRMO. Fully discharged batteries are not hazardous and could be disposed of in a permitted landfill. Assurances must be sought that the batteries have reached their fully discharged state. Manual discharging methods such as soaking in an aqueous solution are not practical means and alternative approaches must be explored.

A recent review presents general information regarding lithium batteries in a condensed form.[164] It includes information about battery technology, safety aspects, purchasing, packaging, transport, storage and disposal.

Ordnance

A number of hazardous ordnance materials are used on Army installations. Ingredients contained in some of them were listed in Table 51. Further details are available in Technical Manual (TM) 9-1300-214.[165] Army directives prohibit burial of ordnance materials or dumping them in waste places, pits, wells, marshes, shallow streams, rivers, inland waterways, or at sea. All existing locations of buried explosives must be identified and marked accordingly. The only means of disposal available is destruction by burning and detonation (discussed in Chapter 10). Proper operating procedures for disposal of discarded ordnance materials should be developed and updated frequently to comply with Federal, State, and local regulations.

Contaminated Soil

Contaminated soil is generated because of leaks or spills of hazardous materials. Some effective source reduction techniques include: installing splash guards and dry boards on equipment, preventing tank overflow, using bellow sealed valves, installing spill basins, using seal-less pumps, secondary containment, plant maintenance, and personnel training to develop good operating practices.

A number of nonthermal and thermal treatment techniques are available for decontamination of soil.[166] Nonthermal techniques include: aeration, biodegradation, carbon adsorption, chemical dechlorination, solvent extraction, stabilization/fixation, and ultraviolet photolysis. Thermal treatment techniques include: stationary rotary-kiln incineration, mobile rotary-kiln incineration, liquid injection incineration, fluidized bed incineration, high-temperature fluid-wall destruction, infrared incineration, supercritical-water oxidation, plasma-arc pyrolysis, and in situ vitrification.

Empty Containers

Containers with residual hazardous materials/wastes must also be treated as hazardous wastes. Under HSWA, if a container with h... ardous residue is found in a cleanup (Superfund) site or other landfill, the generator (Army) is liable and has to pay for part of the cost of cleanup. Even "triple

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[163] *Evaluation of Lithium Sulfur Dioxide Batteries, US Army Communications - Electronics Command and US Electronics Research and Development Command, Fort Monmouth, New Jersey*, USAEHA-37-26-0427-85 (USAEHA, Aberdeen Proving Ground, MD, 1985).

[164] W.N. Garrard, *Introduction to Lithium Batteries*, MRL-GD-0018; DODA-AR-005-652 (Materials Research Laboratory, Ascot Vale, Australia, 1988).

[165] Technical Manual (TM) 9-1300-214, *Military Explosives* (HQDA, 20 September 1984).

[166] *Standard Handbook of Hazardous Waste Treatment and Disposal.*

rinsed" containers could contain some residue. Scrap dealers and landfills are becoming reluctant to accept "clean" empty 55-gal drums or other containers.

The problem of disposing of empty drums and containers can be minimized by giving careful consideration to the kinds and sizes of containers in which materials are originally received. When purchasing materials in bulk, the suppliers must be asked to send them in rinsable and/or recyclable containers. A number of commercial recyclers (listed in Regional Waste Exchange bulletins/newsletters or directories) accept containers less than 30 gal.[167] Treating empty containers by triple rinsing is a good waste minimization technique. However, the rinsate, if hazardous, must be properly managed.

Some of the other options to consider when procuring materials, and in the ultimate disposal of containers, are:[168] returning drums to suppliers, contracting with a drum conditioner, contracting with a scrap dealer, and, lastly, disposal in an approved landfill.

Returning Drums to Suppliers

When buying material, a purchase agreement must be established to include the option of returning empty containers to the suppliers. Cash deposits may be required and drums should be maintained in good condition. All the accessories, such as bungs, rings, and closures, must also be kept and returned with the drums.

Contracting With a Reconditioner

If the suppliers do not sell chemicals in returnable drums, ask them to send materials in heavy steel (18 to 20 gauge) drums that can be reconditioned when "empty." A typical 55-gal heavy drum should have a 20-gauge side and 18-gauge ends. A good market exists for these drums and they can be sent to reconditioning contractors for minimal or no cost. Empty heavy drums must be treated as a valuable asset and personnel should be trained in their proper handling (including keeping the bungs, rings, etc.). Another good practice is to avoid accumulating the drums for long periods of time, thus, preventing deterioration.

Contracting With a Scrap Dealer or Disposal in a Landfill

Scrap dealers and landfill operators usually require certain conditions to be met before they accept drums or other containers. Generators have to drain the drums or containers thoroughly, remove the residues by triple rinsing, certify that they do not contain hazardous materials, remove both the ends, crush them before transporting, and pay for disposal.

[167] Ventura County Environmental Health, p 3-2.
[168] *Managing Empty Containers*, Fact Sheet (Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Table 53

PCB Replacement/Treatment/Disposal Services

Company	Address
ENSCO	P.O. Box 1975, El Dorado, AR 71730, (501) 863-7173
ENSR (formerly SunOhio)	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 452-0837
USEPA Mobile Incinerator	Woodbridge Ave., Raritan Depot Bldg. 10, Edison, NJ 08837, (201) 321-6635
GSX Chemical Services	121 Executive Center Dr., Congaree Bldg. # 100, Columbia, SC 29221, (800) 845-1019
Rollins	P.O. Box 609, Deer Park, TX 77536, (713) 479-6001
General Electric	One River Road/Bldg 2-111B, Schenectady, NY 12345, (518) 385-9763
SCA Chemical Services	1000 E. 111th St., 10th Fl., Chicago, IL 60628, (312) 660-7200

Table 54

PCB Transformer Retrofilling Services

Company	Address
DOW Corning Corp	P.O. Box 0994, Midland, MI 48686-0994, (517) 496-4000
ENSR (formerly SunOhio)	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 452-0837
General Electric	One River Road/Bldg 2-111B, Schenectady, NY 12345, (518) 385-9763
Hoyt Corporation	251 Forge Rd., Westport, MA 02790-0217, (800) 343-9411
Retrotex	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 453-4677
Transformer Service Inc.	78 Regional Dr., P.O. Box 1077, Concord, NH 03301-9990, (603) 224-4006
Unison Transformer Services	1338 Hundred Oaks Dr., Charlotte, NC 28210, (800) 544-0030
Westinghouse/Industry Services	875 Greentree #8-MS 804, Pittsburgh, PA 15220, (800) 441-3134

12 ECONOMIC ANALYSES OF HAZARDOUS WASTE MINIMIZATION OPTIONS

HSWA requires generators of hazardous wastes to develop a waste minimization program that is economically practicable. Therefore, once the alternatives for minimization are identified, their economic feasibility must also be studied. A major source for funding for hazardous waste minimization projects has been through the Defense Environmental Restoration Account (DERA). If the payback from a project is expected to be 1 year or less, funding is also available from the Defense Productivity Enhancing Capital Investment (PECI) program. In many instances, minimization is a cost-effective means of conducting business. In such instances, any account may be used to finance minimization and benefit from the resultant savings. However, with the multiplicity of alternative treatment technologies available to treat various hazardous waste streams, it is imperative that installation environmental personnel use a standard methodology to evaluate hazardous waste minimization options.

In 1984, DOD initiated a Used Solvent Elimination (USE) program. In conjunction with the USE program, USACERL developed a model for performing an economic analysis on various alternatives for recycling or disposing of used solvents. Based on this earlier model, a microcomputer model has been developed for economic analysis of minimization options. (Refer to USACERL Technical Report N-89/XX[169] for a detailed discussion of the process of economic analysis and use of the model.) A part of the model related to nonspecific or "general" waste types is used to determine the life cycle costs and comparison of alternatives for waste streams in this report. Many other publications on economic analysis are available.

The caveat of an "economically practicable" level of waste minimization, as defined in HSWA, is very important. It is not necessary (and is impossible in most cases) to completely eliminate generation of wastes. An economic analysis provides a reasonable methodology for choosing between options for waste minimization. The typical costs considered for any option are initial capital costs and operating costs such as labor, materials, transportation, and waste disposal. Benefits achieved from a waste minimization option (e.g., reduced liability) can also be quantified and given dollar values.

The costs are summed to obtain life cycle costs over the assumed economic life for each option. Net present value (NPV) of the total life cycle costs can be calculated for each option. Comparing the NPVs provides a basis for selecting a minimization technique. Results of detailed economic analysis for the selected waste streams are provided in the sections below.

Used Waste Oil

A large quantity of waste oil, primarily engine lubricating oil, is generated on Army installations. Fort Ord generates 44,044 gal/yr of waste oil. Lubricating oil is drained from wheeled and tracked vehicles by the traditional drip-pan method and collected in 55 gallon drums or larger storage tanks. Some of the contaminants found in used oil are trash/rags, solvents, hydraulic fluids, and wear metals. Oil is normally changed from larger vehicles (2 1/2-ton size class and above) based on the AOAP test. Smaller vehicles follow a regular service interval of 6 months or 6000 miles.

A source reduction method for minimizing waste oil generation is a change in the process of draining the oil. A FLOC system can be implemented to replace the gravity-drain (drip-pan) method. A description of the technique is provided in Chapter 5. Adapters have to be purchased for all the

[169] J.B. Mount, et al.

different types of Army vehicles. The major savings is in the labor costs. The amount of extraneous contaminants in the used oil is considerably reduced if the the procedure is implemented.

A comparison of the life cycle (10-year) costs for the two techniques was performed for fleets ranging from 50 to 5000 vehicles.

Investment costs for the purchase of a FLOC evacuation unit and engine adapter kits are assumed to all occur in the first year. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for both options. The model's default values retained for this analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16.00/hr; labor rate (laborer) - $11.00/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5 percent of equipment costs; transportation of hazardous waste - $0.04 per pound; and, annual logistics and procurement - 1.6 percent of other Operational and Maintenance (O & M) costs. Other assumptions made in the analysis are:

- The average crankcase oil per vehicle is 3.25 gal.
- The average number of oil changes per year is 2.
- Liability due to spills, including labor costs for cleanup, is $177 for the gravity drain system.
- The time required for an oil change using the gravity drain system is 15 minutes.
- The time required for an oil change using the FLOC system is 4.5 minutes.
- A labor time of 0.7 hours is assumed for removal of an accumulation of up to 50 gal in a 55-gal drum.
- The procurement cost of a small FLOC evacuation unit and engine adapter kits is approximately $2260. An additional $2265 is required to implement this system for costs of site preparation and training of personnel. The costs of larger evacuation units increases with size.
- The system is used 260 working days per year.
- The utility cost for each FLOC unit is $75/yr/unit.
- Costs do not escalate.
- Repair and maintenance is $50/yr/unit.
- One FLOC unit can handle approximately 35 to 40 vehicles per day. If more than 10,000 oil changes are conducted annually, two or more units will be required.

Table 55 lists the saving to investment ratios (SIRs) and discounted payback periods (DPPs) for implementing a FLOC system to service 100, 250, 500, 1000, and 5000 vehicles twice per year. In almost every case, the SIR is 0.39 (1 = economical) and therefore provides no DPP within the expected economic lfe of the equipment. Table 56 lists the computed SIRs and DPPs when the average number of oil changes per vehicle increases from two to six times per year for 1000 vehicles. Only when the number of oil changes per vehicle each year is six or greater, which is not likely to occur, does the FLOC system become cost effective to implement.

Other options analyzed for management of used oil include: (1) offsite disposal as a hazardous waste (status quo), (2) offsite sale as a nonhazardous waste, and (3) offsite sale as a nonhazardous waste from a centralized storage facility. Proper segregation of used oil from other waste streams and additional testing are prerequisites for management options 2 and 3. Cost estimates used in options 2 and 3 for the sale of used oil were obtained from Evergreen Oil Company, Newmark, CA.

In accordance with regulations mandated by the State of California, all used oil generated on Fort Ord is managed as hazardous waste. However, preliminary test results from 12 randomly selected used oil samples revealed flashpoint, PCB, and heavy metal concentrations (lead, chromium, arsenic, cadmium, and chloride) lower than threshold levels established by the State for characterization as hazardous. For this reason, offsite sale of used oil as a nonhazardous waste without additional processing was considered a feasible option. Blending and burning used oil with a virgin heating fuel (No. 2 oil or natural gas) for energy recovery was not considered a practical management option due to the logistical and economic restraints of retrofitting existing boilers and to strict air pollution regulations imposed by California on such activities.

An investment cost of $1.34/gal of used oil was used for the centralized storage option. This estimate was based on a default value presented in the economic model for purchasing and installing four 4000-gal capacity storage tanks and was adjusted accordingly for analyses at different annual generation rates. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for this option. The model's default values retained for analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent installed equipment costs; labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5.75 percent of equipment costs; and annual logistics and procurement - 1.6 percent of other Operations and Maintenance (O&M) costs.

The major assumptions used in this analysis were:

- Disposal cost for hazardous used oil through DRMO is $1.05/gal (FY 90 price list).
- Transportation costs for the onsite transfer of used oil from points of generation to DRMO or to satellite accumulation tanks before offsite disposal are $0.215/gal and $0.0215/gal, respectively.
- Sampling and testing costs incurred before the offsite transfer of used oil in options 2 and 3 are $0.308/gal and $0.015/gal, respectively.
- Labor requirements for the onsite transfer of used oil from points of generation to DRMO or to a centralized storage facility are 0.01 hr/gal.
- Liability costs for onsite transportation and transfer of hazardous and nonhazardous waste oil to DRMO or to centralized storage are $0.002/gal and $0.0002/gal, respectively. Liability associated with all offsite transportation is $0.002/gal.

- Managerial labor is assumed to accrue at a rate of 1 hr/5000 gal of used oil disposed of or sold.

- 55-gal disposal drums required in option 1 are $20 each and are assumed to be full at 90 percent capacity.

- Maintenance and repair costs for centralized storage and satellite accumulation tanks are approximately $0.001/gal.

- The cost of disposing of nonhazardous used oil from satellite accumulation tanks is $0.05/gal (option 2).

- There is no disposal cost for nonhazardous used oil accumulated at the centralized storage facility (option 3).

- For options 1 and 2, 75 percent of the used oil waste stream is transported offbase through DRMO and 25 percent from satellite accumulation points.

- For option 3, 100 percent of the used oil waste stream would be transported offbase from the proposed centralized storage facility.

- Escalation rates for the above costs are as follows: transportation - 4 percent; liability - 4 percent; disposal - 8 percent; sampling and testing - 4 percent; other materials and supplies (disposal drums) - 4 percent; and maintenance and repair - 4 percent.

Figure 5 shows the comparison between the NPV total of the life cycle (10-yr) costs for used oil generation rates between 10,000 and 120,000 gal/yr for the three management options examined in this section. Option 1 (status quo) is the most expensive at all generation rates. At the current generation rate (44,044 gal/yr), the NPV of O&M costs for this option amounts to $455,957 ($45,596 per year). Options 2 and 3 result in NPV operating costs of $166,689 ($16,669 per year) and $121,828 ($12,183 per year), respectively. With an additional NPV investment of $75,963 in centralized storage equipment (option 3), an NPV savings of $323,229 ($32,323 per year) over the current practice of offsite disposal could be realized. This analysis indicates that a centralized storage facility for used oil could provide a SIR of 4.40 and a DPP of 3.31 years. As such, continued efforts to implement a centralized storage facility on Fort Ord for used oil should proceed.

Antifreeze Solution

MPVMs are the primary generators of spent antifreeze solution, followed by IMSS. This waste stream results from the regular servicing of vehicle cooling systems and from the overhaul or replacement of vehicle radiators. Since spent antifreeze solution may not be considered a hazardous waste in some states, it can be diluted with water and discharged to the sewage treatment plant on many Army installations. Spent antifreeze (ethylene glycol) is a listed California hazardous waste and disposed of from Fort Ord as such. Recycling is possible as discussed in Chapter 5. It was considered as a minimization alternative. The results of the economic analysis are presented in this section. Management options considered in this analysis are: (1) offsite disposal as a hazardous waste through DRMO (status quo); (2) onsite recycling and reuse through the purchase of one Glyclean system; (3) offsite disposal through a local recycler (Antifreeze Environmental Service Corporation [AES], Palo Alto, CA); (4) offsite disposal through AES and purchase of their recycled antifreeze; and (5) onsite recycling and reuse through the purchase of two Glyclean systems.

Investment costs for the antifreeze recycling system(s) are assumed to all occur in the first year of the analysis. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for all the options. The model's default values retained for analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance -5.75 percent of equipment costs; annual logistics and procurement - 1.6 percent of other O&M costs; and costs of sampling and testing.

Some of the assumptions made in the economic analysis are:

- Disposal cost of spent antifreeze through DRMO is $5.40/gal (FY90 price list).
- Disposal cost of spent antifreeze through a private contract (AES-options 3 and 4) is $0.90/gal.
- Labor hours for: manager (bids, etc.) - 1 hr/1000 gal; and laborers (drumming and transport) - 1 hr/100 gal.
- The cost of one Glyclean recycling system is $2368.
- Two Glyclean systems are required when waste generation rates exceed 10,000 gal/yr.
- The cost of a 55-gal drum of Glyclean additives is $26.65/gal.
- The quantity of additives needed is 0.03 gal/1 gal of antifreeze recycled.
- The time required to recycle 100 gal of used antifreeze is 0.5 hr.
- The purchase price of new antifreeze is $8.45/gal (on GSA schedule).
- The purchase price of reconditioned antifreeze from private contractor (AES-option 4) is $4.90/gal.
- Recycled antifreeze is equivalent to a 50 percent mixture of antifreeze and water.
- Utility costs associated with Glyclean machine operation is $0.02/gal of waste.
- A 50 percent dilution with water is used for the first year of purchase; no dilution is required in subsequent years.
- Repair and maintenance costs associated with onsite recycling systems is $0.006/gal.
- Liability for both disposal and reuse is $0.01/gal.
- Escalation is 8 percent for disposal and 4 percent for others.

- Onsite transport cost from point of waste generation to recycling facility and back, or to DRMO for disposal is $2/100 gal.

Figure 6 compares the total life cycle (10-yr) costs of offsite disposal with onsite recycling, one and two Glyclean recycling systems, and offsite disposal through DRMO. Onsite recycling of antifreeze solution saves a considerable amount of money at any generation rate compared to offsite disposal through DRMO or through a private contractor (options 3 and 4).

Fort Ord generates 7717 gal/yr of antifreeze solution. The NPV of current O&M costs amounts to $631,294/10 yr ($63,129/yr). Purchasing two Glyclean recycling systems would require an NPV investment of $36,384. The resultant NPV savings would be $549,353 ($54,935/yr). The SIR and DPP for the conversion are 15.70 and 1.59 years, respectively. Conversion from the current disposal method to recycling of antifreeze with Glyclean machines is recommended.

Cleaning Solvent Waste

Cleaning solvents such as petroleum distillates (PD680-II), petroleum naptha, varsol, etc., are used in parts cleaning operations as discussed in Chapter 5. At Fort Ord, spent cleaning solvents are disposed of through DRMO as hazardous waste. Alternative management options such as recycling and reuse provide favorable economic returns over offsite disposal by minimizing waste and reducing raw material dependency. Implementation of a solvent recycling program, through either an offsite, closed-loop recycler such as Safety Kleen, or through the purchase of distillation equipment for use onsite, reduces both the quantity of solvent related wastes requiring disposal and the liability associated with hazardous waste disposal. The feasibility of implementing a specific recycling program depends on the type and volume of spent solvent generated. Fort Ord generates approximately 5573 gal/yr of spent PD680-II.

An economic analysis was performed to compare the practice of periodically purchasing fresh solvent and disposing of the waste offsite with recycling solvent by onsite distillation and offsite recycling by contract. Investment costs for onsite distillation options are assumed to all occur in the first year of the analysis. A 10-yr economic life, and midyear discounting at a rate of 10 percent are assumed for all options. The model's default values retained for analysis include: logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5.75 percent of equipment costs; and annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other major assumptions applied in the calculations are listed below.

- An annual escalation rate of 4 percent was applied to raw materials and replacement materials, maintenance and repair, other materials and supplies, utilities, sampling and testing, and liability.

- Escalation rates of 8 percent and 6 percent were used for recurring disposal and contractual costs, respectively.

- The liability costs were assumed as follows: onsite distillation and reuse - $0.03/gal; offsite disposal/sale - $0.03/gal; and contract recycling - $0.01/gal.

- Twenty percent of the solvents are assumed lost because of open lids (evaporation) and other poor operating practices.

- The volume of the still bottoms is assumed to be 10 percent of the waste volume.

- Fresh solvent is expected to be 30 percent of the volume.

- Repair and maintenance costs are calculated as 5.75 percent of the original cost of the equipment (in dollars per year) and are based on 2080 hours of operation. If the equipment is used less, the costs are adjusted.

- Laboratory analysis costs are assumed to be $75/yr for onsite distillation options.

- Transportation and warehousing costs are based on the volume of wastes generated at $2/100 gal.

- The cost of electricity is $0.05/kWh.

- The cost for disposal of still bottoms (assumed hazardous) and spent solvent through DRMO are $1.15/gal (FY90 price).

- The cost of new solvent (Safety Kleen - flash point 105 °F, boiling point 310-400 °F) is $1.60/gal; PD 680-II (NSN 6850-00-285-8011) is $2.24/gal.

- Because the boiling point of solvent is above 325 °F (PD680-II - b.p. > 350 °F), a vacuum attachment must be used in the distillation process.

- Labor cost for loading and unloading the still will be less than the 2 hr. According to manufacturers, the loading and unloading of a 55-gal still varies from 1/4 to 1/2 hours per batch.

- Utility costs are often provided by still manufacturers and typically range from $0.06 to $0.12/gal of solvent distilled ($0.10/gal was used for a 55-gal still).

- Labor associated with the transport of spent solvent to the distillation site is 1 hr/100 gal.

- Labor for 15- and 55-gal still operation are assumed to be 0.75 and 1.5 hours per batch, respectively.

- Three different size (10-, 20-, and 30-gal) parts washers are used in calculations for contract recycle options.

- A one-time installation charge of $30 is associated with each 30-gal capacity washer and is considered an investment cost.

- The still prices on GSA schedule (by Finish Engineering, Table 57) were used in the analysis. (Recyclene and Progressive Recovery, Inc. do not have GSA contracts.) Shipping costs for equipment are not included in the price. The purchase prices for 15- and 55-gal stills, with vacuum attachments, are $13,361 and $24,609, respectively.

- For onsite distillation options, 70 percent of the initial purchase of raw materials is included as an investment cost; the remaining 30 percent is included as an annual O&M cost.

- The same amount of waste generation (accounting for frequency of change) is assumed for owned equipment and disposal and contract recycling at 12.5 changes (services) per year.

Figure 7 shows the comparison of NPVs of the total life cycle (10-yr) costs for the following options: (1) purchase of fresh cleaning solvent and offsite disposal of waste through DRMO (status quo); (2) onsite distillation and reuse with a 55-gal still; (3) contract recycling offsite with leased parts washing equipment (LE) and low flash point (105 °F) solvent; (4) contract recycling offsite with owned parts washing equipment (OE) and low flash point (105 °F) solvent; (5) onsite distillation and reuse with two 15-gal stills; and (6) contract recycling offsite with leased parts washing equipment (LE) and high flash point (140 °F) solvent. The NPV of 10-yr costs were calculated for each of these options at waste generation rates between 1000 and 10,000 gal/yr.

Safety-Kleen (SK) is a typical contract recycling firm (on GSA schedule through June 1991). They offer two types of contracts. Under one contract, the solvent is supplied and the user leases equipment (recommended option). Under the other, only the solvent is supplied and recycled by the company and the user purchases equipment. The cleaning solvent supplied is equivalent to PD680 Type I (flash point 105 °F) or II (flash point 140 °F). In option 4 of this analysis, the necessary parts washing equipment is considered to have already been purchased and in place. Maintenance and repair of this equipment is the responsibility of the user.

Onsite distillation with a 55-gal still (option 2) is the most economical option at waste generation rates greater than 3000 gal/yr. An NPV investment of $39,917 results in NPV savings of $96,763 ($9676/yr) at the actual generation rate for Fort Ord (5573 gal/yr) when compared to the current practice of offsite disposal (option 1). NPV O&M costs associated with the current practice are $162,248 ($16,225/yr). The resultant SIR and DPP from the purchase and use of a 55-gal still are 2.61 and 4.75 years, respectively. Although onsite distillation is an economical option, the change in procurement, storage, and disposal procedures that would result could cause logistical and other problems for personnel involved in degreasing operations. Despite these considerations, recycling and reuse of spent solvent after distillation using a 55-gal still is recommended for Fort Ord.

Paint Thinner Waste

Paint thinner waste is generated from cleaning painting equipment as discussed in Chapter 7. Onsite distillation with 15- and 55-gal batch stills were the two options examined and compared with the current practice of purchasing fresh thinners and offsite disposal of thinner waste (1700 gal/yr).

Investment costs required for onsite distillation options are assumed to all occur in the first year of the analysis. A 10-yr economic life, and midyear discounting at a rate of 10 percent are assumed for all the options. The model's default values retained for analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5.75 percent of equipment costs; and annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other assumptions made in this economic analysis are given below.

- An escalation rate of 4 percent was applied to raw materials and replacement materials, maintenance and repair, other materials and supplies, liability, sampling and testing, and utilities.
- An escalation rate of 8 percent was used for offsite disposal costs.
- Liability costs were as follows: onsite distillation and reuse - \$0.03/gal; and offsite disposal - \$0.08/gal.
- In the recycling process, it is assumed that 20 percent of the waste stream must be replaced with new material in each cycle. Ten percent of the original material is assumed to evaporate and 10 percent is disposed of with the residue. Residue and thinner make up 20 percent of the original volume for disposal.
- Repair and maintenance is an annual cost at 5.75 percent of the original cost of the equipment and is based on 2080 hours of use per year. If the equipment is used less, the costs are adjusted.
- Laboratory analytical costs are estimated to be a certain percentage of labor costs. However, the minimum laboratory cost per sample may be substantially higher than the computed value for wastes generated in small volumes. A minimum of \$50 is assumed.
- Transportation and warehousing costs depend on the volume of waste handled and the distance between points of waste generation and distillation. For recycling/reuse options (2 and 3) an estimate of \$0.02/gal was used.
- Transportation costs for bringing waste thinner to DRMO for disposal are \$10/100 gal.
- Coc'ing water and electrical utility costs were based on model default values of \$0.70/1000 gal and \$0.05/kWh, respectively.
- Disposal cost of thinner waste is \$6/gal (FY90 price - DRMO).
- Distillation stills are available with or without vacuum attachments. If the boiling point of the solvent is below 300 or 350 °F, a still without vacuum attachment is considered. For recovery of solvents with boiling points between 300 and 500 °F, a vacuum attachment is necessary. Most paint thinners have a boiling point less than 300 °F. Although vacuum attachments may not be required on distillation equipment, they were considered in this analysis.
- The GSA price for a 5-gal container of paint thinner is \$3.65/gal. If available in a 55-gal drum, the price could be even lower. For this analysis, a price of \$3.65/gal is assumed.
- Labor costs for loading and unloading the still, especially for 15- or 55-gal sizes, will be less than 2 hr (default value in the model). The labor requirement for operating 15- and 55-gal stills are 3/4 and 1 hr per batch, respectively.

- Labor costs for drumming and transporting waste thinner to DRMO were estimated to be 1 hr/100 gal of waste. Managerial labor was estimated to accrue at a rate of 1/2 hr/100 gal.

- Utility costs (electricity and water) for still operation can be determined from the power input to the still and the rate of cooling water used. The cost of power per gallon of solvent distilled is estimated at $0.10.

- Equipment manufacturers such as Finish Engineering, Recyclene, and Progressive Recovery, Inc., were contacted for the price of distillation equipment. The price of one manufacturer was competitive with the price of similar equipment of another manufacturer (Table 57). Since Finish Engineering currently has a GSA contract, the corresponding GSA prices (15-gal, $13,361; 55-gal, $24,609) for stills with vacuum attachments were used.

- Eighty percent of the initial raw material purchase cost is included with the initial cost of equipment. The remaining 20 percent was included as an annual O&M cost.

With the above assumptions, life cycle costs were calculated for: (1) offsite disposal and purchase of fresh thinner (status quo or current practice); (2) onsite distillation with a 55-gal still; and (3) onsite distillation with a 15-gal still. Net present values of total 10 year costs were calculated for the above options for a number of annual generation rates ranging from 500 to 2000 gal/yr. Figure 8 shows the comparison between the NPVs for all the options.

No investment costs are associated with option 1. The purchase prices of the stills are shown in Table 57 (Finish Engineering prices). When compared to the other management options, a 15-gal still (option 3) is cost effective throughout the waste generation range as depicted in Figure 8.

Fort Ord generates approximately 1700 gal/yr of paint thinner waste which is disposed of through DRMO. The NPV O&M costs for the current practice are $143,706 ($14,371/yr). Investing $19,645 for a 15-gal still will result in an annual savings of $10,922. The SIR and DPP are 5.80 and 2.65 years, respectively. Purchasing a 15-gal still is therefore recommended. In addition to minimizing wastes, a payback can be expected in less than 3 years.

Spent 1,1,1-Trichloroethane/Degreaser Tank Bottoms

Several small capacity (75-gal) 1,1,1-trichloroethane vapor degreasing tanks were once located and frequently used within DOL vehicle and industrial maintenance shops on Fort Ord. Most of these tanks have been either retrofitted to use PD680-II, replaced with hot water jet washers, or deactivated from use. The tanks were used to clean a variety of vehicle components and other parts of grease, wax, or other oily grime before repair or overhaul. Each tank required cleaning at least three times per year. This involved complete draining and drumming of spent 1,1,1-trichloroethane, removing bottom sludges and accumulated trash, and replacing with fresh 1,1,1-trichloroethane. An additional 50 gal of fresh solvent was added to each tank every 45 days to replenish that lost during use to evaporation and equipment carry-off. To reduce the quantity of hazardous waste generated from DOL facilities and to improve the quality of working environments for personnel involved in degreasing operations, the use of 1,1,1-trichloroethane as a degreasing solvent was discontinued. Implementation of HAZMIN technologies, such as hot water jet washers that use biodegradable detergents, has eliminated the need for DOL personnel to purchase, store, or handle this toxic solvent. The logistics and liabilities associated with handling and disposal of spent waste and degreaser tank bottoms is also eliminated.

Investment costs to purchase new equipment are assumed to all occur in the first year of analysis. A 10-yr economic life, and midyear discounting at a rate of 10 percent are assumed for the two options. The model's default values retained for analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - \$16/hr; labor rate (laborer) - \$11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5.75 percent of equipment costs; transportation of hazardous waste - \$0.04 per pound; and annual logistics and procurement - 1.6 percent of other O&M costs.

Other assumptions made in this economic analysis are given below.

- An escalation rate of 4 percent was applied to the recurring costs of raw materials and replacement materials, liability, utilities, other materials and supplies, maintenance and repair, and sampling and testing.

- An escalation rate of 8 percent was used for offsite disposal costs.

- Liability costs were as follows: vapor degreaser operation - \$0.01/gal, and offsite disposal - \$0.08/gal.

- Evaporative loss from the operation of one vapor degreaser were known to be 45 gal every 6 weeks.

- Repair and maintenance costs for major equipment was based on use rates and 5.75 percent of the original purchase price. If equipment was to be used less than 2080 hours per year, costs were adjusted.

- Disposal costs for spent 1,1,1-trichloroethane and tank bottoms are \$2.50/gal (FY90 price).

- The volume of waste 1,1,1-trichloroethane generated for disposal (225 gal/yr) was based on the reported maintenance interval (3 times per year) and the working capacity of the degreasing equipment (75-gal).

- Purchase cost for fresh 1,1,1-trichloroethane is \$6/gal.

- Electrical utility and cooling water costs were based on model default values of \$0.05/kWh and \$0.70/1000 gal, respectively.

- Labor costs associated with vapor degreaser cleaning, maintenance, and solvent replenishment were estimated to be 24 man-hours/yr.

- Managerial labor costs were assumed to accrue in a supervisory capacity for option 1 at a rate of 1 hr/500 gal of waste generated for disposal.

- No labor costs were associated with maintaining and cleaning the jet washers.

- The purchase price for one Model-60 Jet Washer manufactured by Better Engineering, Mfg. (Baltimore, MD) is \$10,220 (including shipping and installation).

- The terminal cost for removing the old degreaser was estimated to be $200.

With the above assumptions, life cycle (10-yr) costs were calculated for options: (1) offsite disposal and purchase of fresh solvent, formerly the status quo; and (2) purchase and use of a hot water jet washer. Table 58 shows a comparison of the two options at the past waste generation and material use rates. The NPV O&M cost for option 1 was $44,287 ($4429 per year). Investing $11,405 in new jet washer equipment would result in an annual savings of $304. The SIR and DPP are 3.62 and 3.56 years, respectively. The results of this analysis indicate that the purchase of a hot water jet washer to replace a 1,1,1-trichloroethane vapor degreaser is an economically sound effort to minimize hazardous waste generation and to produce savings in annual O&M costs. The results of this analysis were included by DOL personnel in their request and justification for purchasing a hot water jet washer.

Spent Xylene Waste

Each year the Silas B. Hayes Army Community Hospital generates approximately 260 gal of spent xylene, an ignitable hazardous waste that requires costly offsite disposal. The majority of this waste stream is generated from laboratory activities within the histology and pathology departments in the hospital where xylene is used for fixation and preservation of tissue specimens. Unlike the xylene used at MPVM, IMMS, or PS for applying spray paints, xylene at the hospital is not entirely consumed in the laboratory process. It must meet strict laboratory purity standards. Waste xylene generated from the hospital is contaminated with paraffin and tissue and is temporarily stored in 5- to 10-gal drums before disposal through DRMO. An economic analysis is presented in this section to compare the costs of the procurement/disposal procedure for xylene currently practiced to those associated with recycling/reuse through the purchase and implementation of a spinning band distillation unit. The proposed recycling equipment is manufactured by BR Instrument Corporation (Pasadena, MD), and is available in 5- or 12-liter batch capacities. Use of such equipment would reduce the volume of hazardous xylene related wastes and consistently provide laboratory staff with a high grade solvent for tissue processing with minimal investment of time and energy.

Investment costs required to implement an onsite distillation program for spent xylene are assumed to all occur in the first year of the analysis. A 10-yr economic life, and a midyear discounting at a rate of 10 percent are assumed for this option. The model's default values retained for this analysis include: site preparation and equipment installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager)-$16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 260; average maintenance - 5.75 percent of equipment purchase costs; and annual logistics and procurement -1.6 percent of other O&M costs.

Other major assumptions made in this analysis are given below.

- An escalation factor of 4 percent was applied to raw material and replacement material purchases, maintenance and repair, other materials and supplies, liability, sampling and testing, transportation and warehouse storage, and utilities.

- An escalation rate of 8 percent was used for offsite disposal costs.

- Liability costs were as follows: onsite distillation and reuse - $0.03/gal; offsite disposal - $0.08/gal.

- In the recycling process, it is assumed that 10 percent of the waste stream is replaced with new material in each cycle. Five percent of the material is assumed to be lost to evaporative processes and 5 percent disposed of with the still bottoms.

- Repair and maintenance is an annual cost tha' is 5.75 percent of the original cost of the equipment and is based on 2080 hours of use per year. If the equipment is used less, the costs are adjusted.

- Laboratory analytical costs are estimated to be a certain percentage of labor costs. However, the minimum laboratory cost per sample may be considerably higher than the computed value for wastes generated in small volumes. A minimum of $50 is assumed.

- Transportation and warehousing costs depend on the volume of waste handled and the distance between points of material storage, waste generation, and waste disposal. For option 1 (offsite disposal through DRMO), a cost of $10.00/20 gal of spent xylene waste transported is used. For option 2 (onsite, in-house recycling) a minimal cost of $10 was used to cover the expense of transporting hazardous still bottoms to DRMO. This cost was held constant for all generation volumes under the premise that still bottom generation would never exceede 20 gal/yr.

- Costs of cooling water and electricity are assumed to be $0.70/1000 gal and $0.05/kWh, respectively. The cost of operating the proposed distillation unit is estimated to be $0.10/gal of recycled xylene.

- Disposal costs for spent xylene and xylene-contaminated still bottom residues are $3/gal (FY90 price DRMO).

- GSA listed price for the purchase of fresh xylene, ACS grade (NSN 6810-00-138-8414) is $6.50/gal.

- The Purchase price for one 12-liter spinning band distillation unit (BR Instruments Corporation, Model 8400) without a vacuum attachment is $11,300.

- Labor costs for drumming and transporting spent xylene waste to DRMO for offsite disposal are estimated at 1 hr/20 gal of waste and 1/2 hr/20 gal of waste for managerial labor.

- Labor required in option 2 is 1/2 hr/12-liter batch and 1/2 hr for still bottom transportation to DRMO for every 100 gal of waste xylene recycled. Managerial labor is assumed to accrue in option 2 at a rate of 1/2 hr for every 100 gal of recycled xylene.

- Ninety percent of the cost of initial raw material purchase is included as an investment in the onsite recycling option as a startup expense. The remaining 10 percent is accounted for as a recurring O&M cost.

With the above assumptions, life cycle costs were calculated for (1) offsite disposal and purchase of fresh xylene (status quo), and (2) onsite distillation with a 12-liter batch still. Net present values of total 10-yr costs were calculated for the options for annual generation rates ranging from 100 to 400 gal/yr. Figure 9 shows the comparison between the NPVs for both options. NPV O&M costs for the current practice are $23,550 (or $2355 per year). Investing $14,061 in a 12-liter distillation unit would result in an annual savings of $1494. The computed SIR and DPP for this option are 1.14 and approximately 10 years respectively.

There are no investment costs associated with option 1 (status quo). Purchase and use of the 12-liter batch still is cost effective at waste generation volumes above 220 gal/yr. An ancillary analysis that used the costs associated with a smaller batch still (5-liter) manufactured by the same company (BR Instruments) provided no economic incentives at the generation rate applicable to the hospital because of increased labor costs. The purchase of a 12-liter distillation unit is therefore recommended for immediate implementation at the Silas B. Hayes Army Community Hospital on Fort Ord.

Aqueous Paint Sludge Waste

Paint sludge is generated from the use of wet-wall (or waterfall type) paint booths. There are two such paint booths of this type at Fort Ord. One booth is located in Bldg 1665 and is used by DPTM-TASC Graphics Shop personnel. The second wet booth is located in Bldg 2252 and is part of DPCAs Arts and Crafts Section. Both booths are considered small and have histories of problems with plumbing and adequate air exchange. An economic analysis is presented in this section to compare the costs of converting these booths to dry filter booths. Such a conversion would completely eliminate the generation of aqueous paint sludge wastes.

Investment costs for wet to dry paint booth conversion are assumed to all occur in the first year of the analysis. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for this option. The model's default values retained for analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man-hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; number of work days in a year - 247; average maintenance -5 percent of equipment costs; transportation of hazardous waste - $0.04/lb; and annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other major assumptions made in the economic analysis for small paint booth conversion are listed below.

- A small paint booth is approximately 6 ft wide, 9 ft deep, and 9 ft high.
- The solids content of the paints used is 40 percent.
- The transfer efficiency is 35 percent.
- The sump capacity is 280 gal.
- Water from the sump is drained and filtered every 4 weeks.
- Eighty percent of the solids deposited in the sump (during various painting operations) is collected as sludge.
- The sludge contains 25 percent solids and 75 percent liquid (mostly water).
- Sludge removed from the collection sump is drummed and shipped offbase as a hazardous waste.

- Liquid is discharged to the wasteweater treatment plant.
- The capacity of the airduct fan is 3 hp.
- The curtain size is 6 ft wide and 6 ft high.
- The capacity of the water pump is 5 hp.
- The frequency of use is 1/2 a working shift/day/5-day workweek.
- The volume of paint used is 5 gal/day.
- The volume of replacement water for the sump is 3500 gal.
- The volume of wastewater is 3500 gal.
- The volume of sludge generated is 26 gal in 4 weeks [solids deposited in sump per day = 0.4 gal; recovery at 80 percent in 4 weeks = 8 x 0.8 = 6.4 gal; volume of sludge (containing 25 percent solids) = 6.4 x 4 = 26 gal in 4 weeks].
- A fiberglass cartridge dry filter system is used for replacement.
- The cost to install the fiberglass filter system is $280/linear ft.
- The filter capacity is 0.02 gal of paint/sq ft.
- Filter replacement cost is $0.20/sq ft.
- The linear flow rate after conversion is 125 ft/min [volumetric flow rate = cross sectional area of booth x 125 = 6 x 9 x 125 = 6750 sq ft].
- The airflow rate through a clean fiberglass filter is 150 ft/min.
- The area of the cartridge is 45 sq ft [i.e. 6750/150 = 45].
- To ensure a sufficiently low pressure drop, a surface area of 50 sq ft is considered [therefore, cost of (5 ft x 50 ft) filter face = 5 ft x $280/ft = $1400].
- The quantity of solids to be collected on the filter is 1 gal.
- The overspray rate is 0.39 gal of solids per day.
- Filter replacement frequency is 2 times per week.
- The fan in the airduct may be downsized from 3 to 2 hp (considered, an even exchange - no additional investment).

- Labor required for filter replacement is 1 hr/week.

- Labor for sump draining, cleaning, and drumming of sludge is 52 hr/yr.

- The cost of electricity is $0.05/kWh.

- The cost of sludge disposal is $300/55-gal drum [number of drums of sludge per year = (52 x 26) / (4 x 55) = 6; disposal cost = $1800/yr].

- Disposal drums cost $20 each.

- The cost of water used is $3/1000 gal.

- Electricity used by one wet paint booth over the course of 1 year is 6214 kWh.

- The escalation rate for disposal is 8 percent and for others it is 4 percent.

- Fiberglass filter replacement costs are $1040/yr.

- Disposal costs for spent dry filters is negligible.

- Electricity used by one dry paint booth over the course of 1 year is 1552 kWh.

Table 59 lists the life cycle (10-yr) costs of two small wet and dry paint booths. The table also provides results of the detailed comparison for conversion of each booth in terms of SIR and DPP.

The NPV O&M costs for one small wet-booth are $25,036 ($2504 per year) . Compared to the NPV O&M costs for one similar sized dry-booth, $13,407 ($1341 per year), conversion of the wet paint booth operation at DPTM-TASC- Graphics Shop to a dry filter type would result in an estimated NPV savings of $10,537 ($1054/yr). Conversion of the wet paint booth operation at DPCA-Arts and Crafts Section would provide a similar NPV savings. An investment of $1562 at each of these facilities provides a SIR of 7.44 and a DPP of 2.45 years. In addition to complete elimination of aqueous paint sludge wastes, a considerable savings and quick payback can be realized. Conversion of both the existing wet paint booths on Fort Ord to use dry filters is recommended.

Spent Drycleaning Filters

AAFES administers various convenience facilities on Fort Ord for military employees and their families. The responsibility of laundry and drycleaning service has been deligated to Economy Cleaners, a privately owned and operated business that functions as a subcontractor of AAFES. The only reported hazardous waste generation from Economy Cleaners is spent drycleaning fluid filters that are managed by Safety Kleen. Safety Kleen provides monthly pickup of spent filters, recyclable disposal containers, and transportation of the filters to an offsite disposal facility. Safety Kleen manifests each pickup as hazardous waste. The filters are known to contain darco carbon, clay, lint, and possibly residual quantities of PD680-II, the drycleaning solvent used by Economy Cleaners. Filters are replaced approximately every 18,000 lbs of drycleaned clothes and are determined as spent based on an observed pressure loss in the solvent supply line. Replacement filters and fresh drycleaning solvent are purchased from private vendors based on competetive bids. A considerable reduction in disposal costs for Economy Cleaners could be achieved if spent filters could be disposed of through DRMO or if the filters could be determined nonhazardous and disposed of as solid waste in the local landfill. Incentives of these alternatives include the possibility of reduced drycleaning costs for patrons of Economy Cleaners and reduction of total hazardous waste generation for Fort Ord.

Model default values retained for this analysis include: labor rate (manager) - $16/hr; labor rate (laborer) - $11/hr; adjustments for leave - 18 percent of total man hours; adjustments for fringe benefits - 36.2 percent of adjusted base labor cost; and annual logistics and procurement - 1.6 percent of other O&M costs. Other assumptions used in this economic analysis are listed below.

- Current disposal cost for spent filters through Safety Kleen was approximated at $1.35/lb. This value was derived from a review of manifest copies kept on file at Economy Cleaners and based on 4 months of generation.

- Disposal cost for the same filters through DRMO was approximated at $0.15/lb based on FY90 prices.

- Liability for filter disposal in both options is $0.008/lb.

- The 30-gal disposal drums used in option 2 cost $15 each and must be purchased annually.

- The cost to transport spent filters to DRMO in option 2 was estimated at $0.01/lb.

- The approximate weight of one spent drycleaning fluid filter was estimated to be 50 lb.

- One hour of labor was assumed necessary to transport 1000 lb of spent filters to DRMO, no managerial labor requirements were considered in either option.

- Annual cost escalations were as follows: offsite filter disposal through DRMO - 8 percent; offsite filter disposal through Safety Kleen - 6 percent; liability, other materials and supplies (disposal drums), onsite transportation, and liability - all 4 percent.

- Annual spent filter generation rate was estimated at approximately 9500 lb. This rate was based on an average monthly generation rate of 793 lb reported for 4 months (March through June, 1989).

With the above assumptions, life cycle costs were calculated for (1) offsite disposal through Safety Kleen (status quo), and (2) offsite disposal through DRMO. Net present values of total 10-yr costs were calculated for the above options for generation rates ranging from 1000 to 15000 lb/yr. Figure 10 illustrates the comparison between the NPVs for both options.

Based on the estimated rate of spent filter generation at Economy Cleaners, the current NPV O&M costs associated with disposal through Safety Kleen are $106,034 ($10,603 per year). Alternatively, the NPV O&M costs of disposal through DRMO are estimated at $24,313 ($2431 per year), which provide an NPV savings of $81,720 ($8172/yr). Since investment costs were not considered with either of these two options, neither SIR nor DPP values could be calculated.

Table 55

Savings to Investment Ratios and Discounted Payback Periods for a Fast Lubricating Oil Change System

Number of Vehicles	SIR	DPP
100	0.38	> 10
250	0.39	> 10
500	0.39	> 10
1000	0.39	> 10
5000	0.39	> 10

Table 56

Savings to Investment Ratios and Discounted Payback Periods for a Fast Lubricating Oil Change System for 1000 Vehicles

Number of Oil Changes	SIR	DPP
2	0.39	> 10
4	0.79	> 10
5	0.98	> 10
6	1.17	9.99

Table 57

Purchase Cost of Distillation Stills (in 1989 dollars)

Manufacturer	Model	Capacity (gal)	Price ($)	
			no vacuum attachment	vacuum attachment
Finish Engineering	LS-Jr	5	2770	4338
	LS-15IID	15	10,128	13,361
	LS-55IID	55	20,123	24,609
Recyclene	R-2	5	2995	
	RS-20	20-25	11,900	
Progressive Recovery, Inc.	SC-25	15	7290	12,865
	SC-50	35	11,300	16,895

Table 58

Comparison of Costs and Calculated SIR and DPP for a Hot Jet Washer and Vapor Degreaser

Option Name	Inv. Costs. $	O&M Costs $ ($/yr)	Total $	SIR	DPP years
1,1,1-Trichloroethane Vapor Degreaser	-	44,287 (4429)	44,214	-	-
Hot Jet Washer	11,405	3036 (304)	14,441	3.62	3.56

Table 59

Comparison of 10-year Costs and SIR and DPP for Wet and Dry Paint Booth Operations

Option Name	Inv. Costs. $	O&M Costs $ ($/yr)	Total $	SIR	DPP years
Wet Booths	-	50,072 (5007)	50,072	-	-
Dry Booths	3124	26,814 (2681)	29,938	7.44	2.45

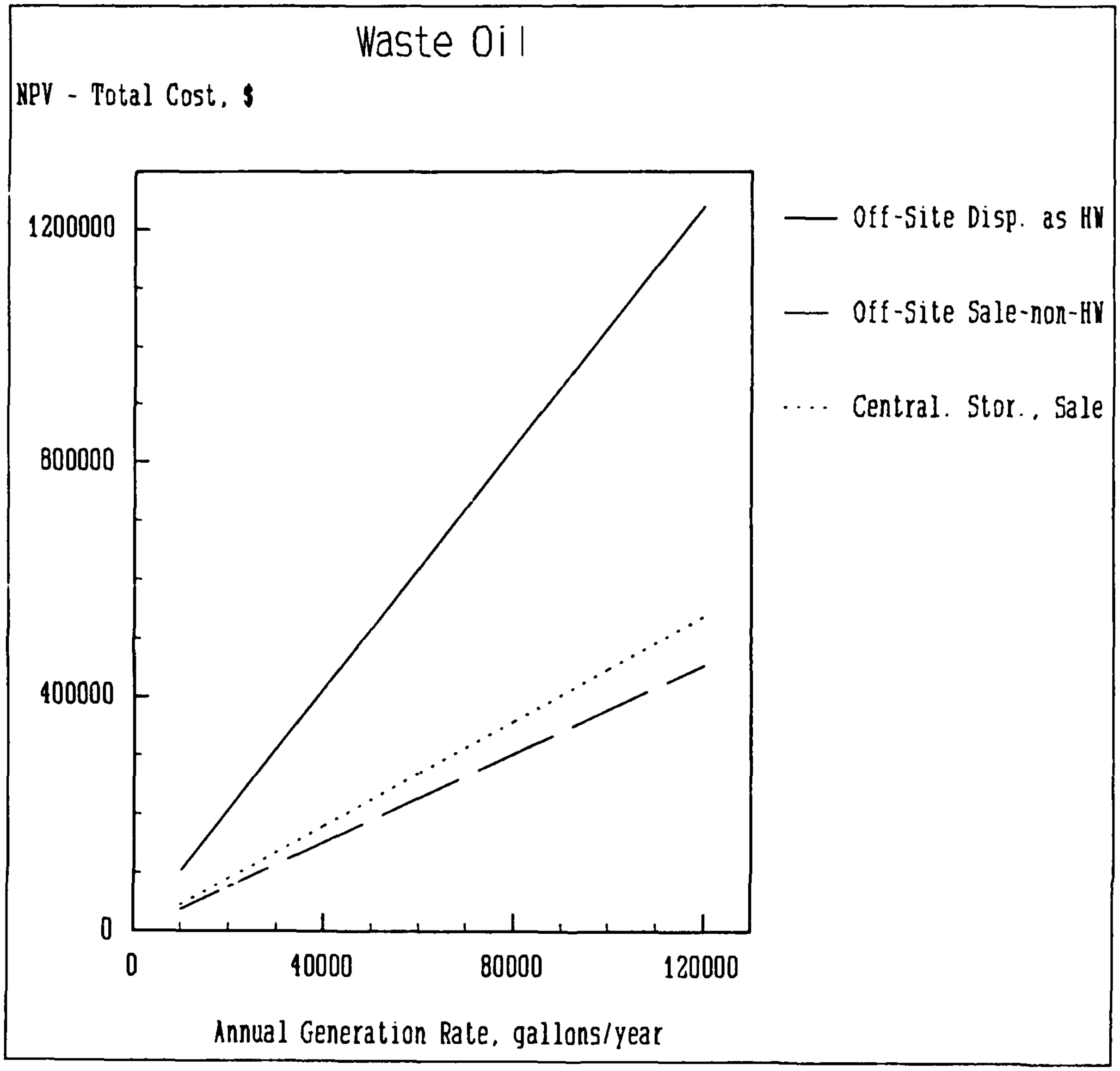

Figure 5. Comparison of the Net Present Values for used oil minimization options. Offsite disposal through DRMO as hazardous waste defines the status quo.

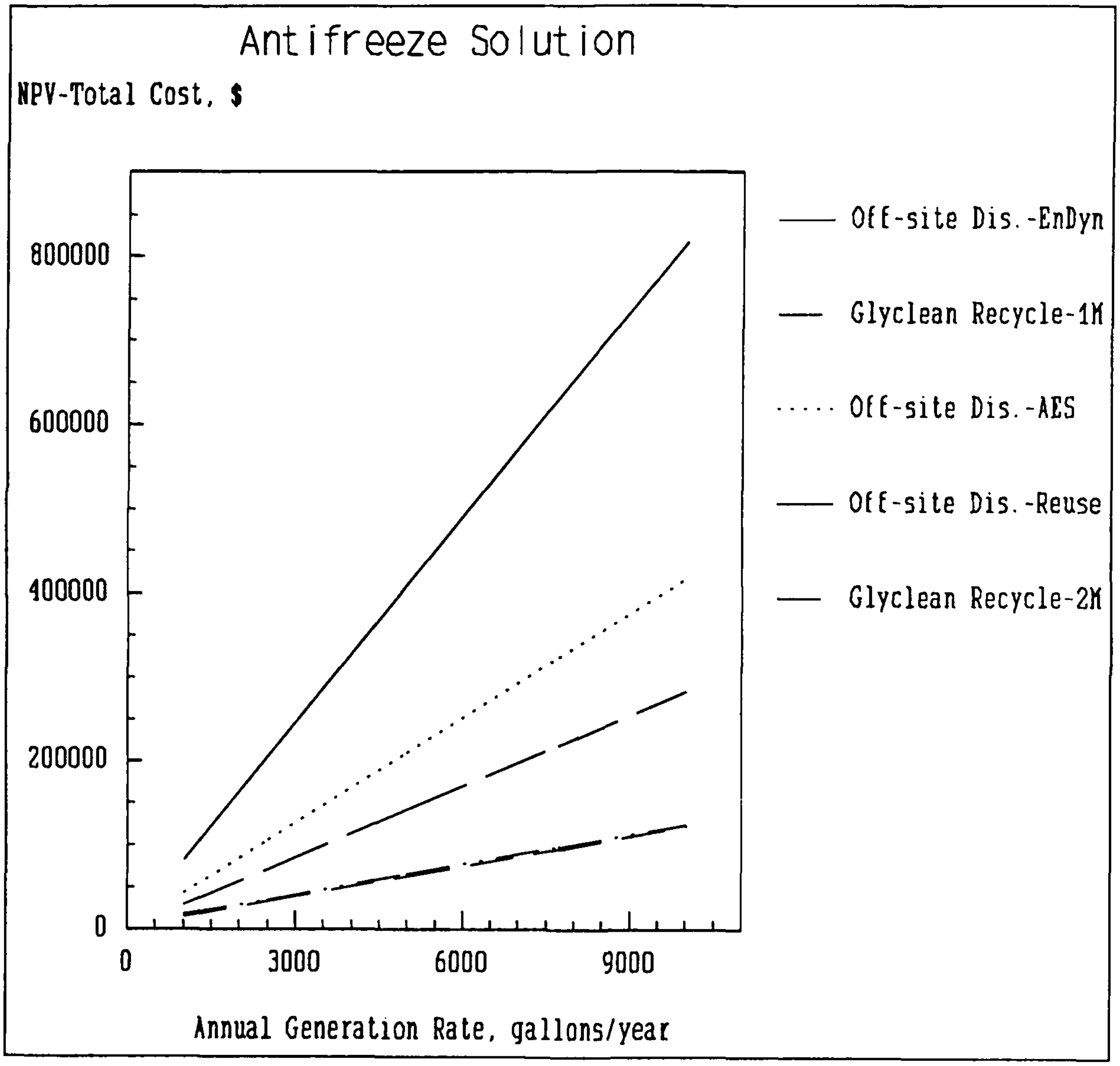

Figure 6. Comparison of the Net Present Values for spent antifreeeze minimization options. Offsite disposal as hazardous waste defines the status quo.

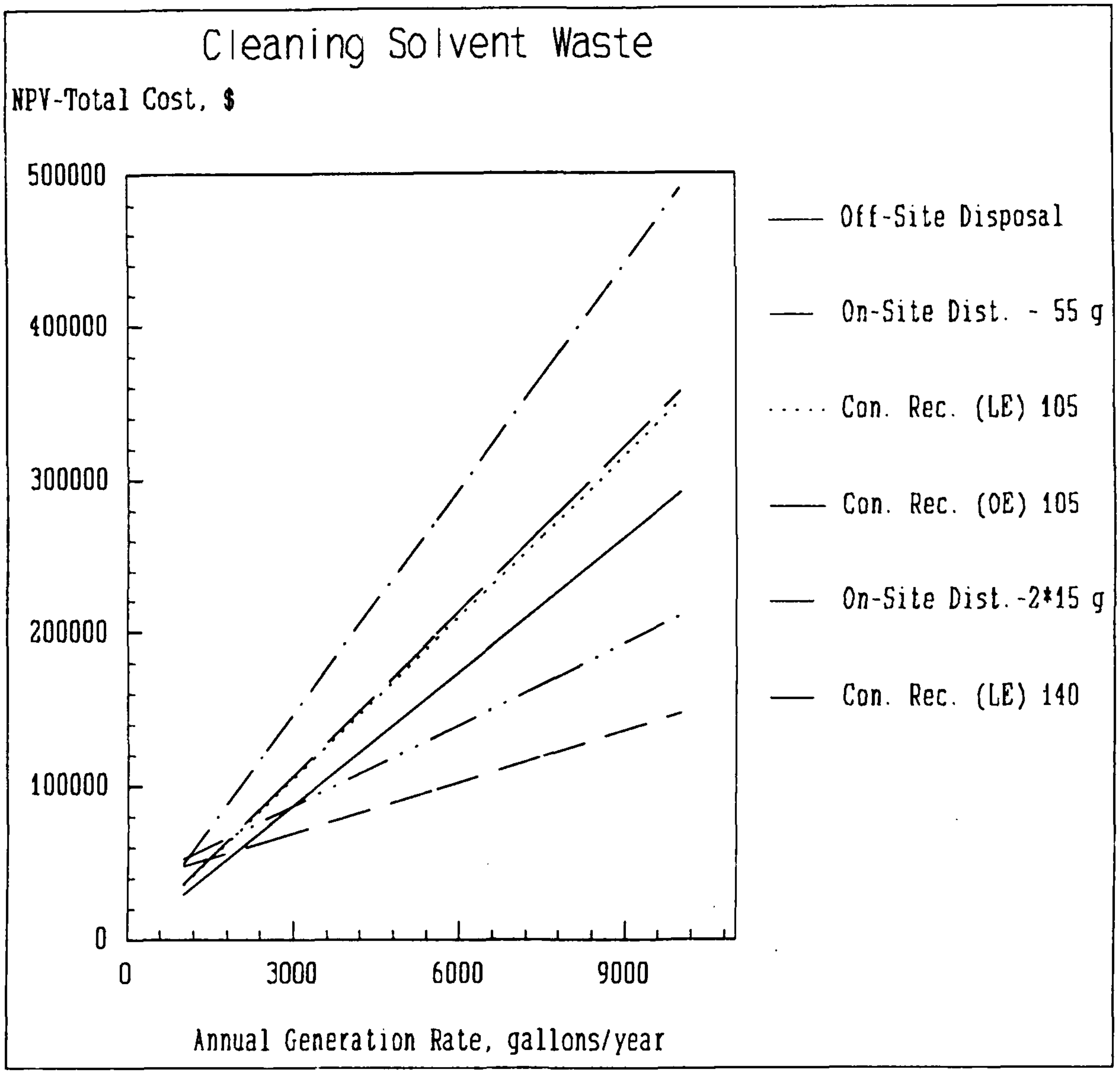

Figure 7. Comparison of the Net Present Values for cleaning solvent waste minimization options. Offsite disposal as hazardous waste defines the status quo.

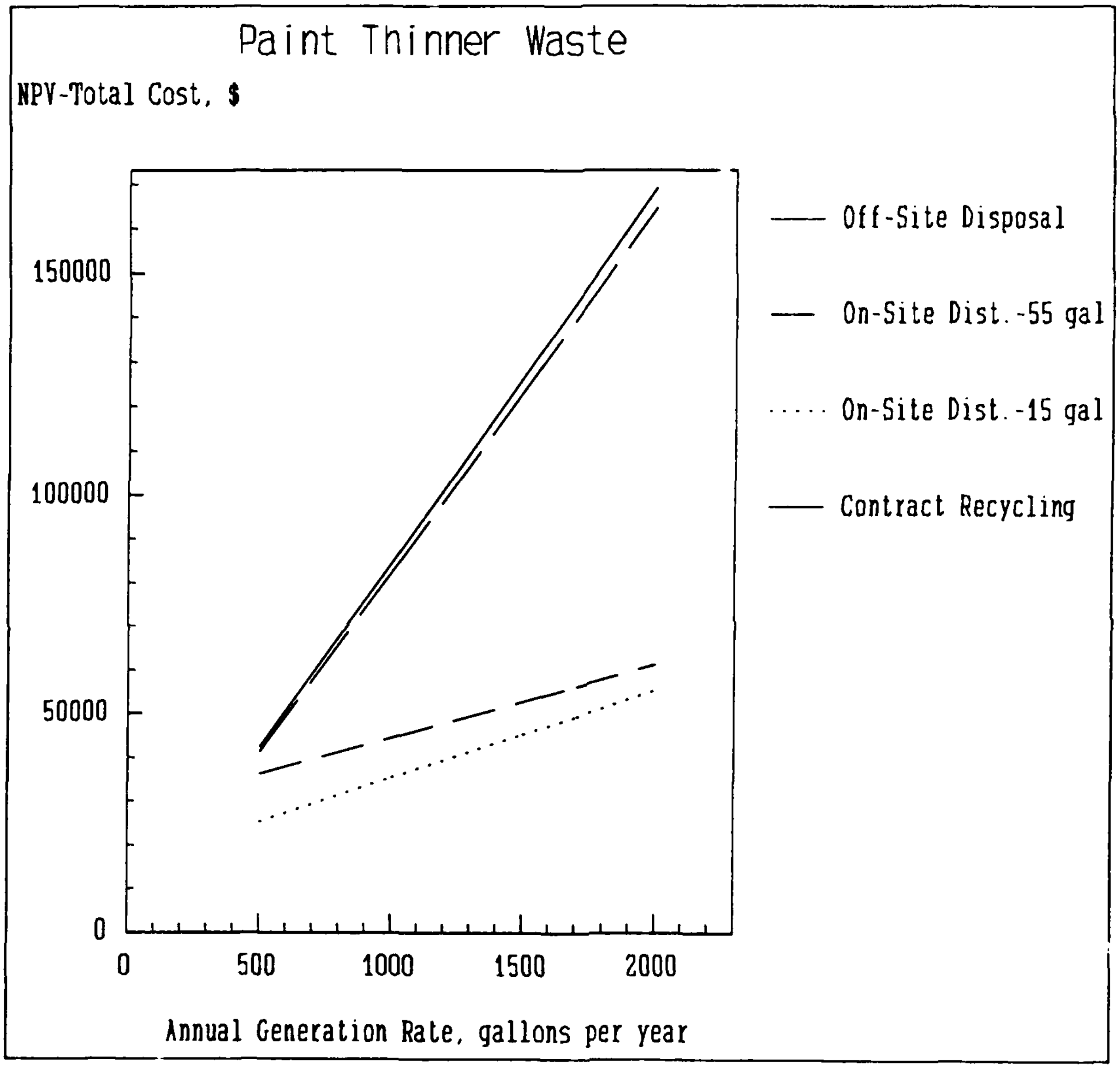

Figure 8. Comparison of the Net Present Values for paint thinner waste minimization options. Offsite disposal through DRMO as hazardous waste defines the status quo.

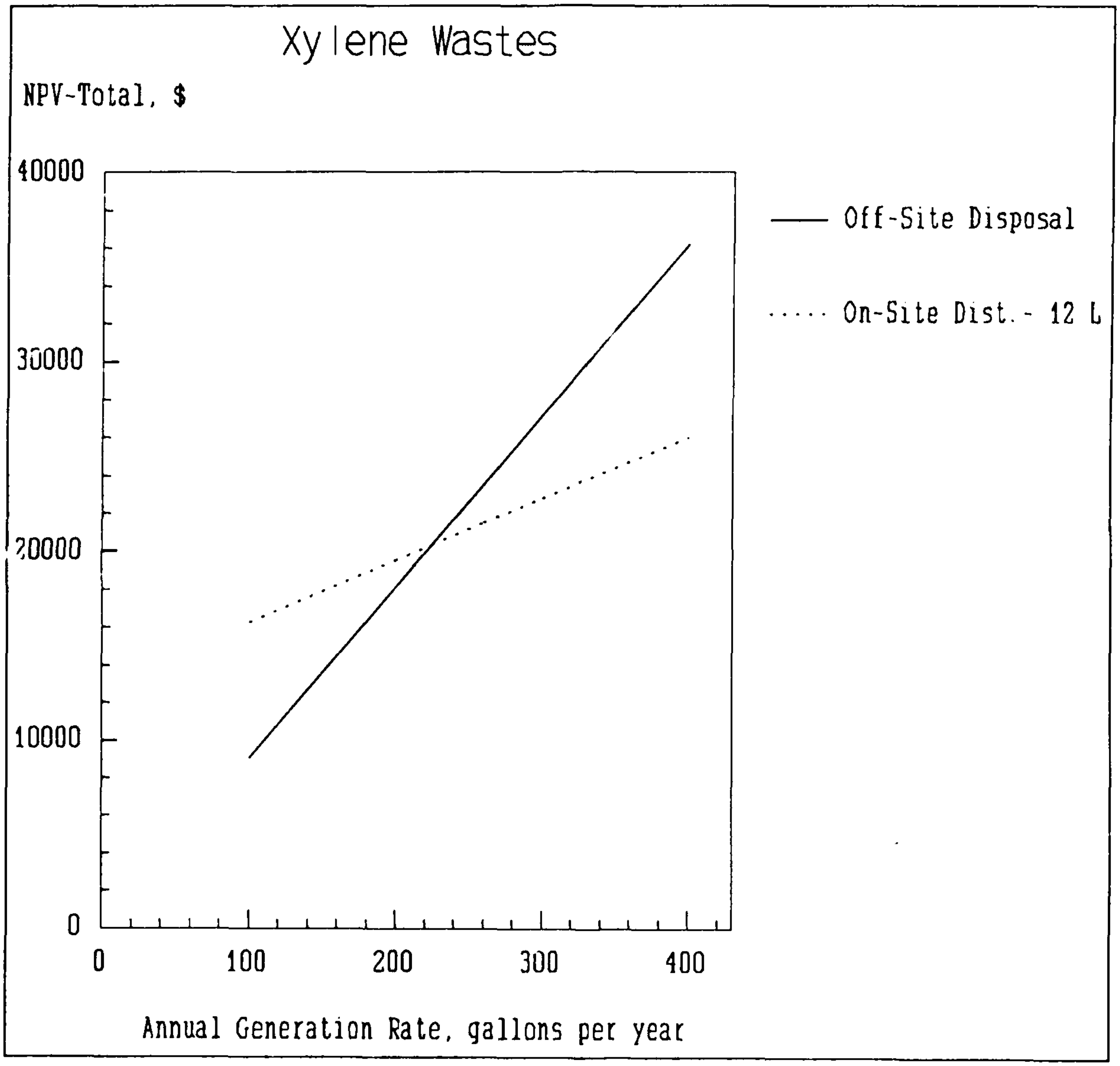

Figure 9. Comparison of the Net Present Values for waste xylene minimization options. Offsite disposal defines the status quo.

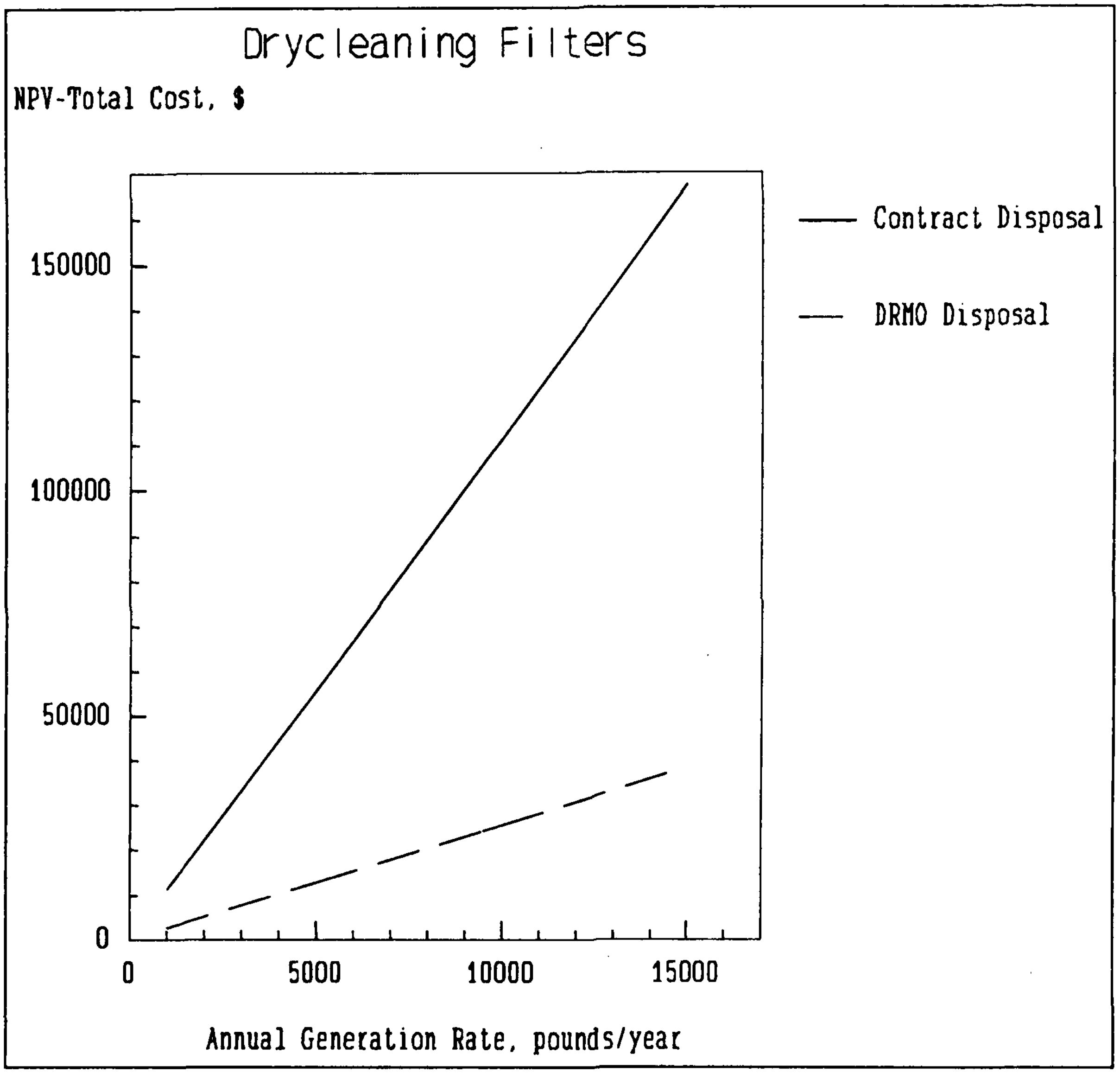

Figure 10. Comparison of the Net Present Values for drycleaning filter waste minimization options. Contract disposal as hazardous waste defines the status quo.

13 SUMMARY AND RECOMMENDATIONS

Summary

All Army installations that are generators or small quantity generators (according to RCRA definitions) are required to implement waste minimization programs to reduce hazardous waste generation. Waste minimization is a method of preventing pollution with the primary focus on reducing waste generation at the source. A number of benefits are accrued by implementing a waste minimization program. The benefits can be classified into the following four categories: economic, regulatory compliance, reduced liability, and positive public image/community relations.

Minimization of a particular waste can be achieved by an appropriate combination of source reduction, recycling onsite/offsite, and treatment techniques. Source reduction is on the top of USEPA's heirarchy of waste management priorities. It is followed by recycling, waste separation and concentration, waste exchange, energy/material recovery, waste incineration/treatment, and, finally, ultimate disposal. A number of waste minimization techniques have been discussed in this report pertaining to wastes generated from: motor pools/vehicle maintenance facilities; aviation maintenance facilities; industrial maintenance, small arms shops; paint shops; printing, photography, arts/crafts shops; hospitals, clinics and laboratories; and other miscellaneous sources on an Army installation.

Fort Ord is a troop installation with very few tenants. It is regulated by the USEPA and the State of California as a generator of hazardous waste and an owner of treatment, storage, and disposal facilities.

A HW management program has been established with the development of a "Hazardous Waste Management Standard Operating Procedure" document and an inspection program that is followed by all the generators. Properly bermed and secure storage areas are available to all generators for temporary storage of hazardous wastes. There is, however, no inventory of HW generated. A formal HW Management Plan does not exist and there is no tracking of HM or HW.

Spent lead-acid batteries are exchanged by generators for new batteries. The used unserviceable batteries are recycled wet through a Department of Energy lead recycling program. By recycling batteries wet, Fort Ord is exempt from RCRA reporting requirements and has already eliminated generation of a considerable quantity of corrosive waste commonly found on FORSCOM installations.

The DOL Maintenance Division has replaced all its vapor degreasers with hot jet washers, thus completely eliminating generation of chlorinated solvent (1,1,1-trichloroethane) wastes. An estimated annual savings of $3,851 has been realized for each of the degreasers replaced. In some cases, PD 680-II is used as substitute solvent in place of 1,1,1-trichloroethane.

In the past, paint was stripped from aircraft using methylene chloride and phenolic formulated chemical strippers. The actual stripping process was conducted on washracks, violating many hazardous waste and water pollution regulations. This process was completely abandoned with the installation of dry plastic media blasting booths. Very small quantities of residual wastes are generated in the dry stripping process. All the wet, waterfall paint booths, except for two, have been converted to dry booths. The generation of aqueous wastes/paint sludge has already been minimized.

POL products are generated in the largest quantity (441,040 lb/yr) at Fort Ord. They are followed by spent ethylene glycol and other alcohols (71,228 lb/yr), spent nonhalogenated solvents (55,732 lb/yr), spent acids and bases (27,597 lb/yr), paint related materials (22,446 lb/yr), miscellaneous chemicals (22,345 lb/yr), and paint thinner (12,740 lb/yr). Other miscellaneous materials account for 352,205 lb/yr. An estimated total of 495 tons per year of wastes are generated. This estimate does not include PCB transformers.

The wastes selected for technical economic analysis included: waste oil, spent antifreeze solution, spent cleaning solvent, paint thinner, xylene, 1,1,1-trichloroethane and sludge containing this solvent, aqueous paint sludge, and drycleaning filters. The options examined include current practices (offsite disposal, burning, etc.), onsite recycling (e.g., distillation, filtration, etc.), contract recycling, segregation/processing, and process equipment modification. Most of the other wastes (e.g., contaminated fuels) can be minimized by implementation of simple source reduction techniques (better operating practices).

Recommendations

A formal HW management plan must be developed and adopted by Fort Ord to comply with AR 420-47. A waste analysis plan to characterize and define all (air, water, liquid, and solid) wastes from all the generators should be implemented, to include frequency of analysis, etc., to ensure compliance with Federal and State of California laws.

A training program must be established to train civilian and military personnel in proper HW management (including packaging, labeling, storing, transport, etc.) and minimization.

The ENRO Office personnel must conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes. Comprehensive inventories of hazardous materials used and wastes generated must be updated periodically to reflect changes and disbanding of certain activities.

An HM and HW tracking (manifest) system should be implemented. Tracking HM from the supply warehouse to users and HW from the generators to final storage before disposal will provide a mass balance and improve minimization opportunities.

All generators must develop an inventory system and maintain proper records (log-books) of materials procured and wastes generated from each of the activities. These records must be subject to regular inspections by the supervisors and ENRO office personnel.

Implementation of the HAZMIN plan (Appendix A) must begin immediately; the plan should be updated annually.

Plan Implementation

Careful planning and a systematic approach are required to implement a successful waste minimization program. Three key elements (policy, commitment, and responsibility) are necessary for a strong program foundation.

The Commander must prepare a formal, written policy on waste minimization and pollution control, including its philosophy, objectives, and proper practices. Such a policy must be publicized in the installation newsletters and distributed to all the military and civilian employees. An example of a policy statement is provided in Appendix C. The installation command heirarchy and all the commanders of tenant activities must adopt and support the policy statement. They should also willingly commit resources necessary to launch and support the waste minimization program.

A leader (such as the Director, EENR) should be appointed to oversee, direct, and assume all responsibility for the program. Supervisors and other employees of waste generating activities must be committed to the program for it to be effective. To encourage such a commitment, the Commanders and supervisors must implement motivational techniques. They must set goals for achieving waste/emissions reduction and provide incentives and awards for implementation of waste minimization ideas.

All waste generators must immediately implement HAZMIN options that require little or no capital investment (e.g., procedural or administrative changes) as discussed in Chapters 5 through 11. These options are generally characterized as "better operating practices," a subcategory of source reduction that does not require detailed technical and economic evaluation. Better operating practices are methods that achieve source reduction by:[169] (1) segregation (e.g., eliminate mixing hazardous and nonhazardous wastes to improve their recyclability); (2) improved material handling and inventory practices (e.g., avoid accumulation of expired shelf-life materials, avoid spills, etc.); (3) preventive maintenance (e.g., prevent leaks and spills); (4) production scheduling (e.g., minimize quantities of unused raw materials and batch-generated wastes); and (5) minor operational changes. Implementation of "better operating practices" usually requires only minimal employee training and changes to standing operating procedures/practices (SOPs).

The feasible options, discussed in Chapter 12, for minimization of waste oil, antifreeze solution, cleaning solvent waste, spent paint thinner, xylene waste, spent 1,1,1-trichloroethane and its sludge, and drycleaning filters must be funded and implemented. Improved segregation practices and construction of a central storage facility for waste accumulation will alleviate the generation of hazardous waste oil. Used oil, if handled properly, is not a hazardous waste. Testing is required, under California rules, to prove that the oil is nonhazardous. If found nonhazardous, the oil can be sold to recyclers with an estimated annual savings of $32,323. A payback period of 3.31 years is expected on the investment in the tank farm. Onsite recycling of cleaning solvent using a 55-gal batch still must be implemented. An investment of $39,917 and an annual operation and maintenance cost of $5789 is required. This recycling will result in an annual savings of $9676 and payback will be realized in 4.75 years. A large quantity of antifreeze solution is generated at Fort Ord. Spent antifreeze can be recycled as discussed in Chapter 5. An investment of $36,384 is required to purchase two Glyclean recycling machines. With an annual savings of $54,935 when compared to offsite disposal, a payback period of 1.59 years is expected. For paint thinner waste, it is recommended that a small 15-gal batch still be purchased at a total investment cost of $19,645. The annual operating cost is $2972 and payback can be expected in 2.65 years. Xylene wastes must also be distilled and the xylene recycled. Purchase of a 12-liter spinning band distillation unit at a total investment of $14,061 will provide an annual savings of $1494 compared to current practice of offsite disposal. The payback period is approximately 10 years if the equipment is used for xylene only. It could also be used to distill ethanol and other organic compounds commonly used in the hospital.

The laundry and drycleaning plant, which is operated under contract by Economy Cleaners, generates filters contaminated with residual amounts of PD 680-II, lint, and dirt. Safety Kleen provides the service of transporting the filters at an annual cost of $10,603. These filters are not a hazardous waste and can be proven so by testing. They could be disposed of as solid waste on post. However, if disposal through DRMO is preferred as an alternative to current practice, an annual savings of $8172 can be realized.

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[169] National Association of Manufacturers, *Waste Minimization: Manufacturers' Strategies for Success* (Prepared by ENSR Consulting and Engineering, 1989).

Conversion of the two remaining wet paint booths to dry operations will require an investment of $3124. With an annual savings of $2108, this conversion will provide a payback in 2.45 years.

Generation of all other wastes can be reduced by more than 30 percent by managerial changes, training, and implementation of better operating practices and other appropriate minimization techniques as discussed in Chapters 5 through 11.

The Fort Ord Hazardous Waste Management Board, chaired by the Assistant Division Commander (Support), must adopt the HAZMIN plan and establish policies and procedures required for its implementation. The expected implementation date is 30 September 1990.

After implementing HAZMIN techniques at the generating activities, progress must be monitored and results recorded. The quantities of wastes generated before and after implementation must be monitored and the achievements in waste minimization (e.g., percent minimized) documented. Waste minimization of 34 percent and "hazardous" waste minimization of 56 percent (see Appendix A, and Table A3) are to be expected upon proper implementation.

A waste minimization program never ends. Preventing waste generation and thereby reducing the pollution of air, land, and water, must be a continuous quest. The goal of such a program must be to reduce wastes to the maximum extent possible. All waste generating processes must be continuously assessed and reassessed to account for changes in economic status (e.g., increase in disposal costs), changes in design of production processes, maintenance procedures, and/or technical/technological breakthroughs.

METRIC CONVERSION TABLE

1 Btu	=	0.293 W
1 gal	=	3.785 l
1 in.	=	25.4 mm
1 mi	=	1.6 km
1 lb	=	0.37 kg
1 psi	=	6.895×10^3 Pa
1 ton	=	0.9 MT
°C	=	5 (°F - 32)/9

CITED REFERENCES

40 CFR 260, *Hazardous Waste Management System: General* (1985).

40 CFR 261, *Identification and Listing of Hazardous Waste* (1985).

40 CFR 262, *Standards Applicable to Generators of Hazardous Waste* (1985).

40 CFR 264.16, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities* (1985).

40 CFR 280-281, *Underground Storage Tanks: Technical Requirements and State Program Approval; Final Rule*, pp 37081 - 37247.

Acurex Corporation, *Navy Paint Booth Conversion Feasibility Study*, CR 89.004 (Prepared for the Naval Civil Engineering Laboratory [NCEL], Port Hueneme, CA, 1989).

Alternative Technology for Recycling and Treatment of Hazardous Wastes, Third Biennial Report (California Department of Health Services, Alternative Technology and Policy Development Section, 1986).

Anderson, C.W., *Cost-Effectiveness Analysis of Lubricant Reclamation by the Navy*, Technical Note 1481 (NCEL, Port Hueneme, CA, 1977).

Army Regulation (AR) 40-5, *Preventive Medicine* (Headquarters, Department of the Army [HQDA], 30 August 1986).

AR 200-1, *Environmental Protection and Enhancement* (HQDA, 15 June 1982).

AR 200-2, *Environmental Effects of Army Actions* (HQDA, 23 December 1988).

AR 420-47, *Solid and Hazardous Waste Management* (HQDA, 1 December 1984).

AR 420-76, *Pest Management* (HQDA, 3 June 1986).

ASTM Standard D2942-86, "Standard Test Method for Total Acid Acceptance for Halogenated Organic Solvents (Nonreflux Methods)," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (American Society of Testing and Materials [ASTM], 1988).

ASTM Standard D2847-85, "Standard Practice for Testing Engine Coolants in Car and Light Truck Service," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (ASTM, 1988).

ASTM Standard D3640-80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (ASTM, 1988).

Beller, J.M., et al., *Biodegradable Solvent Substitution - A Quick Look Report* (U.S. Air Force Logistics Command, Tyndall Air Force Base, FL, 1988).

Bonds, J.D., K.J. Tribbey, and K.A. Civitarese, *Update of the Initial Installation Assessments of Fort Ord and Subinstallations, Presidio of Monterey, and Fort Hunter Liggett*, AMXTH-IR-A-196(U) and 196D(U) (Prepared for the Commander, 7th Infantry Division and Fort Ord, Fort Ord, CA, and the U.S. Army Toxic and Hazardous Materials Agency [USATHAMA], Aberdeen Proving Ground, MD, August 1986).

Brinkman, D.W., W.F. Marshall, and M.L. Whisman, *Waste Minimization through Enhanced Waste Oil Management*, NIPER B06803-1 (National Institute for Petroleum and Energy Research, 1987).

Brinkman, D.W., M.L. Whisman, and C.J. Thompson, *Management of Used Lubricating Oil at Department of Defense Installations: A Guide*, NIPER B06711-1 (National Institute for Petroleum and Energy Research, 1986).

Campbell, M.E. and W.M. Glenn, *Profit from Pollution Prevention - A Guide to Industrial Waste Reduction and Recycling* (The Pollution Probe Foundation, Toronto, Canada, 1982).

Chicoine, L.C., G.L. Gerdes, and B.A. Donahue, *Reuse of Waste Oil at Army Installations*, Technical Report N-135/ADA123097 (U.S. Army Construction Engineering Research Laboratory [USACERL], September 1982).

Ciccone, V.J. and Associates, Inc., *Program Status Report: Department of the Army Hazardous Waste Minimization* (U.S. Army Environmental Office, August 1988).

Collins, W., et al., *Installation Assessment of Fort Ord, California*, DRXTH-AS-IA-81196 (Prepared for the Commander, Fort Ord, CA, and USATHAMA, Aberdeen Proving Ground, MD, 1983).

Comarco, Inc., *U.S. Navy Lithium Battery Disposal*, Report No. CESD-88-179 (Prepared for the Naval Weapons Support Center, High Energy Battery Systems Branch, Crane, IN, January 1989).

Conley, J.H. and R.G. Jamison, "Additive Package for Used Antifreeze," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986).

Conley, J.H. and R.G. Jamison, *Reclaiming Used Antifreeze*, Report 2168/ADA027100 (U.S. Army Mobility Equipment Research and Development Command [USAMERDC], Fort Belvoir, VA, 1976).

Darvin, C.H. and R.C. Wilmoth, *Technical, Environmental, and Economic Evaluation of Plastic Media Blasting for Paint Stripping*, USEPA/600/D-87/028 (U.S. Environmental Protection Agency [USEPA], Water Engineering Research Laboratory, 1987).

Defense Utilization and Disposal Manual, DOD 41620.21-M (Defense Logistics Agency, Office of the Assistant Secretary of Defense, Alexandria, VA, September 1982), pp VI-42 and XVII-A-5 to XVII-A-10.

Department of Defense Memorandum for Deputy for Environment, Safety and Occupational Health, OASA (I&L); Deputy director for Environment, OASN (S&L); Deputy for Environment and Safety and Occupational Health (SAP/MIQ); Director, Defense Logistics Agency (DLA-S); 28 January 1986, subject: Regulation of Used Oil for Burning.

Dharmavaram, S., et al., "A Profile and Management of the U.S. Army's Underground Storage Tanks," *Environmental Management*, Vol 13 (1989), pp 333-338.

Donahue, B.A., and M.B. Carmer, *Solvent "Cradle-To-Grave" Management Guidelines for Use at Army Installations*, Technical Report N-168/ADA137063 (USACERL, December 1983).

Donahue, B.A., T.J. Hoctor, and K. Piskin, *Managing Underground Storage Tank Data Using dBase III Plus*, Technical Report N-87/21/ADA182452 (USACERL, June 1987).

Donahue, B.A., et al., *Used Solvent Testing and Reclamation, Volume I: Cold-Cleaning Solvents*, Technical Report N-89/03/ADA204731, Vol I (USACERL, December 1988).

Donahue, B.A., et al., *Used Solvent Testing and Reclamation, Volume II: Vapor Degreasing and Precision Cleaning Solvents*, Technical Report N-89/03/ADA204731, Vol II (USACERL, December 1988).

Drabkin, M., C. Fromm, and H.M. Freeman, "Development of Options for Minimizing Hazardous Waste Generation," *Environmental Progress*, Vol 7 (1988), pp 167-173.

Drycleaning and Laundry Plants, Hazardous Waste Fact Sheet (Small Quantity Generators Activity Group, Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Durney, L.J., "How to Improve Your Paint Stripping," *Product Finishing* (December 1982), pp 52-53.

Ecology and Environment, Inc., *Waste Audit Study - General Medical and Surgical Hospitals* (California Department of Health Services, Sacramento, CA, 1988).

Economic Analysis of Solvent Management Options, Technical Note 86-1 (Department of the Army, May 1986).

Efficient Boiler Operations Sourcebook, F.W. Payne, Ed. (The Fairmont Press, Inc., Atlanta, GA, 1986), pp 79-106.

Electroplating Engineering Handbook, L.J. Durney, Ed., Fourth ed. (Van Nostrand Reinhold Company, 1984).

Environmental Operations Review - Fort Ord, Fort Hunter Liggett, and The Presidio of Monterey, California, Study No. 32-24-1376-87 (USAEHA, Aberdeen Proving Ground, MD, June 1987).

EPA Guide to Infectious Waste Management, EPA/530-SW-86-014 (USEPA, 1986).

The EPA Manual for Waste Minimization Opportunity Assessment, EPA/600/2-88-025 (USEPA, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, 1988).

Evaluation of Lithium Sulfur Dioxide Batteries, US Army Communications - Electronics Command and US Electronics Research and Development Command, Fort Monmouth, New Jersey, USAEHA-37-26-0427-85 (USAEHA, Aberdeen Proving Ground, MD, 1985).

Federal Register, Vol 50, No. 23, pp 49164-49249.

Federal Register, Vol 51, No. 190 (October 1986), pp 35190-35194.

Fu, T.T. and R.S. Chapler, *Utilization of Navy-Generated Waste Oils as Boiler Fuel - Economic Analysis and Laboratory Tests*, Technical Note N-1570 (U.S. Navy Construction Battalion Center, 1980).

Gardner, J., *Dry Paint Stripping Utilizing Plastic Media: A New Solution to an Old Problem*, Technical Bulletin (Clemco Industries, 1988).

Garrard, W.N., *Introduction to Lithium Batteries*, MRL-GD-0018; DODA-AR-005-652 (Materials Research Laboratory, Ascot Vale, Australia, 1988).

Gibbs, L.M., "Recovery of Waste Organic Solvents in a Health Care Institution," *American Clinical Products Review* (November/December 1983).

GLYCLEAN - Antifreeze Recycling System, brochure (FPPF Chemical Co., Inc., 117 W. Tupper St., Buffalo, NY 14201, 1988).

Guide to Infectious Waste Management, EPA/530-SW-86-014 (USEPA, Washington, DC, 1986).

Hart Associates, Fred C., *Aerospace Waste Minimization Report* (California Department of Health Services and Northrop Corporation, 1987).

Hazardous Waste Management Survey, No. 37-26-0389-84 (USAEHA, Aberdeen Proving Ground, MD, 1984).

Hazardous Waste Management Survey - Fort Ord, Monterey, California, No. 37-26-7062-88 (USAEHA, Aberdeen Proving Ground, MD, 1988).

Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops (California Department of Health Services, Toxic Substances Control Division, 1988), 24 pp.

Hazardous Waste Reduction Checklist - Automotive Repair Shops (California Department of Health Services, Toxic Substances Control Division, 1988).

Hemstreet, R.H., "How to Conduct Your Waste Minimization Audit," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 61-75.

Huisingh, D., *Profits of Pollution Prevention: A Compendium of North Carolina Case Studies* (North Carolina Board of Science and Technology, Raleigh, NC, 1985).

Hunt, G.E., and R.N. Schecter, "Minimization of Hazardous-Waste Generation," in *Standard Handbook of Hazardous Waste Treatment and Disposal*, H. M. Freeman, Ed. (McGraw Hill, New York, NY, 1988), pp 5.3-5.27.

ICF Associates, Inc., *Guide to Solvent Waste Reduction Alternatives: Final Report* (Prepared for California Department of Health Services, October 1986).

Infectious Hazardous Waste Handling and Disposal, Technical Guide Number 147 (USAEHA, MD, 1986).

Isooka, Y., Y. Imamura, and Y. Sakamoto, "Recovery and Reuse of Organic Solvent Solutions," *Metal Finishing* (June 1984), pp 113-118.

Jacobs Engineering Group, Inc., *Waste Audit Study - Commercial Printing Industry* (California Department of Health Services, Sacramento, CA, May 1988).

Jones, E.B., W. Banning, and R.C. Herndon, "Waste Exchanges and Waste Minimization and Reclamation Efforts," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 78-85.

Kohl, J., P. Moses, and B. Triplett, *Managing and Recycling Solvents: North Carolina Practices, Facilities, and Regulations* (North Carolina State University, Raleigh, NC, 1984).

Kraybill, D., T. Mullen, and B.A. Donahue, *Hazardous Waste Surveys of Two Army Installations and an Army Hospital*, Technical Report N-90/ADA088260 (USACERL, August 1980).

Layman, P.L., "Paints and Coatings: the Global Challenge," *Chemical and Engineering News* (September 30, 1985), pp 27-68.

Layton, D.W., et al., *Demilitarization of Conventional Ordnance: Priorities of Data-Base Assessments of Environmental Contaminants*, UCRL-15902 (USAMRDC, Fort Detrick, Frederick, MD, 1986).

Makwinski, J., and P.N. Cheremisinoff, "Special Report: Underground Storage Tanks," *Pollution Engineering*, Vol 20 (1988), pp 60-69.

Management/Equipment Evaluation Program, Report H82-1B (1st Space Support Group, U.S. Air Force, Peterson Air Force Base, CO, 1983).

Managing Empty Containers, Fact Sheet (Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Medical Waste Sanctions Act of 1988, Report 100-1102 (House of Representatives, 100th Congress, October 1988).

Military Explosives, TM 9-1300-214 (HQDA, Washington, DC, 1984).

Minimization of Hazardous Waste. Executive Summary and Fact Sheet, EPA/530/SW-86/033A (USEPA, Office of Solid Waste, 1986).

Mount, J.B., et al., *Economic Analysis of Hazardous Waste Minimization Alternatives*, Draft Technical Report (USACERL).

National Association of Manufacturers, *Waste Minimization: Manufacturers' Strategies for Success* (ENSR Consulting and Engineering, 1989).

National Research Council, *Prudent Practices for Disposal of Chemicals from Laboratories* (National Academy Press, Washington, DC, 1983).

Nester, F.W., and L.L. Smith, *Propellant Reuse Technology Assessment*, AMXTH-TE-CR-86076 (USATHAMA, Aberdeen Proving Ground, MD, 1986).

Protocol Health Care Facility Waste Management Surveys (USAEHA, Aberdeen Proving Ground, MD, 1987).

Prolonging Machine Coolant Life, Fact Sheet (Minnesota Technical Assistance Program, Minneapolis, MN, 1988).

Public Law 94-480, *Resource Conservation and Recovery Act* (1976).

Public Law 98-616, *Hazardous and Solid Waste Amendments* (1984).

Public Law 99-499, *Title III, Superfund Amendments and Reauthorization Act* (1986).

Reay, W.H., "Solvent Recovery in the Paint Industry," *Paint & Resins* (March/April 1982), pp 41-44.

Resch, M.E., "Hazardous Waste Minimization Audits Using a Two-tiered Approach," *Environmental Progress*, Vol 7 (1988), pp 162-166.

Salvesan, R.H., Associates, *Used Oil and Solvent Recycling Guide*, Final Report (Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1985).

SCS Engineers Inc., *Waste Audit Study - Automotive Paint Shops* (California Department of Health Services, Sacramento, CA, January 1987).

Standard Handbook of Hazardous Waste Treatment and Disposal, H.M. Freeman, Ed. (McGraw Hill, New York, NY, 1989).

Solvent Minimization and Substitution Guidelines, DAEN-ZCF-U Technical Note 86-2 (Department of the Army, Office of the Chief of Engineers, Facilities Engineering Division, Washington, DC, 1986), 18 pp.

Toy, W.M., *Waste Audit Study - Automotive Repairs* (Prepared for the California Department of Health Services, Sacramento, CA, 1987).

Union Carbide Corporation, *Ecological Aspects of UCAR Deicing Fluids and Ethylene Glycol* (Hazardous Materials Technical Center, Rockville, MD, 1984).

Ventura County Environmental Health, *Hazardous Waste Reduction Guidelines for Environmental Health Programs* (California Department of Health Services, Sacramento, CA, 1987).

Woodhouse, C., *Waste Ink Reclamation Project* (California Department of Health Services, Toxic Substances Control Division, August 1984).

Winslow, H., *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986).

UNCITED REFERENCES

Dharmavaram, S., et al., "Hazardous Waste Minimization at Army Installatins," Paper No. 88-11.4 (Presented at the 81st Annual Meeting of Air and Waste Management Association, Dallas, TX, 1988).

Economic Implications of Waste Reduction, Recycling, Treatment and Disposal of Hazardous Wastes, The Fourth Biennial Report (California Department of Health Services, Sacramento, CA, July 1988).

Fortuna, R.C., and D.J. Lennett, *Hazardous Waste Regulation - The New Era* (McGraw Hill, New York, NY, 1987).

Hazardous Waste Minimization: Corporate Strategies and Federal/State Initiatives (Government Institutes, Inc., Rockville, MD, 1988).

Higgins, T.E., *Hazardous Waste Minimization Handbook* (Lewis Publishers, Inc., Chelsea, MI, 1989).

Jacobs Engineering Group, Hazardous Waste Minimization Potential Workbook (California Department of Health Services, Sacromento, CA, 1987), 65 pp.

APPENDIX A:

FORT ORD HAZMIN PLAN

1. BACKGROUND

The Hazardous and Solid Wastes Amendments (HSWA)[1] to the Resource Conservation and Recovery Act (RCRA),[2] passed in 1984, require the generators of hazardous wastes to certify that they have a waste minimization program. Every waste shipment manifest is accompanied with the following declaration, in compliance with Section 3002 (b) of HSWA:

> The generator of the hazardous waste has a program in place to reduce the volume and toxicity of such waste to the degree determined by the generator to be economically practicable;...

Therefore, all facilities that meet the RCRA definitions of Generator (more than 1000 kg or 2205 lb/month) and Small Quantity Generator (100 to 1000 kg or 220 to 2205 lb/month) of HW have to implement waste minimization programs.

HSWA [Section 3002(a)] also requires the generators of hazardous wastes to submit a biennial report, including documentation on efforts to reduce the volume and toxicity of wastes generated. Facilities that treat, store, or dispose of hazardous wastes are required [HSWA, Section 3005(h)] to submit annual reports accompanied with similar declarations on waste minimization.

In the broadest sense, HAZMIN may be defined as the process of reducing the net outflow of hazardous waste effluents from a given source (or generating process). Minimization would include any source reductions in the generation of hazardous wastes as well as any recycling activities that would result in either a reduction in the total volume or quantity of hazardous wastes, or a reduction in the toxicity of hazardous wastes produced or both as long as it is consistent with the national goal of minimizing present and future threats to the environment.[3] HAZMIN, therefore, can be achieved by:

> Source Reduction - which refers to reduction or elimination of waste generation at the source, usually within a process. It also implies any action taken to reduce the amount of waste leaving a process;
>
> Recycling Onsite/Offsite - which is the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in a process. Recycling also implies the reclamation of useful constituent fractions from within a waste or removal of contaminants allowing it to be reused; and/or
>
> Treatment - eliminating hazardous characteristics of a waste making it nonhazardous to human health and environment.

[1] Public Law 98-616, *Hazardous and Solid Waste Amendments*, 1984.
[2] Public Law 94-480, *Resource Conservation and Recovery Act*, 1976.
[3] *Minimization of Hazardous Waste. Executive Summary and Fact Sheet*, EPA/530/SW-86/033A (USEPA, Office of Solid Waste, Washington, D.C., 1986).

For any particular waste, the minimization options must be evaluated in the hierarchy of source reduction first, followed by recycling (including, recovery and reuse), and, finally, treatment. There may always remain some small amount of residue (e.g., ash) which will require "ultimate" disposal (e.g., landfill burial). Although attempts have been made to clearly define the three HAZMIN categories, there may be overlap for certain specific techniques. Maximum waste reduction is usually achieved by using the best combination of suitable techniques from all three categories.

Recognizing the liabilities of improper disposal and the advantages of waste minimization, the Joint Logistics Commanders set a DOD-wide goal of 50 percent reduction in hazardous waste generation by 1992, based on the baseline generation in 1985. The Department of Army has adopted this DOD goal and established a policy[4] applicable to all Active Army, Reserve, and National Guard installations.

2. PURPOSE

The purpose of the Fort Ord Installation Hazardous Waste Minimization (HAZMIN) plan is to provide a specific plan of action to reduce the quantities and toxicities of hazardous wastes (HW) generated within the installation boundaries.

3. SCOPE

The scope of the plan extends to all the HW regulated under the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Wastes Amendments (HSWA), and the State of Colorado Hazardous Waste Regulations.

4. GOALS

4.1 Department of Army (DA) HAZMIN Goals

Process, Operation, or Condition	Percent HW Reduction Desired by 1992
Cleaning/degreasing	40
Transportation vehicle maintenance	0
Fueling operations	30
Battery shop operations	50
Painting	50
Sand blasting	60
Metalworking	15

[4] Office of the Assistant Chief of Engineers, "Hazardous Waste Minimization (HAZMIN) Policy," Department of the Army, 1989, 15 pages.

Graphic Arts	40
Electrical maintenance	60
Waste treatment sludge	60

4.2 **Fort Ord HAZMIN Goals**

Same as DA HAZMIN goals.

4.3 **HAZMIN Reduction Estimation**

Percent HW reduction for any calender year (CY) =

$$\frac{(\text{Baseline Year HW Generation} - \text{CY HW Generation}) * 100}{\text{Baseline Year HW Generation}}$$

5. **PROGRAM MANAGEMENT**

5.1 Fort Ord will manage the HAZMIN program according to the revised AR 200-1 and AR 420-47. The installation's Hazardous Waste Management Board (HWMB) shall review and adopt this plan, and establish other policies and procedures for implementation. The HWMB is to be chaired by the Assistant Division Commander (Support) and consists of the following members:

Assistant Division Commander (Support) (ADC/S)
Garrison Commander (GS)
Director of Engineering and Housing (DEH)
Chief, Environment and Natural Resources Office (ENRO)
Director of Logistics (DOL)
Director of Personnel and Community Activities (DPCA)
Director of Reserve Component Support (DRCS)
Director of Plans, Training, and Mobilization (DPTM)
Assistant Chief of Staff (ACofS, G1/AG)
Assistant Chief of Staff (ACofS, G2)
Assistant Chief of Staff (ACofS, G3)
Assistant Chief of Staff (ACofS, G4)
Assistant Chief of Staff (ACofS, G5)
Deputy Chief of Staff (DC/S)
Inspector General (IG)
Chief, Defense Reutilization and Marketing Office (DRMO)
Installation Safety and Occupational Health Manager
Public Affairs Officer (PAO)
Staff Judge Advocate (SJA)
Director of Resource Management (DRM)
Director of Health Services (DHS)
Director of Dental Services (DDS)
Commander, 1st Brigade
Commander, 2nd Brigade
Commander, 3rd Brigade

Commander, Division Artillery
Commander, Division Support Command
Commander, Bayonet Combat Support
Commander, 2nd Battalion, 62nd Air Defense Artillery
Commander, 13th Engineering Battalion
Commander, 127th Signal Battalion
Commander, 107th Military Intelligence Battalion
Commander, Combat Aviation Brigade

5.2 The activities at Fort Ord that are generators of hazardous waste, used oil, and miscellaneous toxic wastes; and references to the appropriate chapter (in the assessment technical report) are:

	Chapter Number
Motor Pools/Vehicle Maintenance Facilities	4, 5
Aviation Maintenance Facilities	4, 5
Industrial Maintenance, Small Arms Shops, etc.	4, 6
Paint Shops	4, 7
Photography, and Printing Operations	4, 8
Hospitals, Clinics, and Laboratories	4, 9
Other Generators	4, 10

6. TRAINING

6.1 Personnel Training

A training program will be developed, by the Chief, ENRO for personnel involved in handling of hazardous materials and management of hazardous wastes to ensure compliance with 40 CFR 264.16.

6.2 Training Content, Schedules, and Techniques

Personnel from HW generating activities must be given supervised on-the-job training and formal courses. The formal courses must be designed similar to the program offered by the U.S. Army Environmental Hygiene Agency, or the U.S. Army Logistics Management Center. Refresher courses should also be offered through ENRO on a regular basis to keep generating units up to date on constantly changing environmental policy of the Army and the state of California.

The objective of a formal (or refresher) course must be to provide each student with the abilities to:[5]

1. Recognize, identify, and classify hazardous materials.

2. Take actions necessary to prevent hazardous chemical incidents, protect personnel health, and prevent damage to the environment.
3. Properly package, label, store, handle, and transport hazardous materials and hazardous waste.

4. Take immediate action in response to hazardous materials spills or other emergencies.

[5] *Defense Hazardous Materials Handling Course (DHMHC)* (U.S. Army Logistics Management Center [ALMC], Fort Lee, VA).

5. Implement appropriate HAZMIN techniques.

6. Properly manage the resources under his/her control to prevent violation of applicable laws, regulations, and policies.

6.3 Implementation of Training Program

The Chief of the Training Division (DPTM) will direct a training program designed by the Chief, ENRO. All new and/or reassigned personnel will not work in positions dealing with hazardous materials/wastes unless they have completed the appropriate program within 6 months of the date of employment or reassignment. All supervisors will, annually, review the training status of their personnel.

6.4 Records

6.4.1 The Personnel Directorate (Fort Ord and tenant activities) will maintain records pertaining to job experience and the training completion requirements. The records must include description of the type/nature of initial and continuing training each person receives.

6.4.2 Fort Ord will maintain records of all current personnel until deactivation of a particular unit/organization or the entire post. Training records of past employees must be kept for at least 3 years after the date of last employment.

7. HAZMIN ACTIONS

7.1 General Actions

7.1.1 Command Initiatives: For the HAZMIN program to be successful, the Assistant Division Commander (Support), the Installation Commander, and the chain of command for all the generators, tenants, and troops must make a commitment to all the goals (section 4) and establish specific goals at the generator (or activity) level.

The Installation Commander will develop an environmental policy statement emphasizing pollution minimization and assign direct responsibility to all personnel as protectors of the environment in their day-to-day work. All personnel will be notified (through the installation newspaper and interoffice memorandums) regarding the command commitment and goals.

Personnel incentives (such as awards, commendation, etc.) must be provided to encourage new HAZMIN ideas and to reward implementation of successful HAZMIN projects.

7.1.2 The installation must solicit cooperation with the host community (Monterey County) for success of HAZMIN projects.

7.1.3 Participation is required among appropriate personnel from: Directorate of Logistics (DOL) - responsible for supply/procurement, transportation; Directorate of Engineering and Housing (DEH) - responsible for interim and long term storage, compliance with federal/state environmental laws, and pollution control guidance; and Defense Reutilization and Marketing Office (DRMO) - responsible for proper disposal; in implementation, programming, and budgeting HAZMIN programs.

7.1.4 A hazardous material (HM) and hazardous waste (HW) tracking (manifest) program will be implemented at Fort Ord (including all the tenants). Tracking HM from the supply warehouse to generators and HW from the generators to final storage before disposal, will provide a mass balance and improve minimization opportunities.

7.1.5 HAZMIN programs will be incorporated into the agenda of the Environmental (and Hazardous Waste) Management Board Meetings. Proper coverage must be provided in the installation newspaper (*Panorama*) to ensure wide acceptance among personnel.

7.1.6 Chief, ENRO, and the Installation Safety and Occupational Health Manager will combine resources to develop a training program for personnel in hazardous materials/waste handling and emergency response (according to Section 6) which is required by law.

7.1.7 Chief, ENRO, will develop a waste analysis program to characterize and define all (air, water, liquid, and solid) waste streams from all the generators to ensure compliance with Federal and California laws.

7.1.8 Chief, DRMO, and the Chief, ENRO, will examine the use of waste exchange programs as a proper recycle methodology for some of the hazardous wastes.

7.1.9 The ENRO Hazardous Waste Program Manager will conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes.

7.2 Generator Actions

7.2.1 All generators must program for disposal of hazardous wastes following the decentralization of funding beginning in Fiscal 1990.

7.2.2 All generators will appoint environmental (hazardous waste) coordinators who would be responsible for minimizing generation (of air emissions, water pollution and solid wastes), proper interim storage, and turn-in of hazardous wastes.

7.2.3 The environmental (or hazardous waste) manager should coordinate with the ENRO Hazardous Waste Program Manager in all matters pertaining to waste management and minimization. Individuals appointed to this duty will devote more time than is customary for a typical "extra duty."

7.2.4 All environmental managers will maintain proper records (logbooks) of hazardous materials procured and hazardous wastes generated by their respective activities and provide such documentation to ENRO on a monthly basis.

7.2.5 All generators must, with the help of ENRO, completely characterize (in terms of composition, periodicity of generation, why and how generated, etc.) all the waste streams, and document and provide relevant data when requested by the ENRO.

7.2.6 All generators will include HAZMIN requirements ("Better Operating Practices" as outlined in Chapters 5 through 11) and specified by the ENRO in their standing operating procedures (SOPs).

7.3 Current HAZMIN Projects

7.3.1 Spent Lead-Acid Batteries/Battery Acid - Source Reduction - No Draining/Sale: Used or dead lead-acid batteries (sealed and unsealed) are exchanged by the generators (e.g., motor pools) for new batteries. They are accumulated at a central location (e.g., storage warehouse) on pallets. These batteries, when bound securely to the pallets, are recycled through a Department of Energy lead recycling program. Since the batteries are being recycled, they are exempt from RCRA reporting requirements and, therefore, do not require reporting and manifesting paperwork necessary for other hazardous wastes.

7.3.2 1,1,1-Trichloroethane/Degreaser Tank Bottoms - Source Reduction - Process Change: In the past, Fort Ord had a number of vapor degreasers used for degreasing of parts. 1,1,1-trichloroethane was the solvent commonly used. With the increasing impetus on hazardous waste minimization and spiralling waste management costs, DOL decided to investigate a change in process. Hot jet washers, with detergent sprays, were found to be a good substitute. The costs and savings given below are for substitution of one degreaser with a hot washer which was accomplished in summer of 1989.

Estimated Price: Investment - $11,405; Annual O&M - $304

Estimated Annual Savings: $3851

Estimated Payback Period: 3.56 years

Estimated Waste Reduction (Source Reduction): 100 percent

Estimated Emissions Reduction (Source Reduction): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

7.3.3 1,1,1-Trichloroethane - Source Reduction - Product Substitution: Some of the DOL shops that used this solvent for degreasing have substituted PD680-II. The same degreaser tanks are used. PD680-II was found to be just as efficient in cleaning parts. This product substitution has completely eliminated the generation of hazardous wastes associated with vapor degreasing.

7.3.4 All Hazardous Wastes - Source Reduction - Proper Management: The vehicle maintenance facilities are now provided with berms for proper storage of wastes. These areas and storage areas at other generating activities are secure and only the hazardous waste managers have access to them. The segregation practices are greatly improved and only small quantities of mixed wastes are generated.

All generators are required to follow the guidelines outlined in "Hazardous Waste Management Standard Operating Procedure"[6] which superseded Appendix D of the maintenance SOP of the 7th Infantry Division (Light). The current SOP includes procedures for proper storage and turn-in of hazardous wastes.

[6]"Hazardous Waste Management Standard Operating Procedure," ENRO (Directorate of Engineering and Housing, Fort Ord, December 1988).

7.3.5 DS2 and STB - Source Reduction - Limited Distribution to Troops: Decontaminating solution-2 (DS-2) and super tropical bleach powder (STB) are hazardous materials issued to troop units for potential use on deployment missions where a threat for chemical warfare exists. DS-2 and STB are never used while in Garrison nor during training manuevers. As such, a tendency has existed for troop units to accumulate these agents in excess of their authorized load for extended periods of time. Storing these corrosive materials beyond their dated shelf-lives, especially in warm, humid environments, often results in pemature deterioration of their packaging and accidental spillage. Commingling with other materials in confined areas creates a potential fire hazard. The recovery of spill residues exposes troop unit personnel to concentrated levels of these agents and results in the additional generation of hazardous waste.

DS-2 and STB are currently stored and distributed to troop units from a centralized warehouse maintained by the DOL. Centralized storage and distribution has provided increased control over the quantities of decontaminating agents accumulated by troop units and ensures compliance with prescribed segregative storage requirements. Using a centralized storage facility has also facilitated the need to regularly inspect containers for possible leakage, eliminating the potential for contamination of other materials. Ancillary methods of source reduction that could further minimize decontaminating agent wastes would include selling expired STB to the original manufacturer as a feedstock for fresh material production or using it for chlorination of swimming pools on post.

7.3.6 Paint Stripping Wastes - Source Reduction - Plastic Media Blasting: Chemical stripping large metallic surfaces at the DOL-Aircraft Maintenance facility has been completely eliminated through the purchase and use of plastic media blasting (PMB) equipment. PMB is a recent waste minimization technology that allows for the recovery and reuse of the blasting media by vacuum devices. The process eliminates the use of large quantities of hazardous halogenated strippers and provides less hazardous working conditions for operators. The only waste generated for disposal through PMB operations is the quantity of removed paint, which may be disposed of as solid waste in the local landfill.

7.3.7 Paint Wastes - Source Reduction - Process Change: Ford Ord has converted all except two of its wet-wall paint booths to dry booths. The aqueous wastes/paint sludge and hazardous air emissions have already been minimized. Converting the remaining two paint booths located at Buildings 1665 (DPTM - TASC - Graphics Shop) and 2252 (DPCA -Arts and Crafts Shop) will completely eliminate the waste generation problems.

Estimated Price (2 Small Booths): vestment - $3124; Annual O&M - $1341

Estimated Annual Savings (2 Small Booths): $2108

Estimated Payback Period (2 Small Booths): 2.45 years

Estimated Waste Reduction (Source Reduction): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

7.3.8 Printing Inks/Solvents - Source Reduction - UV Inks: Ultraviolet (UV) inks are used at DPTMs-TASC-Graphics Shop to partially substitute for traditional printing inks. The switch to UV inks has reduced the required cleaning frequency of printing equipment and the corresponding need to purchase and dispose of quantities of solvent formerly required for application and cleaning operations.

7.3.9 Infectious Wastes - Source Reduction - Segregation: Infectious wastes include blood and other bodily fluids, articles of clothing heavily contaminated with the above, medical cultures, disposable equipment used in laboratories and surgical rooms, and other items associated with the treatment of patients with infectious diseases. These wastes are currently accumulated in specifically designated containers and red bags, collected by specially trained hospital personnel, and transported to the post sterilization facility for treatment before disposal as solid waste in the local landfill. Efforts are being made on behalf of hospital personnel to minimize the quantity of infectious waste requiring such treatment through methods of source reduction. To date, these efforts have included improved segregation of infectious waste from noninfectious waste in hospital laboratories and patient rooms and an increased emphasis on the proper disposal of specific wastes in appropriate containers.

7.3.10 POL Solids - Source Reduction - Draining & Disposal: Solids contaminated with petroleum or other lubricants are generated primarily by MPVM or IMSS operations where solvents, oils, and greases are routinely used for the mainteneance or repair of vehicles. Specific POL solids generated in appreciable quantity on Fort Ord include spent fluid filters, contaminated dry sorbent used to recover spills, heavily soiled rags, sediment cleaned from maintenance bay grease traps, and soil contaminated by leaking POL containers in material or waste storage areas. Fort Ord has exerted a tremendous effort in educating personnel at these facilities in proper handeling, storage, and spill recovery procedures for POL materials or wastes and has stressed source reduction as the best means for minimizing POL wastes. Specially constructed waste storage sheds have been built at several locations, providing roofed shelter from the elements and bermed concrete floors to prevent the proliferation of accidental spills and drips. Filters changed from vehicles during maintenance or repair are inverted on simple, but innovative drain racks before being overpacked in partially spent dry sorbent. The use of dry sorbent to clean up spills has been restricted at all maintenance areas and is prohibited from use altogether at other locations; it is replaced by aqueous biodegradable detergents.

7.3.11 All Wastes - Source Reduction - Satellite Accumulation: Several small quantity generators of hazardous waste on Fort Ord have been granted SAP (Satellite Accumulation Point) status and are allowed to store their generated wastes beyond the 30-day limitation imposed by the State of California. The SAP program enables these generators to maximize and economize on the use of disposal containers and has lessened the incidence of turning partially full containers of hazardous waste in to DRMO. The program has been particularly useful for minimizing the cost and volume of wastes such as spoiled paint and spent halogenated solvents.

7.3.12 Lithium Batteries - Source Reduction - Product Substitution: Lithium battery cartridges are used in a variety of communications and electronics equipment used by troops in the field and during training missions. Lithium batteries are considered reactive hazardous wastes and require special disposal considerations. Efforts to procure and distribute a type of lithium cartridge that allows for manual discharge would eliminate this hazardous waste stream and should persist.

7.4 Future HAZMIN Projects

7.4.1 Cleaning Solvent - Recycle Onsite/Offsite - Contract Recycling: A used solvent recycling program must be designed to collect and recycle used cleaning solvent (PD680-II) used in motor pools, vehicle/aviation maintenance facilities, and other parts cleaning activities. Source reduction (e.g., better operating practices, testing, etc.) must be implemented by all generators to reduce the quantities used. Use of a substitute (e.g., Citrikleen) must also be explored.

Based on solvent use at a total rate of 5600 gal/yr, onsite distillation using a 55-gal batch still is the most economical option compared to the current practice of offsite disposal. The purchase of a 55-gal still is recommended. It could be installed and operated at the DOL vehicle maintenance shop.

Estimated Price: Investment - $39,917; Annual O&M - $5789

Estimated Annual Savings: $9676

Estimated Payback Period: 4.75 years

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated Hazardous Waste Reduction: 90 percent

7.4.2 Waste Oil - Source Reduction - Segregation and Disposal: Used oil is currently accumulated by all the generators and turned in to DRMO for disposal as a hazardous waste. Approximately 44,044 gal/yr of waste oil is generated. In the past it was contaminated with halogenated solvents, nonhalogenated solvents, and hydraulic fluids. The segregation practices have improved and the construction of berms and secure facilities have facilitated proper waste management. Further plans are already underway for construction of a central tank farm to accumulate the waste oil. If proven nonhazardous through testing, efforts should be made to sell used oil generated on post to nearby oil recyclers/re-refiners.

Continued segregation of waste oil is required at all the generators. Chlorine detection kits (e.g., CLOR-D-TECT™1000 and CLOR-D-TECT™Q4000)[7] can be used to detect the level of chlorinated solvent contamination of oil at the generators before the oil is transported to the central storage facility. Contaminated oil should not be mixed with oil collected from other sources. A complete laboratory analysis of the oil collected at the tank farm is required to determine flash point, and the total halogens, sulfur, and heavy metals (As, Cd, Cr, Pb) content.

Estimated Price: Investment - $75,963; Annual O&M - $12,183

Estimated Annual Savings: $32,323

Estimated Payback Period: 3.31 years

Estimated Waste Reduction (Source Reduction): 30 percent

Estimated Hazardous Waste Reduction: 100 percent

If the halogen content in the waste oil is less than 1000 ppm and the heavy metals are within specifications, the oil could be blended and burned in an industrial boiler. Fort Ord currently does not have an industrial boiler. However, if one is installed, burning oil for heat recovery should be explored as an alternative. An air pollution permit must be obtained for such an activity.

7.4.3 Used Antifreeze Solution - Onsite Recycling: Used antifreeze solution is generated at the rate of 7717 gal/yr by the vehicle maintenance facilities at Fort Ord. It is drummed and disposed of as a hazardous waste through the DRMO. The price of new antifreeze has more than

[7]CLOR-D-TECT is a trademark of the Dexsil Corporation [1 Hamden Park Drive, Hamden, CT 06517, (203) 288-3509]. CLOR-D-TECT 1000 is a go-no-go kit for determining if used oil is contaminated with chlorinated solvents. CLOR-D-TECT Q4000 is a quantitative test for determination of chloride (0 to 4000 ppm) in used oil.

doubled in the past two years ($4.00 to $8.45/gal). A technology (Glyclean filtration system - unit price: $2400) exists for recycling the 50 percent antifreeze solution.

Use of the Glyclean system (2 machines) is recommended.

Estimated Price: Investment - $36,384; Annual O&M - $6018

Estimated Annual Savings: $54,935

Estimated Payback Period: 1.59 years

Estimated Waste Reduction (Recycling Alone): 100 percent

Estimated Waste Reduction (Source Reduction and Recycling): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

7.4.4 Paint Thinner/Residue - Recycle Onsite/Offsite - Distillation: The paint shops on Fort Ord generate 1700 gal/yr of paint thinner waste. This waste is disposed of through the DRMO.

The Paint Shop belonging to the DOL Maintenance Division will purchase a 15-gal distillation still for recycling paint thinner wastes. Thinner wastes generated elsewhere on Fort Ord will be brought to the DOL shop and distilled. The still bottoms have to be disposed of as hazardous waste. Permit requirements, if any, will be reviewed by the Environmental Office before the installation and operation of the still.

Estimated Price: Investment - $19,645; Annual O&M - $2972

Estimated Annual Savings: $10,922

Estimated Payback Period: 2.63 years

Estimated Waste Reduction (Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated Hazardous Waste Reduction: 90 percent

7.4.5 Xylene Waste - Onsite Recycling - Distillation: Approximately, 260 gal/yr of spent xylene waste is generated at the Silas B. Hays Army Community Hospital. The histology and pathology departments use xylene for fixation and preservation of tissue specimens on slides. The waste xylene is contaminated with paraffin and tissue. It must be recycled with the use of a 12-liter spinning band batch distillation unit.

Estimated Price: Investment - $14,061; Annual O&M - $747

Estimated Annual Savings: $1494

Estimated Payback Period: 10 years

Estimated Waste Reduction (Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated Hazardous Waste Reduction: 90 percent

The estimated payback period is high because of the high cost of initial investment. The spinning band distillation unit is much more expensive than the batch distillation stills used to recycle other wastes. Once installed, it can also be used to recycle other commonly used organics such as ethanol that are commonly used.

7.4.6 Drycleaning Filters - Treatment - Disposal: Spent drycleaning filters are generated at the laundry and drycleaning shop operated by a contractor (Economy Cleaners). These filters are contaminated with clay, lint, and residual amounts of PD680-II (used as drycleaning solvent instead of perchloroethylene). Safety Kleen provides monthly pickup and disposal of spent filters at a very high cost. The annual generation rate is estimated to be 9500 lb. Since the filters are likely to be nonhazardous, they can be disposed of as a solid waste or through the DRMO. An immediate switch to disposal through the DRMO is recommended.

Estimated Price: Annual O&M - $2431

Estimated Annual Savings: $8172

Estimated Waste Reduction (Source Reduction and Recycling): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

7.4.7 Other Wastes - Source Reduction: Other wastes can be reduced by implementing "better operating practices" and other appropriate minimization techniques according to references in Section 5.2.

Estimated Waste Reduction: 30 percent

Estimated Hazardous Waste Reduction: 20 percent

7.5 Overall Estimate of Expected Waste Reduction

Expected Waste Reduction: 37 percent

Expected Hazardous Waste Reduction: 54 percent

8. REFERENCES

8.1 Fort Ord installation waste generation data is given in Tables A1 and A2.

8.2 The calculations for the "overall" estimated waste reduction (in section 7.5) are presented in Table A3.

8.3 This plan is in Appendix A of the *Hazardous Waste Minimization Assessment: Fort Ord, CA.*

9. IMPLEMENTATION

Estimated Implementation Date: September 30, 1990.

10. RESPONSIBILITIES

10.1 The duties and responsibilities of persons directly responsible for implementation of this plan and success of the HAZMIN program are described in this section. The following personnel will form the Fort Ord HAZMIN committee that will oversee implementation of this plan and keep it revised and updated in the future.

Job Title	Name	HAZMIN Activity
Chief, Environmental and Natural Resources Office	Ms. Claire Murdo	Overview of the entire program; chair the committee; and others as noted in section 10.3.
Hazardous Waste Program Manager, ENRO	Mr. Willison	Establish a hazardous materials/ waste training program; establish waste inventory and inspection program; establish a HW/HM tracking program; coordinate with Safety Officer, Fire Chief, DRMO and all the environmental coordinators.
Installation Safety and Occupational Health Manager		Establish a chemical inventory program; flag and control purchase of hazardous materials; coordinate with the environmental engineer regarding maintaining and updating inventory.
Chief, Defense Reutilization and Marketing Office		Establish proper waste turn-in procedures; waste contract management; explore offsite reclamation and waste exchange options.
Chief, GE Operations and Maintenance Division	Mr. White	Inventory control of materials and wastes; vehicle/equipment maintenance, painting and laboratory wastes minimization; pesticides management; PCB transformer inventory management.
Chief, DEH Fire Prevention and Protection Division	Mr. Whitley	Coordinate with safety office; inventory flammable/toxic materials; SARA Title III compliance.
Chief, DOL Transportation Division		Inventory control of materials and wastes; vehicle maintenance wastes minimization.

Chief, DOL Maintenance Division	Mr. Robboti	Inventory control of materials and wastes; painting, machining, and weapons cleaning wastes minimization.
Chief, DOL Supply and Services Division	Mr. Short	Flag and control procurement of hazardous materials; coordinate with Safety and ENRO; establish chemical use inventory and demand history by each generator.
Chief, DEH Supply and Storage Division	Mr. Dunleavy	Flag and control procurement of hazardous materials; coordinate with Safety and ENRO; establish chemical use inventory and demand history by each generator.
Chief, DHS Logistics	LTC Kammerer	Flag and control procurement of hazardous materials; coordinate with Safety and ENRO; establish chemical use inventory and demand history by each laboratory and generator.
Chief, DPCA Education Office	Mr. Scalise	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DPTM Training and Audiovisual Support Center	Mr. Wilson	Inventory control of materials and wastes; photographic and printing wastes minimization.
Chief, DPTM Photolab	Mr. Philips	Inventory control of materials and wastes; photographic wastes minimization.
Chief, DPTM Aviation Division	LTC Jones	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, Preventive Medicine Silas B. Hays Army Community Hospital	Dr. Layton	Establish inventory of hazardous materials/wastes; establish waste generators monitoring program; coordinate minimization and proper disposal practices (infectious, hazardous, and radioactive wastes) with environmental office.
XO, 1st Brigade	MAJ Swannack	Inventory control of materials and wastes; vehicle maintenance wastes minimization.

XO, 2nd Brigade	LTC Galloway	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 3rd Brigade	LTC Campbell	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, Combat Aviation Brigade	LTC Jones	Inventory control of materials and wastes; aviation and vehicle maintenance wastes minimization.
XO, Division Artillery	LTC Lanier	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, Division Support Command	MAJ Youngblood	Inventory control of materials and wastes; vehicle maintenance and industrial maintenance wastes minimization.
XO, Bayonet Combat Support	LTC McMillan	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 2nd Battalion, 62nd Air Defense Artillery	LTC Franklin	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 13th Engineering Battalion	LTC Meuleners	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 127th Signal Bn.	LTC Armell	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 107th MI Battalion	LTC Hayden	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, HHC 7ID(L)	CPT Redmond	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Environmental (or Hazardous Waste) Managers	As appointed	As discussed in Section 10.4.

10.2 Responsibilities of all HAZMIN Committee Members (except Chief, ENRO)

10.2.1 Identify and prioritize goals required necessary for achieving the goals outlined in this plan.

10.2.2 Provide information on HAZMIN techniques to the hazardous waste generators.

10.2.3 Organize a team to conduct annual HAZMIN assessments (or audits) to determine sources, types, and quantities of hazardous materials used and hazardous wastes generated.

10.2.4 Report on the status of the HAZMIN program to the Chief, ENRO regularly.

10.2.5 Assist the Chief, ENRO, in preparing an Annual HAZMIN status report.

10.3 Responsibilities of the Chief, Environment and Natural Resources Office

10.3.1 Oversee and provide resources (including technological assistance) in the conduct of the annual HAZMIN assessments. Report the state of the HAZMIN program to the commander.

10.3.2 Revise and update this plan annually.

10.3.3 Prepare a HAZMIN status report when requested by HQFORSCOM or HQDA.

10.3.4 Program funds necessary to accomplish HAZMIN goals.

10.3.5 Chair the HAZMIN Committee.

10.3.6 Conceive, develop, and implement HAZMIN techniques consistent with this plan.

10.4 Responsibilities of Environmental (or Hazardous Waste) Managers

10.4.1 Establish goals for minimizing all forms of environmental pollution (air, water, solid, and hazardous waste).

10.4.2 Obtain training (organized by ENRO) on all the applicable environmental laws and train all subordinate personnel.

10.4.3 Implement "better operating practices" through: inventory control (maintaining logbooks for materials procured and pollution generated); segregation of wastes; spill and leak prevention; and scheduling frequent preventive maintenance of equipment.

10.4.4 Examine and implement the use of substitute nonhazardous or less hazardous materials in place of hazardous materials.

10.4.5 Examine and implement "process changes" such as: process modifications; equipment modifications; and changes in operation settings, to reduce the quantities of pollution generated.

10.4.6 Examine and implement technologies for recycling, reuse, or treatment of wastes. Information about technologies and equipment suppliers can be obtained from environmental personnel at ENRO.

Table A1

Waste Generation Summary of Fort Ord

Waste Generating Operation, Process, or Condition	Waste Category*	lb/yr	lb/yr/unit	Waste Stream Unit
Motor Pools, excluding DOL	1	36302	36302	PD680 - II
	2	990	990	Carburetor Cleaner
	3	342063	239813	Waste Engine Oil
			39024	Waste Transmission Fluid
			22659	Waste Diesel Fuel
			6358	Waste Oil Contaminated with Water
			8213	Waste Fog Oil
			6215	Used Oil Contaminated with Paint
			4765	Used Oil Contaminated with Solvent
			3303	Used Oil Contaminated with Other Fuels
			2302	Grease
			3326	Hydraulic Fluid
			2972	MOGAS
			2031	Brake Fluid
			1082	Penetrating Oil
	4	66648	65608	Antifreeze (Ethylene Glycol)
			1040	Methanol
	5	24272	1532	Lead-Acid Battery Electrolyte
			22740	Detergent/Caustic
	6	2490	1280	Xylene
			1210	Paint Thinner - Unspecified
	7	10376	4577	Paint
			5091	PRM - Unspecified
			708	Corrosion Inhibitor
	9	117	62	Adhesives
			55	Sealing Compounds
	10	231590	93200	Lead - Acid Batteries
			34307	Oily Dirt
			37934	Spent Sorbent
			7572	Dirty Rags

*1: spent cleaning solvent (nonhalogenated), 2: spent cleaning solvent (halogenated), 3: waste petroleum products, 4: waste alcohols and glycols, 5: spent acids or bases, 6: spent paint thinner, 7: waste PRM, 8: spent photo or print chemicals, 9: miscellaneous chemicals, 10: miscellaneous materials.

Table A1 (Cont'd)

Wastes Generating Operation, Process, or Condition	Waste Category	lb /yr	lbs/yr/unit	Waste Stream Unit
			13489	Empty Cans
			11935	Hazardous Parts
			23407	Filters
			9746	Other
Aviation Maintenance Facilities	1	6350	6350	PD 680-II
	2	852	745	MEK
			107	Paint Stripper
	3	18530	5805	Used Engine Oil
			8420	Avgas
			490	Calibrating Fluid
			130	Grease
			3685	Hydraulic Fluid
	4	402	402	Methanol
	6	786	591	Xylene
			195	Thinner (unspecified)
	7	3774	525	Paint
			2770	Paint Related Material (unspecified)
			84	Corrosion Preventative
			395	Empty Paint Caustics
	9	3978	3	Adhesives
			180	Sealing Compound
			155	Cleaning Compound
			1740	Floor Wash
			1560	Detergent
			140	Nicad Electrolyte
			200	Deicer Solution
	10	9738	210	Nicad Cells
			100	Filters
			1250	Sorbent
			5035	Oily Dirt
			830	Hazardous Pants
			2313	Other

Table A1 (Cont'd)

Wastes Generating Operation, Process, or Condition	Waste Category	lb/yr	lb/yr/unit	Waste Stream Unit
Industrial Maintenance Facilities and Small Arms Shops	1	13000	13000	PD680 - II
	2	2695	2625	TCA
			10	TCE
			60	Carburetor Cleaner
	3	46932	36675	Used Oil
			630	Oil Contaminated with Water
			18	Grease
			4000	MOGAS
			840	Diesel
			2269	Oil Contaminated with Solvent
			430	Hydraulic Fluid
			1920	Transmission Fluid
			150	Brake Fluid
	4	3672	3672	Antifreeze
	5	3165	60	Phosphate Solution
			1040	*Spent Sodium Hydroxide*
			2065	Lead - Acid Battery Electrolyte
	6	1020	1020	Paint Thinner (unspecified)
	7	5647	2587	Paint
			3060	Paint Related Material (unspecified)
	10	54307	6550	Lead - Acid Batteries
			334	Nickel Cadmium Cells
			42635	Scrap Fuel Tanks
			2587	Filters
			170	Empty Cans
			1733	Oily Dirt
			2885	Other
Troop Units	7	851	733	Paint
			118	Paint Related Material
	9	10354	6753	DS - 2
			102	Super Tropical Bleach
			800	Lindane
			400	Rifle Bore Cleaner
			708	Calcium Hypochlorite
			1000	Shelf-Life Chemicals
			591	Insecticide

Table A1 (Cont'd)

Hazardous Wastes Generating Operation, Process, or Condition	Hazardous Wastes Category	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
	10	43143	16080	Magnesium Batteries
			15004	Lithium Batteries
			10405	Mercury Batteries
			48	Nickel Cadmium Batteries
			500	Contaminated Soil
			1106	Other
Hospitals, Clinics, and Labs	8	2400	2400	Photo Solution
	9	7896	1950	Xylene
			498	Formaldehyde
			48	Mercury
			5400	Pharmaceutical
	10	10920	2520	Pathological
			8400	Medical Infectious
Paint Shops	2	190	190	Paint Stripper
	4	506	506	Alcohol
	6	8294	8294	Thinner
	7	1598	830	Paint
			658	Filters
			110	Paint Cans
	10	937	450	Sludges
			487	Other
Printing, Photography, and Arts/Crafts Shops	2	310	300	Blankrola
			10	TCA
	5	160	160	Ammonium Hydroxide
	6	150	150	Thinner
	7	200	200	Paint Wastes
	8	10191	3246	Developer
			2502	Fixer
			646	Stabilizer
			806	Photo Bleach
			2081	Miscellaneous Photo Chemicals
			910	Bath Dumps
Other Generators	10	20	20	Empty Caustics
	1	80	80	PD 680 - II
	3	3515	600	Fuel Oil
			2475	Used Oil
			440	Hydraulic Fluid
	10		510	Other

Table A2

Total Waste Generation Rates Sorted By Waste Categories*

Generator	Total	1	2	3	4	5	6	7	8	9	10
Motor pool and vehicle Maintenance	714848	36302	990	342063	66648	24272	2490	103376		117	231590
Aviation Maintenance Facilities	44410	6350	852	18350	402		786	3774		3978	9738
Industrial Maintenance Small Arms Shops, etc.	130438	13000	2695	46932	3672	3165	1020	5647			54307
Troop	54348							851		10354	43143
Hospitals, Clinics & Laboratories	21216								2400	7896	10920
Paint Shops	11525		190		506		8294	1598			937
Photography, Printing, and Arts/Crafts Shops	11031		310			160	150	200	10191		20
Other	4105	80		3515							510
Total	991921	55732	5037	411040	71228	27597	12740	22446	12591	22345	351165

*Quantities are reported in pounds per year.

Table A3

Calculation of the Overall Waste Reduction Factors

Waste	Quantity lb/yr (gal/yr)	Estimated Reduction	Estimated "HW" Reduction
Waste Oil	308,308 (44,044)	0.30	1.00
Antifreeze	69,453 (7717)	1.00	1.00
Cleaning Solvent	55,732 (5573)	0.90	0.90
Paint Thinner	12,740 (1700)	0.80	0.90
Xylene	1950 (260)	0.80	0.90
1,1,1-Trichloroethane	2625 (341)	1.00	1.00
Drycleaning Filters	9500*	0.00	1.00
Paint Sludge	4992** (624)	1.00	1.00
Other Wastes	541,113	0.20	0.20
	Weighted Average	0.34	0.56

*Not reported in Tables A1 and A2. Estimated from drycleaning plant operations.
**Not reported in Tables A1 and A2. Estimated from assumed water use rate.

APPENDIX B:

HAZMIN PROTOCOL AND SURVEY FORMS

HAZMIN Protocol

Goals

1. Define current status of waste generation and management practices.
2. Identify and evaluate new waste minimization alternatives.
3. Identify support for existing alternatives/activities.
4. Identify areas/activities requiring further research and development.

Approach

I. Review information available at the installation.

II. Talk to several groups of individuals.

III. Develop a list of waste streams and rank them.

IV. Develop information on each waste stream.

V. Identify minimization options for each waste stream.

VI. Evaluate and rate options (preliminary or first screen) for each waste stream.

VII. Conduct detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

HAZMIN Protocol

I. Review information available at the installation.

The information reviewed by the survey team includes:

1. Installation policies/programs on waste minimization, if any.
2. Hazardous waste manifests, annual (and biennial) reports, and other RCRA information since 1985.
3. State and local regulations that are more stringent than federal regulations.
4. Environmental audit/review reports.
5. Emission inventories.
6. Permit and/or permit applications, and any regulatory violations.
7. Contracts with waste management firms.
8. Waste assays and/or tests.
9. Materials purchase orders, purchase records.
10. Maps, organizational charts, list of activities associated with different buildings.
11. Production/maintenance schedules.
12. Operator data logs, batch sheets.
13. Operation manuals, process descriptions, standard operating procedures (SOPs).
14. Process flow diagrams (PFDs) and facilities layout.
15. Heat and material balances for production processes and pollution control systems.
16. Safety procedures for handling hazardous materials.

Products:

1. List of information sources.
2. Waste stream list.
3. Survey agenda or checklist detailing what is to be accomplished.
4. List of questions that need to be resolved.
5. List of information that needs to be gathered.

HAZMIN Protocol

II. Talk to several groups of individuals.

Identify appropriate individuals to interview among:

1. Environmental personnel
   - who compile USEPA/State reports
   - who compile DRMO reports
2. Waste generators
   - supervisors
   - shop foremen and production employees

3. Hazardous waste managers
   - operators of onsite treatment, storage, and disposal (TSD) facilities
   - transporters of waste from generation points to TSD facilities

4. Individuals responsible for purchasing/acquisition of hazardous materials (for possible substitution alternatives, costs of purchase, etc.)

5. Individuals with broad HAZMIN responsibilities
   - finance and accounting
   - construction/renovation of facilities
   - higher levels of management
   - legal advisors

HAZMIN Protocol

III. Develop a list of waste streams and rank them.

Develop a waste generation inventory based on reports, permits, and observation. Inventory must be representative of "normal" operations.

Ranking criteria:

1. Composition
2. Quantity (volume or mass generated per year and unit of production)
3. Degree of hazard (toxicity, flammability, corrosivity, etc.)
4. Method and cost of disposal
5. Potential for minimization and recycling
6. Compliance status (in or out)
7. Potential liability (past spills or accidents; proximity to water)
8. Degree of acceptability of changes at the installation
9. Installation personnel preference for options

Products:

1. Waste description with rationale for selection
2. Description of facilities, processes, and waste streams

IV. Develop information on each waste stream.

The following information must be developed on each waste stream based on observation and available reports:

1. Waste characterization
   - chemical/physical analysis
   - reason for hazardous nature

2. Waste source

3. Baseline generation

4. Present method of TSD and associated costs

5. Past/present minimization efforts and associated costs

Some points to be reviewed in the above determination are:

- actual point of generation
- details about subsequent handling/mixing
- "hazardous" versus nonhazardous
- physical and chemical characteristics
- quantities by waste treatability category
- potential variations in the rate of production, maintenance, etc.
- potential for contamination or upset
- true costs for management, onsite and offsite including tax, fringe, and overhead for labor; cost of space; vehicle insurance, maintenance, fuel, etc.

V. <u>Identify minimization options for each waste stream</u>.

Follow USEPA guidelines on waste minimization. The categories arranged in a heirarchical order are:

1. Source reduction
   a. product/material substitution
   b. source control
      i. input material changes (e.g., dilution, purification)
      ii. technology changes (e.g., process changes, layout changes, etc.)
      iii. procedural/institutional changes

2. Recycle/reuse
   a. onsite
   b. offsite

3. Waste separation and concentration

4. Waste exchange

5. Energy/material recovery

6. Waste incineration/treatment

7. Treatment

8. Ultimate disposal

HAZMIN Protocol

VI. Evaluate and rate options (preliminary or first screen) for each waste stream.

Some considerations for a preliminary evaluation and rating of minimization options for each waste stream are:

1. Waste reduction effectiveness (i.e., reduction of waste quantity and/or toxicity)
2. Extent of current use in the facility
3. Industrial precedent
4. Technical soundness
5. Cost (preliminary capital and operating cost evaluation)
6. Effect on product quality
7. Effect on operations
8. Implementation period
9. Resources availability and requirement

VII. Detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

The following aspects must be considered in the final detailed analysis:

1. Technical soundness and commercial availability

2. Evaluation of detailed life cycle costs of all the options for each waste stream

3. Detailed comparison of costs of the current practices with alternative options to obtain savings to investment ratios and discounted payback periods

4. Implementation period

HAZMIN Survey Forms

Installation____________________Date__________POC____________________
Phone__________

WASTE STREAM/MATERIALS USAGE: Motor Pools & Vehicle Maintenance Facilities

Generator (Unit Name)_________________Building_______DODAAC________UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
Carburetor cleaner		Carburetor cleaner	
Waste oil		Engine oil	
Antifreeze solution		Antifreeze	
Lead-acid batteries		Lead-acid batteries	
Battery acid		Battery acid	
Aqueous detergent or caustic wastes (engine/radiator washing)		Caustic/detergent	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (mogas/diesel)		Fuel: diesel mogas	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Other fluids (transmission, brake, etc.)		Other fluids (transmission, brake, etc.)	
Mixed wastes			
Hazardous faulty parts (e.g., brake pads)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC,______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Aviation Maintenance Facilities

Generator (Unit Name)________________Building_______DODAAC______UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
MEK degreaser & cleaner		Methyl ethyl ketone	
Calibrating fluid (specify)		Calibrating fluid (specify)	
Paint stripper (specify)		Paint stripper (specify)	
Paint thinner (specify)		Paint thinner (specify)	
Filters (paint booth)		Filters (paint booth)	
Used paint cans			
Waste engine oil		Engine oil	
Deicer solution		Deicer	
Nickel-cadmium batteries		Nickel-cadmium batteries	
NICAD battery electrolyte		Battery electrolyte (pottasium hydroxide)	
Aqueous detergent or caustic wastes (engine washing)		Caustic/detergent (engine washing)	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (Avgas)		Fuel (Avgas)	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation______________________Date__________POC______________________
Phone__________

WASTE STREAM/MATERIALS USAGE: Industrial Maintenance, Small Arms Shops, etc.

Generator (Unit Name)________________Building________DODAAC______UIC_____

Waste Stream	**Generation Rate** (indicate units: gal/yr lb/yr, pints/mo, etc.)	**Material Input**	**Usage Rate** (indicate units: gal/yr lb/yr, pints/mo, etc.)
Degreasing solvent (trichloroethylene)		Trichloroethylene	
Degreasing solvent (1,1,1-trichloroethane)		1,1,1-trichloroethane	
Degreasing solvent (others)		Degreasing solvent (others, specify)	
Paint thinners (specify)		Paint thinners (specify)	
Surface cleaners (specify)		Surface cleaners (specify)	
Paint wastes			
Waste oil		Lubricating oil	
Hydraulic/cutting fluids		Hydraulic & cutting fluids	
Corrosive chemicals (caustic soda)		Caustic soda	
Corrosive chemicals (phosphoric acid)		Phosphoric acid	
Corrosive chemicals (chromic acid)		Chromic acid	
Corrosive chemicals (phosphate solution)		Phosphate	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Tank bottoms (specify)			
Paint/sand blasting wastes			
Steam cleaning compound (alkali wastes)		Alkali	
Radioactive wastes		Radioactive sources	
Batteries (lead-acid, NICAD)		Batteries: Lead-acid Nickel-cadmium	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________**Date**__________**POC**______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Paint Shops

Generator (Unit Name)________________**Building**_______**DODAAC**______**UIC**_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Old/used paint cans			
Old/used paint			
Paint thinners (specify)		Paint thinners (specify)	
Paint strippers (specify)		Paint strippers (specify)	
Caustic wastes		Caustic soda	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Filters from paint booths		Filters (paint booths)	
Sludges from water-wall booths			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________**Date**__________**POC**________________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Hospitals, Clinics, and Laboratories

Generator (Unit Name)________________**Building**_______**DODAAC**________**UIC**___

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Pathological wastes (specify)			
Medical infectious wastes (specify)			
Pharmaceutical wastes (specify)			
Chemical wastes (specify)		Laboratory chemicals (xylene) Laboratory chemicals (mercury) Laboratory chemicals (others, specify)	
Radioactive wastes (specify)			
Photographic wastes (specify)		Photographic chemicals (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________ Date__________ POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Photography, Printing, Arts/Crafts Shops, etc.

Generator (Unit Name)________________ Building_______ DODAAC_______ UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Solvents (specify)		Solvents (specify)	
Inks (specify)		Inks (specify)	
Photographic chemical wastes (specify)		Photographic chemicals (specify)	
Printing chemical wastes (specify)		Printing chemicals (specify)	
Bath dumps			
Paint wastes			
Paint/sand blasting wastes			
Other dry wastes			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation__________________ __Date__________POC_____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Heating and Cooling Plants

Generator (Unit Name)________________Building_______DODAAC_______UIC___

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
		Waste oil	
Contaminated fuel oil		Fuel oil	
		Natural gas	
Combustible chemicals (cyclohexylamine)		Combustible chemicals (cyclohexylamine)	
Combustible chemicals (other, specify)		Combustible chemicals (others, specify)	
Corrosive chemicals (caustic soda/potash)		Corrosive chemicals (caustic soda/potash)	
Corrosive chemicals (other, specify)		Corrosive chemicals (other, specify)	
Boiler blowdown			
Toxic emissions			
Ash			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Laundry and Drycleaning Facilities

Generator (Unit Name)________________Building_______DODAAC_______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Corrosive chemicals (caustic soda)		Corrosive chemicals (caustic soda)	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Drycleaning compound (perchloroethylene)		Perchloroethylene	
Drycleaning compound (others, specify)		Drycleaning compound (others, specify)	
Equipment filters		Filters	
Contaminated water			
Other dry wastes (specify)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Miscellaneous Generators

Generator (Unit Name)________________Building_______DODAAC_______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Wet chemical wastes (specify)		Wet Chemicals (specify)	
Dry chemical wastes (specify)		Dry Chemicals (specify)	
Off-shelf life chemicals			
Used chemicals (pesticides, etc.)			
Batteries (specify)		Batteries (specify)	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Contaminated soil			
Demilitarized ammunition			
Decontaminating agents (STB, DS2, etc.)			
Hazardous empty containers (drums etc.)			
Contaminated equipment (PCB transformers etc.)			
Contaminated water		Water	
Sludge from water treatment		Water treated	
Leachate into groundwater			
Infectious wastes			
Ordnance			
Fire-fighting foam		Fire fighting foam	
Miscellaneous (specify)		Miscellaneous (specify)	

APPENDIX C:

EXAMPLE OF INSTALLATION ENVIRONMENTAL POLICY

MEMORANDUM FOR DISTRIBUTION

SUBJECT: INSTALLATION ENVIRONMENTAL POLICY[8]

1. Fort Ord is committed to continued excellence, leadership, and stewardship in protection of the environment. Environmental protection is a primary command responsibility, as well as the responsibility of all tenant activities and every military and civilian employee on the installation.

2. Our objective as an Army installation is to reduce waste and achieve minimal adverse impact on the air, water, and land through excellence in environmental control.

3. All the directorates and commanders of tenant activities will issue the following guidelines in support of the above policy:

   a. Every employee is responsible for environmental protection in the same manner he or she is for safety. It is therefore an important measure of employee performance.

   b. Minimizing or eliminating the generation of waste has been and continues to be a prime consideration in all mission related activities; and is viewed by the command like safety and loss prevention.

   c. Reuse and recycling of materials has been and will continue to be given first consideration prior to classification and disposal of waste.

4. This environmental policy is consistent with the Department of Army Hazardous Waste Minimization (HAZMIN) Policy[9] (see enclosure), and must be adopted and implemented throughout the installation.

Encl Garrison Commander

DISTRIBUTION

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[8] *The EPA Manual for Waste Minimization Opportunity Assessments* (U.S. Environmental Protection Agency, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, 1988).

[9] *Hazardous Waste Minimization (HAZMIN) Policy*, Draft Policy (Department of the Army, Office of Chief of Engineers, Washington, D.C., 28 September 1988).

ABBREVIATIONS AND ACRONYMS

AAFES	Army Air Force Exchange Service
AAQS	Ambient Air Quality Standards
AFB	Air Force Base
AFFF	Aqueous Film Forming Foam
AFPMB	Armed Forces Pest Management Board
AHS	Academy of Health Sciences
AMC	Army Materiel Command
AMF	Aviation Maintenance Facilities
AOAP	Army Oil Analysis Program
AR	Army Regulation
ARCOM	U.S. Army Reserve Command
BMO	Battalion Maintenance Officer
BOD	Biological oxygen demand
CARC	Chemical agent resistant coating
CE	Corps of Engineers
CEWI	Combat Electronic Warfare Intelligence
CFR	Code of Federal Regulations
CIC	U.S. Army Criminal Investigation Command
CW	Chemical Wastes
DA	Department of the Army
DEH	Directorate of Engineering and Housing
DENTAC	U.S. Army Dental Activity
DERA	Defense Environmental Restoration Account
DESR	Defense Environmental Status Report
DHS	Directorate of Health Services
DLA	Defense Logistics Agency
DOD	Department of Defense
DOHS	Department of Health Services
DOL	Directorate of Logistics
DOT	U.S. Department of Transportation
DPCA	Directorate of Personnel and Community Activities

DPP	Discounted Payback Period
DPTM	Directorate of Plans, Training, and Mobilization
DRMO	Defense Reutilization and Marketing Office
DRMS	Defense Reutilization and Marketing Service
EA	Environmental Assessment
ENRO	Environment and Natural Resources Office
EOD	Explosive Ordnance Disposal
EOR	Environmental Operations Review
ETIS	Environmental Technical Information Service
ETL	U.S. Army Engineering Technical Laboratory
FLOCS	Fast Lube Oil Change System
FORSCOM	U.S. Army Forces Command
FR	Federal Register
FY	Fiscal Year
GSA	General Services Administration
GW	General Waste
HAZMIN	Hazardous Waste Minimization
HCL	Hospitals, Clinics, and Laboratories
HM	Hazardous Material
HMSC	Headquarters and Main Support Company
HMTC	Hazardous Materials Technical Service
HQDA	Headquarters, Department of the Army
HSC	Health Services Command
HSWA	Hazardous and Solid Waste Ammendments
HW	Hazardous Waste
HWMB	Hazardous Waste Management Board
IL	Infectious Linen
IMSS	Industrial Maintenance and Small Arms Shops
INSCOM	U.S. Army Intelligence and Security Command
ISC	U.S. Army Information Systems Command
ISCP	Installation Spill Contingency Plan
IW	Infectious Waste

IWTP	Industrial Wastewater Treatment Plant
JAG	Judge Advocate General
JLC	Joint Logistics Commanders
LPI	Leak Potential Index
LW	Laboratory Waste
MACOM	Major Command
MBUAPCD	Monterey Bay Unified Air Pollution Control District
MEDDAC	Medical Department Activity
MI	Military Intelligence
MPVM	Motor Pools and Vehicle Maintenance Facilities
MSB	Main Support Bulletin
MSDS	Material Safety Data Sheet
MWSA	Medical Waste Sanctions Act of 1988
NAAQS	National Ambient Air Quality Standard
NIPDWR	National Interim Primary Drinking Water Regulations
NIPER	National Institute for Petroleum and Energy Research
NPDES	National Pollution Discharge Elimination System
NPV	Net Present Value
NSDWR	National Secondary Drinking Water Regulations
NSN	National Stock Number
OB/OD	Open Burning/Open Detonation
OEM	Original Equipment Manifest
OSHA	Occupational Safety and Health Administration
PC	Perchloroethane
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PL	Public Law
PMB	Plastic media blasting
POL	Petroleum, Oils, and Lubricants
PPAS	Photography, Printing, and Arts/Crafts Shop
PPM	Parts Per Million
PS	Paint Shops
RCRA	Resource Conservation and Recovery Act

RDC	Regional Data Center
RO	Reverse Osmosis
RW	Radioactive Waste
SATCOM	Satellite Communication
SIP	State Implementation Plan
SOP	Standing Operating Procedure
SPCCP	Spill Prevention Control and Countermeasures Plan
SQG	Small Quantity Generator
TASC	Training and Audiovisual Support Center
TCE	Trichloroethylene
TLV	Threshold Limit Value
TMP	Transportation Motor Pool
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSO	Technical Supply Office
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
USACERL	U.S. Army Construction Engineering Research Laboratory
USACIDC	U.S. Army Criminal Investigation Division Command
USAEHA	U.S. Army Environmental Hygiene Agency
USAISC	U.S. Army Information Systems Command
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USE	Used Solvent Elimination
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound
XO	Executive Officer

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