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Hazardous Waste Minimization Assessment: Fort Meade, MD

by
Seshasayi Dharmavaram
Bernard A. Donahue

On November 8, 1984, the U.S. Congress signed into public law the Hazardous and Solid Waste Amendments (HSWA) act establishing a national policy on waste minimization. Regulations created to support the HSWA require hazardous waste generators to develop and follow a hazardous waste minimization program. Moreover, the Department of Defense has established a goal of 50 percent reduction in hazardous waste generation by 1992 (compared to 1985 generation data).

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FOREWORD

This work was performed for Headquarters, U.S. Army Forces Command (HQFORSCOM), under 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 Director.

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HAZARDOUS WASTE MINIMIZATION ASSESSMENT: FORT MEADE, MD

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

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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 155.

[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.

by the installations. The installations do not have a separate funding account for waste disposal and 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. This report is the first of the plans and provides a framework for surveying similar installations and developing their HAZMIN plans.

Objective

The objective of this research was to develop a hazardous waste minimization plan for Fort Meade, MD 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 Meade from 17 through 21 October 1988, 7 through 9 February 1989, and 22 through 24 March 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

Although an attempt was made to quantify all the hazardous materials procured by and hazardous wastes generated at Fort Meade, 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 Meade 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 Meade 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 wastes. Some examples of material substitution are:[13] replacing chlorinated solvents (e.g., trichloroethylene [TCE],

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[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).

[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).

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 solvents, burning used oil for heat content, etc.). Offsite recycling includes methods used to process

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[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.*

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 Meade.

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 Meade 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.

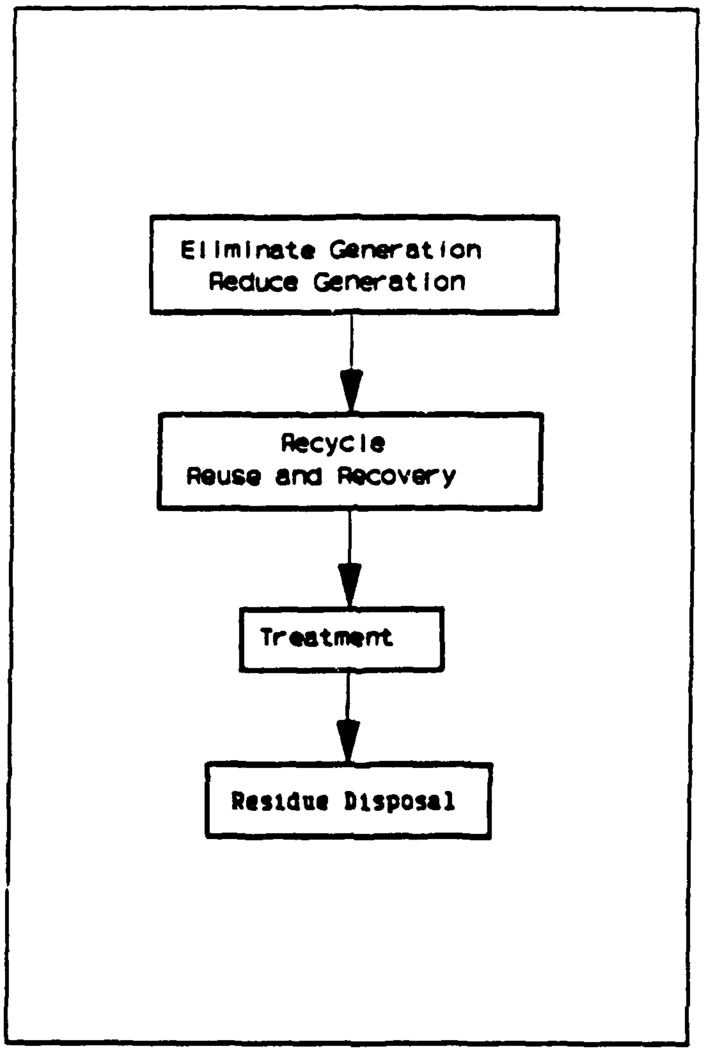

Figure 1. Waste minimization hierarchy.

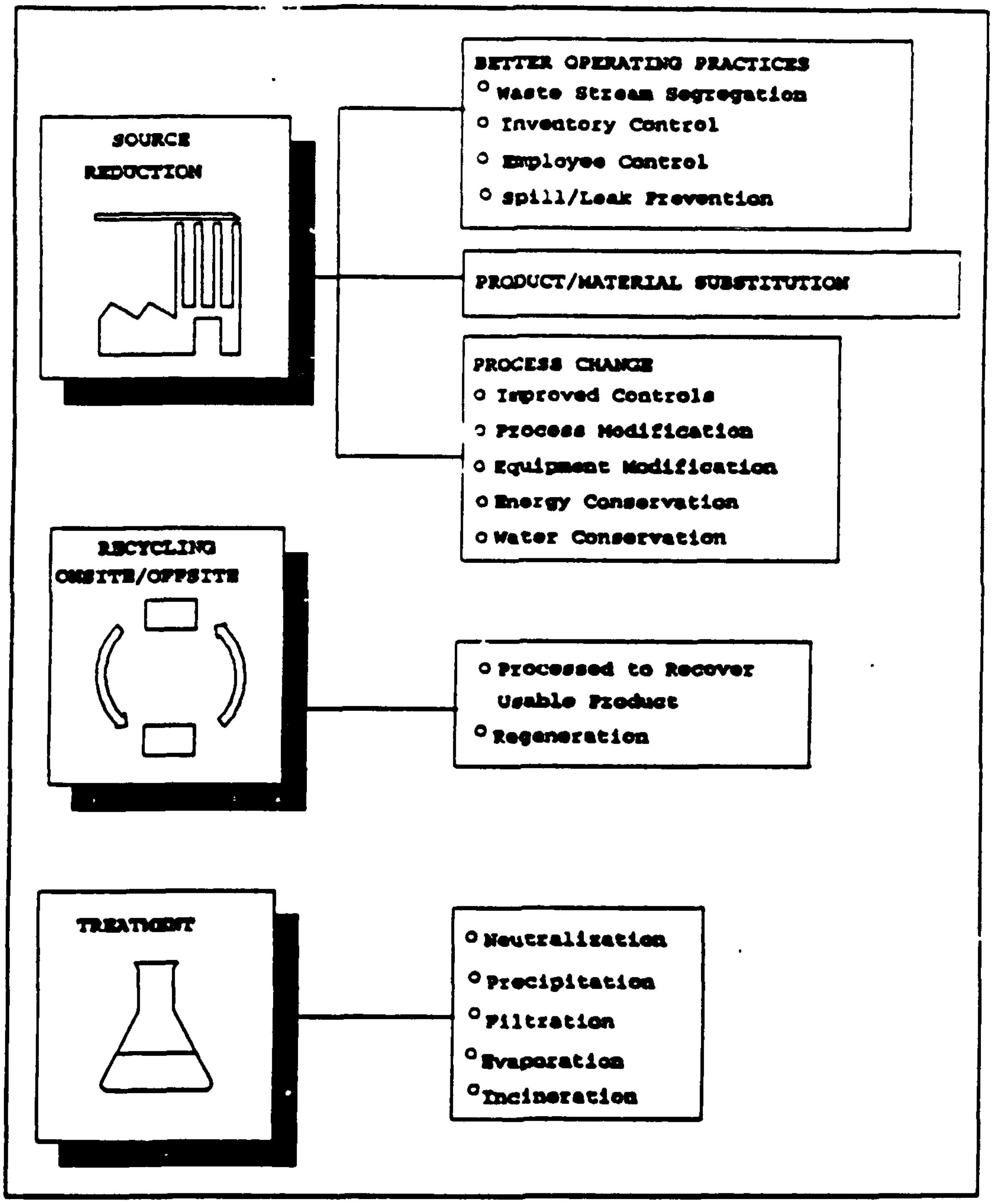

Figure 2. Waste minimization techniques.

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

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

Georgia Waste Exchange*
c/o American 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
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Newark, NJ 07102
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Manitoba Waste Exchange
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Montana Industrial Waste Exchange
Montana Chamber of Commerce
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South Waste Exchange
Urban Institute
UNCC Station
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(704) 547-2307

Southern Waste Information Exchange
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(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 Tencon
Associates**
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*For profit information exchange.
**Material waste exchange.

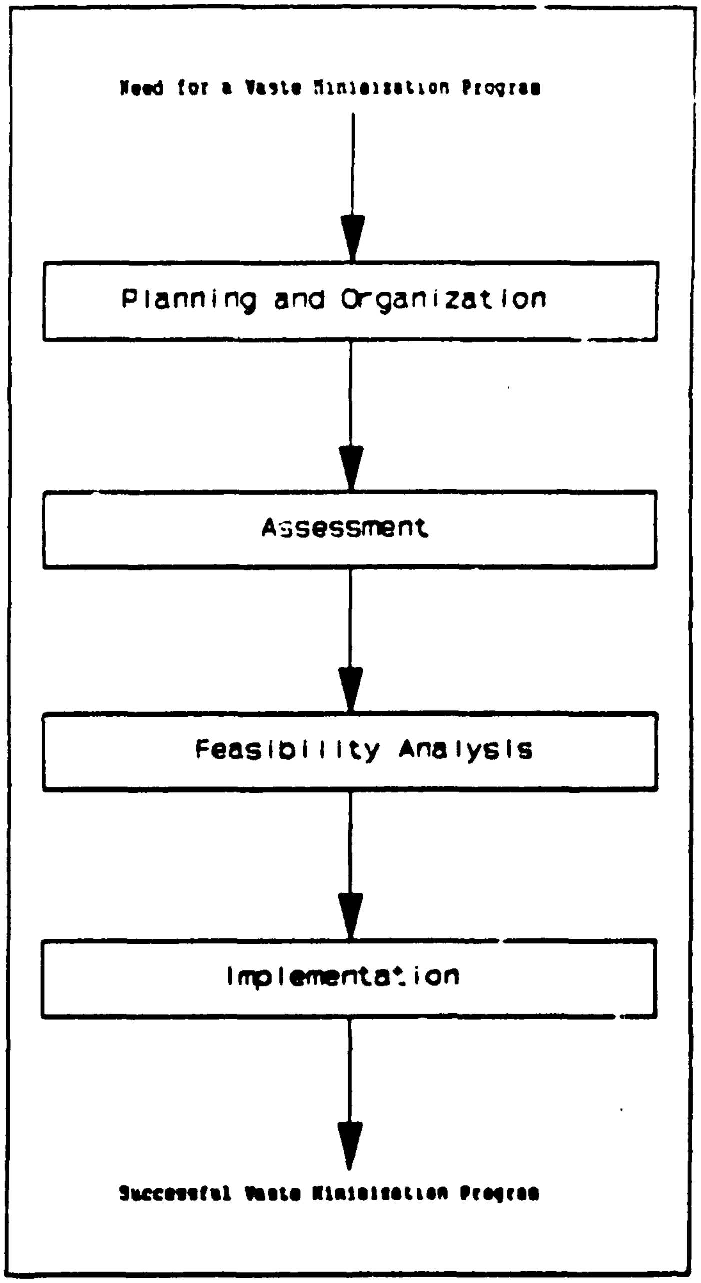
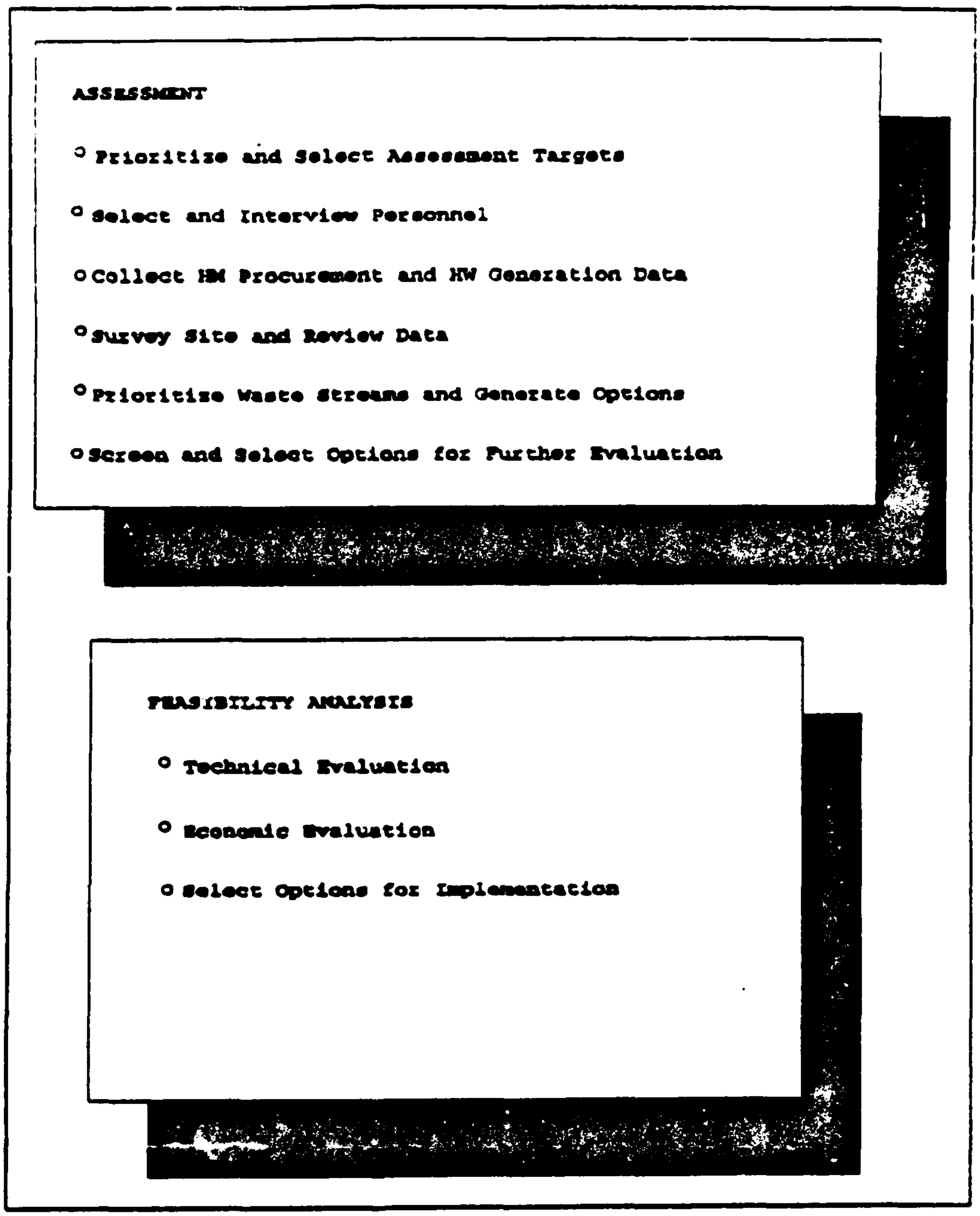


Figure 3. Hazardous waste minimization program development procedure.



ASSESSMENT

- ○ Prioritize and Select Assessment Targets
- ○ Select and Interview Personnel
- ○ Collect HM Procurement and HW Generation Data
- ○ Survey Site and Review Data
- ○ Prioritize Waste Streams and Generate Options
- ○ Screen and Select Options for Further Evaluation

FEASIBILITY ANALYSIS

- ○ Technical Evaluation
- ○ Economic Evaluation
- ○ Select Options for Implementation

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

3 FORT MEADE

History/Geography

Fort Meade, located in Anne Arundel County, MD, is a FORSCOM installation. It has an area of 21 sq mi and is located to the east of the Baltimore-Washington parkway about 20 mi from Washington, DC. One-third of the installation consists of administrative, recreational, and housing facilities; most of the remaining portion is used as a training area and combat range.

In 1917, the U.S. Congress authorized the building of Fort Meade as a troop cantonment facility for use during World War I. In 1928, it became a permanent Army installation. Thousands of troops have been trained at Fort Meade.

Presently, Fort Meade is an administrative post that houses the First U.S. Army (FUSA) Headquarters, the National Security Agency (NSA), U.S. Army Intelligence and Security Command (INSCOM) and many other tenants. The mission of Fort Meade is to provide administrative support and services to all its tenant units and all reserve units located within the regional purview of the FUSA.

Tenants

Of the more than 60 tenants (see Appendix C) located within the geographic boundary of Fort Meade the major tenants are listed below:

1. Headquarters, FUSA, Building 4550.
2. INSCOM, Buildings 4552, 4553, and 4554.
3. Kimbrough Army Community Hospital (KACH), Building 2840.
4. National Security Agency (NSA).
5. Intelligence Material Activity (IMA), U.S. Army Material Command, Building 4544.
6. U.S. Army Institute of Dental Research (USAIDR), Building 2832.
7. 11th Engineer Battalion, Company C, Buildings 8610, and 8492.
8. 85th Medical Battalion, Buildings 8542, 8543, 8545, and 70.
9. 209th and 293rd Military Police Companies, Buildings 8478, 8479, 8486 and 8487.
10. 327th Aviation Company, Building 90, and Tipton Airfield.

Headquarters, Fort Meade administrative offices are located in buildings 4215, 4216, and 4217. The major services and tenant support activities are managed by the Directorate of Engineering and Housing (DEH), the Directorate of Logistics (DOL), Directorate of Personnel and Community Activities (DPCA), and the Training/Audiovisual Support Center (TASC).

Environmental Programs

The Installation Commander is responsible for complying with all the environmental regulations and for control of pollution from sources within the installation boundaries. However, the DEH through its Environmental and Energy Control Office (EECO) coordinates the environmental policy, permits, and compliance matters with the Federal, State and local regulatory agencies. The EECO bears the direct responsibility of developing and directing an environmental compliance program.

In addition to Federal/State/local regulations, Army Regulation (AR) 200-1[34] also requires all Army installations to do everything possible to protect the environment in fulfilling their mission. Fort Meade added a supplement to AR 200-1, in 1980, extending the visibility of the environmental program throughout the post. All the directorates were required to appoint environmental coordinators. Following the passage of the RCRA (1980) and HWSA (1984), hazardous materials and hazardous wastes managers were appointed at every unit identified as a generator of hazardous waste. A summary of the Fort Meade environmental program is provided below.

Air Pollution Control

Fort Meade is required to comply with the regulations of the Metropolitan Baltimore Air Quality Region, which are more stringent than the rest of the State of Maryland. Because Fort Meade was out of compliance with respect to the total suspended particulate ambient air quality standard due to emissions from the pathological incinerator at KACH, a new incinerator was installed and permitted in 1980 by the State of Maryland. The incinerator brought Fort Meade into compliance, which continues to date.

Water Pollution Control

Two waste water treatment plants (WWTPs) were operated at Fort Meade from 1975 to 1980. In 1980, USAEPA found that the treatment plants did not meet the water quality standards and issued a compliance order. A contract was then issued to Metcalf and Eddy through the Baltimore District of the U.S. Army Corps of Engineers to build a treatment facility to meet the water quality standards. One of the WWTPs was deactivated and the second plant was upgraded to meet the additional influent flow. Fort Meade had to receive a permit to discharge the backwash from the first treatment plant filter before the second plant was upgraded. The backwash has been diverted to the upgraded WWTP for treatment.

Radiation Pollution Control

The primary source of radiation at Fort Meade is the radiological equipment used at KACH and the dental clinics. A 1979 radiation protection survey conducted by the AEHA concluded that all the operations were in good order. No radioactive isotopes are used or stored at these facilities.

Solid Waste Management

Municipal and domestic wastes at Fort Meade are deposited in the installation's only active landfill. The refuse section of the DEH operates dumpsters and transporters for these wastes. The sanitary landfill was operated using the "trench fill" method before 1976. Following the passage of RCRA, Fort Meade was required to obtain a permit to construct and operate a landfill. A transition was made in late 1976 to operate the landfill using the "area fill" method and, after extensive review by the USAEPA, the State of Maryland, and Anne Arundel County, a permit was issued in 1980.

Hazardous Materials and Waste Management

A program to control toxic materials (e.g., insecticides, herbicides, etc.) has been underway since 1980. Some of the hazardous materials being used on the post are listed below:

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[34] Army Regulation (AR) 200-1, *Environmental Protection and Enhancement* (Headquarters, Department of the Army [HQDA], 15 June 1982).

Insecticides: Sevin, Dursban, Korlan, Ficam, Chlordane, Lindane, Pyrethrum, Phostoxin, Drione, boric acid, Baygon, Diazinon, Malathion, DDT.

Herbicides: Amizine, Amitrol-T, Simazine, 2,4-D, Bromocil, Dicambra, Tordon, Maintain, Roundup, Phytar, Crop rider.

Fungicides: Lignasan, Benlate, Zineb.

Rodenticides: Diphacinone, Talon, Warfarin, Zinc Phosphide, Razol Tracking Powder.

Petroleum products: Gasoline, kerosene, #2 fuel oil, diesel fuel, thinners, paints, lacquers, cleaning solvents, trichloroethylene (TCE), 1,1,1-trichloroethane, JP-4, crankcase oils.

Compressed gases: Chlorine, ammonia, acetylene, ethylene oxide.

Acids/Alkalis: Hydrochloric acid, sulfuric acid, nitric acid, acetic acid, phosphoric acid, sodium hydroxide, potassium hydroxide, lime.

Miscellaneous: Univer, fluoride, alum, etc.

In 1988, the Installation Safety Officer instituted a new program to identify hazardous materials for all users on the post. A data base of the quantities procured and stored is being developed to comply with the requirements of Title III of the Superfund Amendments and Reauthorization Act (SARA)[25] (i.e., Community Right-To-Know).

A plan for spill prevention control and countermeasures was added to Supplement 1 of AR 200-1 in 1978. Although that plan is still in effect, it will be modified soon. A plan for management and disposal of hazardous waste was developed and adopted in 1984. Some of the unique problems at Fort Meade are discussed in the following paragraphs.

Hazardous Waste. Because of stored DDT awaiting disposal, Fort Meade applied in 1979 for an Interim Status Permit as a generator and storage facility. The storage classification was expected to be lifted after disposal of the DDT. However, Fort Meade continued to generate and store controlled hazardous substances and, therefore, was required to obtain other permits. Currently, Fort Meade has a Controlled Hazardous Substances Facility Permit issued by the State of Maryland in May 1988.

Waste Oil. Fort Meade generates about 40,000 gallons of waste oil per year, which is transported and burned at one of the central boiler plants for heat recovery. A State of Maryland air quality permit has been obtained to continue this operation.

Asbestos Hazard. Friable asbestos has been found in various old buildings on the installation. Primarily in insulation, it is left intact if the insulation is still intact. Only nonasbestos replacement insulation is used. Workers are required to use safety equipment during demolition of old buildings and in other asbestos-hazard workplaces. Asbestos wastes are treated as hazardous wastes and properly disposed of.

Waste Disposal. In 1980 and 1986, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) surveyed Fort Meade to determine past and present activities generating hazardous wastes. One of their recommendations was to properly secure an area identified by Fort Meade as a potential mustard gas burial site. Further details of the two USATHAMA surveys are provided below.

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[25] Public Law 99-499.

Installation Restoration Assessments

An installation restoration survey of Fort Meade was first conducted in 1980.[26] The purpose of the assessment was to determine the existence of toxic and hazardous materials, and related contamination, with a major emphasis on the study of potential offpost migration. All the onsite records were evaluated to assess the use of toxic materials. All the past and current industrial and nonindustrial activities and operations were reviewed. The major activities were vehicle maintenance, guided missile shop, boiler plants, photographic laboratories, laundry and drycleaning, locomotive shop, ordnance shops, spray painting, battery shops, vapor degreasing, electrical shop, chemical and clinical laboratories, training areas, water and wastewater treatment, and demolition and burning. Some of the findings of the study were as follows:

> The two sewage treatment plants were not meeting National Pollution Discharge Elimination System (NPDES) permit requirements because of occasional upsets caused by discharges from NSA plating activities. A new WWTP was constructed and has been operational since 1983.
>
> A sanitary landfill that has been in use since 1958 was monitored for potential leaching of contaminants into groundwater. The question of the possible presence of leachate in groundwater was not answered by monitoring conducted by the State of Maryland.
>
> A clean-fill dump site is located in a boggy area south of the sanitary landfill. A survey by USAEHA revealed that many prohibited items were illegally disposed of in this area.
>
> Behind the boiler house (Building 8481), there is an open drain next to the bermed waste oil tank that provides a pathway for transport of petroleum, oils, and lubricants (POL) into the sewer. Flammable solvents were improperly stored behind Building 2246.
>
> A suspected mustard gas burial site was not posted or secured. Proper notices were not installed at the training range impact areas. Pesticides were improperly stored and portable latrine wastes were disposed of at the sanitary landfill.
>
> The potential for offpost migration of contaminants improperly buried in the landfill exists via surface and subsurface water.

Some of the recommendations of the 1980 study were that: (1) Fort Meade must coordinate with NSA to ensure that the plating rinsewaters do not upset the chemical balance in the WWTP; (2) the drain adjacent to the boiler house should be sealed; (3) the flammable solvents and POL must be properly stored; (4) public service personnel should be notified of hazardous material locations; (5) a warning must be posted at the mustard gas burial site; (6) pesticides should be stored properly; and (7) a mustard gas warning should be posted on the training range impact area.

A major conclusion reached as a result of the 1980 survey was that a site investigation of the sanitary landfill must be conducted to ensure that contaminants such as pesticides, heavy metals, oil, and grease are not migrating beyond the installation boundaries.

The second survey was conducted in 1986.[27] The findings, conclusions, and recommendations were:

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[26] W.D. Ludemann, et al., *Installation Assessment of Fort George G. Meade (Including Gaithersburg Research Facility), Maryland*, Report No. DRXTH-ES-IA-81187 (U.S. Army Toxic and Hazardous Materials Agency [USATHAMA], Aberdeen Proving Ground, MD, 1982).

[27] J.D. Bonds, J.K. Sherwood, and K.A. Civitarese, *Update of the Initial Installation Assessment of Fort George G. Meade, and Gaithersburg Research Facility*, Report No. AMXTH-IR-A-187(U) (USATHAMA, Aberdeen Proving Ground, MD, 1987).

Findings. Contaminants including POLs and solvents have been disposed of in the landfill. The soils at the landfill, especially the near-surface soils, are permeable and susceptible to migration. Ground water and surface water analyses conducted by the State of Maryland and USAEHA indicate the presence of contaminants.

The installation has recently installed two new potable water wells in the vicinity of the landfill. The extent of the cone of depression created in the aquifer by those new wells is unknown. It is also unknown if the ground water under the landfill is hydraulically connected to the aquifer in which the potable water wells are located. The possibility exists that contaminants in the landfill could migrate into the aquifer in which the potable water wells are located.

Conclusions. Available geological evidence, information on contaminant sources (relative to the present sanitary landfill), and surface and ground water analyses indicate a potential for migration of contaminants via surface and subsurface waters.

Recommendations. U.S. Army Toxic and Hazardous Materials Agency should conduct a limited sampling-and-analysis investigation in the vicinity of the present landfill. This investigation should consist of installing additional monitoring wells to determine the ground water flow direction and an analysis of the ground water to confirm the presence of contaminants found in previous studies.

In response to the recommendations of the 1986 survey, USATHAMA is currently conducting an extensive investigation of the sanitary landfill and the potential migration of pollutants via surface and ground water outside the boundaries of Fort Meade.

National Security Agency

The NSA is a tenant on Fort Meade. However, the agency has a separate USEPA identification number (distinct from Fort Meade), is considered an independent waste generator, and is regulated as such. The only problems resulting from NSA activities are due to the effluent from the plating activities upsetting the chemical balance at the WWTP. These problems may have been rectified (the data is classified). The known waste generation activities at NSA, as discussed in the USATHAMA[28] and USAEHA[29] surveys are briefly mentioned in the following paragraphs. Because NSA is an independent generator, the organization will not be discussed in detail in this report.

NSA operates metal finishing shops in Buildings 9800 and 9817. The activities include degreasing, rustproofing, anodizing, etching, and plating. The plating activities include tin, copper, cadmium, nickel, silver, and chrome finishing. The materials treated in these operations are classified. In the past, the rinse waters and acidic plating bath solutions were discharged untreated into the sanitary sewer. However, a pretreatment plant was designed and is currently operating to treat the waters before discharge.

Large photographic processing laboratories operate in Building 9800 where color and black-and-white films are processed. These laboratories operate 7 days a week and discharge many wastes into the sanitary sewer. Silver is recovered from the photographic waste solutions.

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[28] W.D. Ludemann *et al.*

[29] *Industrial Wastewater Characterization-Fort George G. Meade, Maryland*, Water Quality Engineering Study No. 32-24-0267-82 (U.S. Army Environmental Hygiene Agency [USAEHA], Aberdeen Proving Ground, MD, 1982); J.J. Resta, "National Security Agency Industrial Discharges to Fort George G. Meade, MD, Advanced Waste Treatment Plant," Memorandum For Record (USAEHA, Aberdeen Proving Ground, MD, 1982).

Building 9811 is the flammable storage warehouse used to store all the chemicals. Names of all the chemicals used, their use rate, and method of disposal (mostly to the sanitary sewer), are listed in the 1980 USATHAMA and 1982 USAEHA surveys.[30] Some of the waste solutions (e.g., gold dragout) from metal plating and treatment operations are sent for material recovery to private recovery firms. Other wastes (e.g., etching solutions, concentrated chemicals) are shipped for disposal through DRMO.

A number of HAZMIN techniques ("best management practices") were suggested in the 1980 USAEHA survey to minimize the amounts of wastes generated. They are:

> Construct a flow equalization tank for combined IRC and S buildings' flows. This tank should have a minimum detention time of 3 days and be equipped with an automatic electrical conductivity and/or pH control system.
>
> Develop a program of water conservation for both the photoprocessing and metal finishing operations, immediately.
>
> Photoprocessing water conservation methods
> - countercurrent rinsings
> - spray washes instead of immersion washing
> - squeegees following washwaters and processing
> - good housekeeping to avoid chemical spills
>
> Metal-finish water conservation
> - counterflow rinsing
> - flow restrictors - aerators on rinse makeup water
> - still rinses
> - electronic flow controls
> - regular maintenance on all leaking valves and connections
> - good housekeeping to avoid spills.
>
> Institute a monitoring program for metals and cyanide in the IRC and S buildings' flows. This should be done immediately.
>
> Reduce the levels of cyanides, particularly ferrocyanides in the IRC and S buildings' effluent. This can be accomplished with some of the following practices.
>
> (a) Regeneration of all ferricyanide bleaches. The most common method to perform this is with a persulfate or ozone regeneration.
>
> (b) Ensure that all expended ferricyanide etchants are collected for separate disposal.
>
> (c) Consider modifying the zinc and copperplating operations from cyanide baths to noncyanide baths. Alternatives include zinc-chloride or sulfate baths and copper alkaline pyrophosphate baths.
>
> (d) Installation of a cyanide destruction system at the Metal Finishing Operation. The most common method of cyanide destruction has been alkaline chlorination. This should only be done after the effects of a strict water conservation program are evaluated.

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[30] W.D. Ludemann *et al.*, Appendix F; J.J. Resta.

Increase the efficiency of all silver reclamation procedures.

Decrease the amount of metals leaving the plating operation, particularly copper, zinc, and lead. Alternatives include:

(a) Separate, offsite disposal of all plating baths.

(b) Installation of a metals precipitation process preceded by a cyanide destruction process. This should only be done after the effects of a strict water conservation program have been evaluated.

Decrease the amount of boron discharged. A water conservation program should accomplish this. Additional methods include:

(a) Separate, offsite disposal for any fluoborate plating baths or excess fluoboric acid.

(b) Separate, offsite disposal for photographic processing developers.

(c) Good housekeeping and management practices to reduce the spills of boron-containing compounds.

Change the method of shredded paper disposal . . . The most common method of disposal is incineration.[31]

NSA should implement (if not already accomplished) the above mentioned HAZMIN techniques and other appropriate techniques discussed in this report and other sources of information listed in the references.

An incinerator, located in Building 9837, is now used daily for incineration of classified documents. The ash is collected and disposed of in the sanitary landfill.

Hazardous Waste Management Consultation

USAEHA conducted a hazardous waste management consultation[32] at Fort Meade between 4 and 6 May 1988. The purpose of the study was to identify, describe, and evaluate solid waste management units at Fort Meade, and to determine which units require further sampling, investigation, or corrective action. Three of the major conclusions of the study were that: (1) the sewage and leaf compost area and the 144th EOD ranges may contain toxic levels of metals and other hazardous constituents; (2) the direct support maintenance shop (Building 2283) was neutralizing spent battery electrolyte, which was an unpermitted operation; and (3) the open drain near the waste oil tanks at the main boiler facility allows oil to flow directly into the storm drain. The recommendations, based on the above conclusions, were that the unit should: (1) sample and analyze soils at the potentially contaminated sites, (2) cap the eroded areas at the sanitary landfill, (3) discontinue neutralizing spent electrolyte, and (4) seal the waste oil containment area from the storm drain at the main boiler house.

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[31] *Industrial Wastewater Characterization-Fort George G. Meade, Maryland.*

[32] *Evaluation of Solid Waste Management Units - Fort Meade, Maryland*, Draft Report, Hazardous Waste Management Consultation No. 37-26-1383-89 (USAEHA, Aberdeen Proving Ground, MD, January 1989).

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. For comparison, Table 2 shows the quantities of waste generated at 22 installations.[23]

Fort Meade is reported to have generated approximately 3.4 and 3.8 tons in 1986 and 1987, respectively, as reported in their annual Defense Environmental Status Report (DESR) and survey forms completed for V. J. Ciccone and Associates, Inc. These are wastes that were turned in to the DRMO for proper disposal; the numbers do not reflect the quantities of: waste oil that is being recycled for heat recovery; recycled lead-acid batteries; burning of gasoline and aviation fuel burning at the fire training area; contaminated water treated at the wastewater treatment plant; hazardous air emissions; etc. Current data indicate that the average waste generation rate at Fort Meade is more than 19,000 lb per year.

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 Meade is mainly an administrative installation with many tenants. The total quantity of waste generated, compared to other FORSCOM installations, is still quite small. Since Fort Meade generates no major waste streams, but small quantities of many different types of wastes, each waste generator was evaluated. The data was used to develop the HAZMIN plan. The first step in the feasibility and technical analysis 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 installation's mission. 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 maintenance of tactical vehicles is performed at various troop and

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[23] V.J. Ciccone and Associates, Inc., p C-4.

tactical vehicle motor pools. Tactical vehicles can be divided into track-laying vehicles (e.g., self-propelled howitzers, guns, mortars, armored personnel carriers, etc.) and wheeled vehicles (e.g., cargo trucks, ambulances, truck tractors, wreckers, etc.). Fort Meade 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, front-end alignment, 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*). Among the 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, varsol, 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 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 Meade should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use. Fort Meade should keep records of the quantities of hazardous and nonhazardous materials typically used that lead to the generation of wastes.

All MPVMs own and operate parts cleaning tanks. PD680-II is the solvent typically used in the tanks. Very small amounts of waste solvent are turned in for disposal. Most of it is allowed to evaporate and fresh solvent is added from time to time. Some of the generators were in the habit of mixing waste solvent and used oil. Used engine oil is accumulated at each MPVM in 55-gal drums or large tanks and is transported to the boiler plant for burning.

MPVM #1, #2, and #3 are shops operated by the DEH maintenance division. Large trucks are repaired and serviced at MPVM #1. MPVM #2 services construction vehicles. Grounds maintenance equipment is maintained at MPVM #3. Approximately 300 gal of antifreeze are used and dumped into the sanitary sewer each year.

MPVM #4 is a DOL-operated motor pool for nontactical vehicles. Diesel fuel is used for parts cleaning. A cleaning solvent is used only for brakes and carburetor cleaning. This new maintenance facility has modern equipment for supplying oil, antifreeze, hydraulic fluids, etc., and has been operating since 1988. Fuels such as gasoline, diesel, and jet fuel (JP-4 and JP-5), are stored near the fuel distribution area. The fuels and used crankcase oils are mixed and accumulated in a 2000-gal underground storage tank. The mixture is periodically transported to the boiler plant for burning.

MPVM #5 was a "tank shop" in the 1950's and 1960's. Operations included major overhaul and rebuilding of tracked vehicles. Only major vehicle repairs are currently performed at the shop. MPVM #6, which is operated by the Auto Crafts Shop, is the only facility that reported generation of used cleaning solvent.

MPVM #7 is a troop motor pool where a number of large, engineering, tactical vehicles are maintained. About 24 to 30 large and small used lead-acid batteries are generated monthly, palletized, and turned in for disposal. Two cleaning solvent tanks are operated and the solvent (PD680-II) is changed every 6 months. There is no segregation of wastes and spills are evident everywhere. Used oil is accumulated in a large tank in a POL storage area. The POL storage area has a 55-gal container buried underground to collect spills and rain water. The contents of this container are pumped into the waste oil tank.

About 45 hospital vehicles (e.g., ambulances, trucks, etc.) are maintained at MPVMs #8 and #9. The solvent dip tanks located in the shops are infrequently used because they have to be repaired and the filters need to be replaced. Wipe cleaning with solvents is the common practice. Vehicle oil changes are performed frequently. The schedule recommended by the Army Oil Analysis Program (AOAP) is used only for replacing oil from diesel engines. Chemical agent resistant coating (CARC) is used to paint vehicles.

No data were available from the other MPVMs.

Aviation Maintenance Facilities (AMF)

Most FORSCOM installations have aviation maintenance facilities for helicopters and airplanes. Various levels of services are performed on the aircraft at each of the facilities including: periodic maintenance (e.g., fluids change, tuneup, etc.), engine repair, brake servicing, battery repair/servicing, and unique repairs (if required, for different aircraft). 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 these facilities include: solvent sinks (parts cleaning), hot tanks (for engine cleaning), and spraying equipment.

Some general categories of hazardous materials used at AMFs are: batteries, oils, petroleum distillates, mineral spirits, varsol, 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 these hazardous materials and also generate hazardous wastes.

AMFs located at Fort Meade are listed in Table 6. Wastes generated are shown in Table 7. Fort Meade should also keep records of the quantities of hazardous and nonhazardous materials used at AMFs. All the AMFs own and operate parts cleaning tanks containing PD680-II. Used oil is generated by all the AMFs, accumulated in 55-gal drums and large containers, and transported to the boiler for burning. Small quantities of paint strippers are used for removing paint from aircraft being repaired. Methylethylketone (MEK) is used for wipe cleaning of parts in all the AMFs. No waste MEK is generated because of its volatility.

AMF #3 is used by a reserve unit for helicopter maintenance. The used oil generated is primarily synthetic (99 percent); less than 1 percent is 10W30 oil. The oil is placed in a used oil tank. Solvents are mixed into the used oil tank, creating a mixture of about 10 percent solvents. Small quantities of isopropyl alcohol were also being used for parts cleaning. Methylene chloride-based paint stripper is used to remove paint from aircraft.

Command Aviation Company operates AMF #4 for maintenance and repair of UH1H and OH 58 helicopters. All the solvent waste is mixed with used oil and accumulated in a 55-gal drum. Chemical stripping of paint from small portions of aircraft is accomplished with a solvent-based paint remover. AMF #4 also has a small dry paint booth for painting aircraft parts. The empty paint cans and filters are thrown in the dumpster. A small battery shop in AMF #4 services and rebuilds nickel-cadmium batteries. There are usually 19 cells in a box that is transferred to DRMO for disposal. Approximately 76 cells are accumulated in 6 months. The battery electrolyte (primarily potassium hydroxide containing cadmium) is drained into the sanitary sewer without treatment.

AMF #5 is operated by the 97th ARCOM and used to maintain 11 CH47 and 16 OH58 helicopters. Some of the chemicals commonly used are: MEK, toluene, naptha, and isopropyl ketone. Synthetic oil, antifreeze, cleaning solvent, and paint stripper are also used. The drum containing used oil is also used to dispose of waste fuel and parts cleaning solvents. An oil-water separator is located outside AMF #5 for collecting and removing waste oil from spills and floor drainings.

The 31st Aviation Group repairs and maintains aircraft in AMF #6. A parts cleaning tank containing PD680-II is located in the hangar. The waste oil generated at this facility is mixed with fuel and accumulated in a 55-gal container. A contractor-operated (Elmer, Inc.) facility (AMF #7) is used for maintenance of four small airplanes. A small quantity of used oil is generated. The facility is very clean and well maintained.

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 8 lists the IMSS located at Fort Meade.

Industrial shops typically use vapor degreasers for degreasing operations, caustic dip tanks for cleaning iron and aluminum parts, battery recharging and neutralization tanks for battery repair/replacement, painting and paint-stripping equipment (see *Paint Shops* section), and phosphoric/chromic acid tanks for small arms refinishing. These operations use hazardous materials and generate hazardous wastes Table 9 shows a list of wastes that may be generated from the industrial shops.

Many different kinds of hazardous materials are typically used at IMSS, including halogenated solvents (TCE, 1,1,1-trichloroethane, etc.), paint thinners (xylene, toluene, etc.), corrosive chemicals (alkalis, phosphoric acid, chromic acid, etc.), and radioactive materials. Although the quantities of hazardous and nonhazardous materials used at the IMSSs are not currently available, proper inventory control will generate data for future use.

No data was available regarding maintenance activities at the DEH maintenance shop (IMSS #1).

The DOL Industrial Maintenance Shop (IMSS #2), located in Building 2246, is a large operation conducting repairs on small arms, office machines, furniture, and nuclear weapons. The small arms shop conducts a parkerizing process to put a dull finish on small arms. The small arms are chemically treated with zinc/potassium phosphate in a 500-gal tank. The phosphate solution, which is changed every 4 years, is drained into 55-gal drums and transferred to DRMO for disposal. All the effluent from the parkerizing process drains into the sewer without any treatment. Degreasing of parts was originally accomplished with TCE in a vapor degreasing tank. However, the degreasing process has been stopped. Sand blasting is used to clean the surface of parts. Approximately 2000 small weapons (M-16, M-45, M-60, etc.) are repaired per year.

IMSS #2 also has a battery shop. The battery shop previously generated 60 gal of waste electrolyte per week. The waste was neutralized with sodium bicarbonate in small plastic containers and flushed down the sanitary sewer. The practice has been stopped; lead-acid batteries are now recycled wet. Battery electrolyte neutralization was also conducted in a number of other buildings (69, 8549, 2124, 2253, 1006, 4661, 8550, the 8400 series, and 2940). All the neutralization processes have been stopped. Generators of spent lead-acid batteries are now required to palletize them wet for recycling/reclamation.

The nuclear weapons support activity uses a number of solvents (toluene, methylethylketone (MEK), TCE, paint thinner, acetone, freon, etc.) to clean nuclear warheads on weapons. Approximately 20 items are repaired per year. Some of the activities conducted include repainting, preserving, refinishing, and remarking parts.

The equipment concentration site (IMSS #3) has a large vehicle maintenance facility and a shop for cleaning weapons. All the equipment available at IMSS #3 (vehicles, grounds equipment, small tactical vehicles, etc.) is used by reserve units for training for 2 weeks at a time. After the equipment is returned from the training exercises, it is serviced and made available to other units. Small arms repair consists primarily of bore cleaning and mechanical damage repairs.

An intelligence activity of the Army Material Command is located in building 4554 (IMSS #4) and consists of shops for electronics fabrication, special (plastic) fabrication, photography, and small maintenance. Very small quantities of wastes are generated by these shops. A closed-loop ferric chloride process is used for copper plating in the electronics shop. A biodegradable cutting fluid is used in the special fabrication shop as a coolant in machining activities. The basement of IMSS #4 contains a large underground tank used for neutralizing pH. However, maintenance has not been performed on the equipment since it was installed and the pH monitor does not function properly. Effluent from the tank is not monitored for heavy metals.

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. The only hazardous waste generated by spray painting with cans, which is common place throughout the installation, is the empty cans with wet/dried paint residue. Paint thinners used in large painting operations result in generation of large quantities of hazardous waste.

The large paint shops located at Fort Meade are listed in Table 10. The wastes generated are listed in Table 11. The quantities of hazardous and nonhazardous materials used are not available. Proper inventory control should generate this data for future use.

A large paint shop belonging to the DOL Maintenance Division (PS #1) is operated by a contractor (Allied Trades) in Building 2286. In Building 2283, the contractor conducts battery repair, radiator repair, and rustproofing of all vehicles. PS #1 has two large painting booths. No lead-based paints are used. CARCs are applied on the exterior of all tactical vehicles. Enamel paints are used on the interiors. At least three different thinners are used. Paint thinner and paint waste (containing 70 percent thinner) is accumulated in 55-gal drums that are transferred to DRMO every 3 months.

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 (e.g., Institute for Dental Research) and laboratories for training personnel belonging to other medical activities in the military services. Other dental and veterinary clinics and facilities may also be located on the installation. The HCL on Fort Meade are listed in Table 12.

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 chemicals and radioactive materials are used in hospitals, clinics, and laboratories. The wastes include: chemical waste, infectious solid waste, noninfectious waste, pharmaceutical waste, and radioactive waste. Table 13 shows the wastes generated. Again, the quantities of materials used are not available. Proper inventory control should generate this data for future use.

KACH (HCL #1), located in Building 2840, has a number of small clinical laboratories. All the liquid chemical wastes are disposed of through the sanitary sewer. Infectious wastes are incinerated at a State-permitted (200 lb/h) incinerator located in the building. Approximately 10 to 15 "red bags" are incinerated each day. Contents of the bags include bandages, throat inserts, autoclaved laboratory wastes, body parts, dressings, blood, needles, and other sharps. Sterilized wastes and the ash from the incinerator are double-bagged and disposed of at the Fort Meade sanitary landfill. In the past, red bags used to contain 10 percent infectious wastes and 90 percent general office wastes. The operations have recently been improved with proper control and logging. The infectious waste control manual was revised in April 1988 to include better management practices. Biological wastes are sterilized in an autoclave before disposal in the landfill.

Walter Reed Army Medical Center Medical Laboratory (HCL #5) conducts laboratory operations that include specialized disease testing and toxicology. Various specimen samples from Walter Reed Army Medical Center (WRAMC) in Washington, DC are tested here. The microbiology and veterinary sections of WRAMC also maintain laboratories and conduct special studies. The infectious wastes are incinerated at a State-permitted incineration facility (15 lb/h) located in the building. Before 1977, all waste chemicals generated were disposed of in the sanitary sewer. Currently all the wastes are disposed of through a contract administered by WRAMC. The waste chemicals, generated at a rate of 5.3 gal per week, are primarily organic (e.g., benzene, toluene, etc.).

HCL #5 also uses radioactive materials for drug abuse studies. They are authorized through a licence issued to WRAMC, Washington, D.C., to use Nickel-63 (56 mCi), Uranium-238 (238 grams), and any other element (2 mCi each up to a total of 100 mCi).

Photography, Printing, and Arts/Crafts Shop (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 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) that 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 six main photographic activities at Fort Meade as shown in Table 14. Five of the laboratories are small. Photographic activities are also conducted at KACH and IMA. The main photographic laboratory, TASC, located in building 4406 (PPAS #2), performs most of the photographic development for the installation (except for NSA). Silver is recovered from all the photographic laboratory wastes. The quantity of silver waste recycled through DRMO is 35 gal per week. A silver recovery program also exists for all X-ray film processed on Fort Meade. The remaining wastes are allowed to drain into the sanitary sewer. These activities need to keep records of the wastes generated and materials used.

TASC has the only large printing shop on Fort Meade. All the liquid wastes generated in the printing processes (e.g., inks, solvents, etc.) are mixed and accumulated in 55-gal drums and turned in for disposal. Small quantities of chemicals are also used at a model shop located at TASC.

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, storage warehouses, water treatment plants, and other miscellaneous sources unique to each installation.

The main boiler facility at Fort Meade (Building 8481) is used to burn waste oil (contaminated with solvent, hydraulic fluids, etc.) which is generated throughout the installation and by offpost reserve centers. Two above-ground 1000-gal tanks and a 20,000-gal underground tank are used to store the waste oil. The potential exists for release of oil through an open tank drain to the storm drain located within the bermed area around the tanks. The underground storage tank must be tested for possible leaks. The potential also exists for toxic air emissions exiting from the boiler stack. Waste oil that is blended (1:15) with fuel oil and burned is not tested.

Three other boiler plants (located in Buildings 268, 2251, and 2482) also burn fuel oil. Some of the pollutants generated at these plants include contaminated fuel oil, boiler blowdown, hazardous ash, and potentially toxic emissions. Corrosive (e.g., caustic potash) and combustible (e.g., cyclohexylamine) chemicals are commonly stored and used at these plants.

DOL operates a laundry and drycleaning facility at Fort Meade. The drycleaning plant is a closed-loop recycling system using about 200 gal of perchloroethylene per month. The filters from the drycleaning machine are cleaned with water, which is allowed to drain into the sanitary sewer. Equipment filters and contaminated water are therefore the wastes generated. Corrosive chemicals (e.g., caustic soda, bleach) are used in the laundering process.

The sanitary landfills operated by the Public Works Branch of the DEH have been surveyed by USATHAMA and USAEHA as mentioned previously. A detailed investigation, including groundwater and soil gas monitoring, is currently being conducted by USATHAMA. Among the wastes buried in the landfills there could be hazardous (POL products), infectious, and ordnance wastes. Groundwater contamination could therefore result from the chemicals leaching through the soil. The potential exists for offpost migration of pollutants through surface and subsurface transport.

The DEH Public Works Branch operates the wastewater treatment plant for treatment of domestic sewage. Acids, bases, solvents, and other chemicals are used in the operation of the plant and in the chemical analysis of water. Except for NSA's advanced pretreatment plant, there are no industrial wastewater treatment plants at Fort Meade.

Since Fort Meade is an administrative post, very few active troop units and many reserve troop units are stationed there. Typical wastes generated from the troop units consist of decontaminating agents (e.g., DS-2, STB), batteries, and pesticide spray cans.

The 144th Ordnance Detachment (EOD) is a major active troop unit that conducts open burning and open detonation (OB/OD) of ammunition. Demolition and burning of small arms ammunition, smoke grenades, ether containers, etc., are conducted at Training Range 16. A potential exists for releasing nitrate salts and ammonia into groundwater and toxic emissions into ambient air. EOD is limited to 5 pounds of explosives per detonation. Demolition requiring larger limits is conducted at Fort A. P. Hill, VA. Before 1981, demolition was also conducted at Training Range 22. Explosives such as TNT and C4 were disposed of.

Two areas on Fort Meade were previously used for firefighting training. The first site, used in the 1960's and 1970's, is now the helicopter hangar at Tipton Army Airfield, MD. The site contains two concrete-lined pits and an unbermed concrete slab. A number of fuels, oils, and inks were burned until consumed at this site. The drainage from this area went on the surrounding land. Another firefighting training area, built in 1979, exists near the airfield. This burn pit is asbestos-lined and has an oil-water separator connected to the drainage pipe. This facility has been used only once since construction. Another training pit, currently in use, is located at the north end of Tipton Army Airfield. Fuel and water are pumped into the pit and ignited for training. Waste fuels such as Mogas, diesel, JP4, and oil are burned. This could lead to potentially toxic air emissions. The soil in the pit and the surrounding area is likely to be contaminated with toxic pollutants. In addition to contaminated soil, the other wastes generated by fire departments include chemicals with expired shelf life and aqueous film-forming foam used in firefighting.

A water quality laboratory is operated at the water treatment plant (Building 8688) where small quantities of chemicals for analysis are stored. Water is analyzed in the laboratory for pH, alkalinity, hardness, chlorine residual, conductivity, and fecal chloroform. Another small laboratory is maintained at the wastewater treatment plant for analysis of wastewaters for biological oxygen demand (BOD), dissolved oxygen (DO), total dissolved solids (TDS), and suspended solids (SS). All the wastes from these laboratories are discharged into the sanitary sewer.

The hazardous waste storage building (Building 6527) is a permitted area used to store waste POL products, paint, film, electronic materials, batteries, decontaminating agents, demilitarized ammunition, and polychlorinated biphenyl (PCB)-contaminated equipment. Other storage warehouses are located throughout Fort Meade. The potential exists for soil contamination from spills.

Pest control at Fort Meade is the responsibility of the Entomology Shop (Building 6212). Malathion, Diazinon, Baygon, Dieldrin, Chlordane, Dibrom, Lindane, Anticoagulant, Borocil IV, Fenuron, Telvar, Dowpon Sodium Salt, Diacamba 49S, 2,4-D, and Warfarin are stored and mixed in the building. Other pesticides are stored at Building 6621. In the past, pesticide rinsewaters were disposed of in the sanitary sewer. Other herbicides and fertilizers are stored and applied throughout Fort Meade by the Land Management Branch. Pesticides and herbicides used for golf course maintenance are also stored in the golf course storage shed (Building 8690). USAEHA has an Entomology Sciences Division where experiments are conducted on the effects of insecticides on cockroaches and other pests.

A small rotatable burn cage (6 to 8 cu ft) located outside the Fort Meade Headquarters building is used to incinerate classified documents.

Wastes Selected for Technical/Economic Analysis

The data presented in the previous section was obtained during the HAZMIN survey. Other sources of information include the annual reports and waste disposal information available from the Defense Reutilization and Marketing Service (DRMS).[34]

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[34] IDMS Data, Defense Reutilization and Marketing Service, Defense Logistics Agency, Battle Creek, Michigan.

Table 15 shows the annual wastes generated by Fort Meade. This data is derived from the annual reports to the USEPA and the State of Maryland, Department of Solid and Hazardous Wastes.

All wastes transferred to the DRMO for offsite disposal are picked up by a contractor who transports them to an authorized treatment, storage, and disposal facility (TSDF). The contractor, Chemical Waste Management, has been employed by Fort Meade since 1986. When the wastes are transported, they are manifested. A copy of the manifest is sent to DRMS. At DRMS the data is logged into a central data base.

The waste disposal data for the past 4 years was obtained from DRMS in hardcopy. All the data was scanned into a microcomputer and transformed into a dBase III Plus data file. Information from copies of manifests was compared with the information in the data base. The waste generation data was then sorted by DOD Address Activity Code (DODAAC) to determine the types and quantities of wastes.

Tables 16 and 17 show summaries of hazardous waste generation for Fort Meade derived from all the sources of information. PCBs were not included in the tables. Used oil is not a hazardous waste. If mixed with solvents and other contaminants, it could become a hazardous waste. Only a small quantity was turned in for disposal. Most of the used oil is burned in a boiler. The quantities of used oil burned were 14,387, 37,756, and 39,734 gals in 1986, 1987, and 1988, respectively. Approximately, 22 percent is from DOL shops, 21 percent from DEH shops, 53 percent from the MPVMs and AMFs, and 4 percent from remaining sources.

Paint thinner, cleaning solvent, and used oil are the wastes considered for detailed technical and economic analysis in Chapter 12. Paint wastes, particularly paint thinner, are generated in large quantities. Although only small quantities of waste cleaning solvent are reported, it is likely to be consumed in parts cleaning and allowed to evaporate. Although used oil is not a hazardous waste, it is generated in the largest amount and hence considered for technical/economic analysis.

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

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*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	4	14
II	Aviation maintenance facilities	4	5	4	13
III	Industrial maintenance, small arms shops, etc.	2	5	5	12
IV	Paint shops	3	3	5	11
V	Hospitals, clinics, and laboratories	2	3	3	8
VI	Photography, printing, and arts/crafts shops	1	3	3	7
VII	Heating/cooling plants	1	3	2	6
VIII	Laundry/drycleaning facilities	1	2	2	5
IX	Sanitary landfills	1	1	2	4
X	Wastewater treatment facilities	1	2	1	4
XI	Troop units	1	1	1	3
XII	Fire departments	1	1	1	3
XIII	Hazardous waste storage facilities	1	1	1	3
XIV	POL storage yards	1	1	1	3
XV	Golf courses	1	1	1	3
XVI	Grounds maintenance and garden shops	1	1	1	3
XVII	Entomology shops	1	1	1	3
XVIII	Electrical maintenance shops	1	1	1	3
XIX	Other storage warehouses	1	1	1	3
XX	Water treatment plants	1	1	0	2
XXI	Miscellaneous	1	1	0	2

Table 4

Motor Pools and Vehicle Maintenance (MPVM) Facilities

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1. DEH Equipment Maintenance - M & S Shop #1; Building 2217
2. DEH Equipment Maintenance - M & S Shop #2; Building 2227
3. DEH Equipment Maintenance - M & S Shop #3; Building 375
4. DOL Transport Branch Operations, Maintenance Section; Building 201, 294
5. DOL Maintenance Division - Tactical Vehicles / Heavy Equipment (BROCKMEYER); Building 2246, 2253
6. ACS Auto Crafts; Building 6530
7. 11th Engineer Battalion, Company D - Motor Pool; Building 8492
8. 85th Medical Battalion - Motor Pool; Building 72
9. 702nd Medical Company - Motor Pool; Building 71
10. 99th ASA CO - Motor Pool; Building 2125
11. 209th Military Police Company - Motor Pool; Building 8487
12. 293d Military Police Company - Motor Pool; Building 8478
13. HQ Company, 902d Military Intelligence Group - Motor Pool; Building 4662
14. NSGA Fort Meade - Vehicle Maintenance

Table 5

Quantities of Hazardous Wastes Generated at MPVM Facilities*

Wastes	MPVM #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Spent cleaning solvent		**			0		195								
Carburetor cleaner															
Engine oil		45536	7589	3795				1366	486						
Antifreeze solution		2829							278						
Lead-acid batteries								360							
Aqueous detergent or caustic wastes															
Detergent solution from floor wash															
Oily dirt with heavy metals															
Spent sorbent															
Contaminated fuel (mogas/diesel)									0	0					
Dirty rags															
Solvent tank-bottom sludges															
Contaminated water								0	0						
Other fluids															
Mixed wastes									0	0					
Hazardous faulty parts (e.g., brake pads)															

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*Quantities are reported in pounds per year.

**A blank in this and similar tables does not mean zero generation. Where data is unavailable, Fort Meade 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 6

Aviation Maintenance Facilities

1. Command Aviation Company; Building 82
2. Det. 1 A Co., 2nd Bn/228th Reg.; Building 84
3. Civilian Work Force; Building ASF 85
4. 11th Spec. Forces Flight Maint.; Building 84
5. B Co. 5th Bn/159th Reg.; Building 90
6. Beechcraft Contract Maint.; Building 84
7. 97th Army Reserve Command
8. C Co. 4th Bn/158th Reg.; Building 85

Table 7

Quantities of Hazardous Wastes Generated at AMFs*

Wastes	AMF #	1	2	3	4	5	6	7	8
Spent cleaning solvent				210	1430	2145			
MEK degreaser & cleaner									
Calibrating fluid									
Paint stripper					141	169			
Paint thinner									
Filters (paint booth)				0		0			
Used paint cans									
Engine oil				2186	417	8197	228		
Deicer solution						23			
Nickel-Cadmium Batteries					152				
Aqueous detergent or caustic wastes									
Detergent solution from floor wash									
Oily dirt with heavy metals									
Spent sorbent									
Contaminated fuel (Avgas)									
Dirty rags									
Solvent tank-bottom sludges									
Contaminated water									

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*Quantities are reported in pounds per year.

Table 8

Industrial Maintenance and Small Arms Shops

1. DEH Maintenance & Repair Branch - Industrial Shop; Building 3000, 4272
2. DOL Maintenance Division; Building 2220, 2246, 2253, 2276
3. Equipment Concentration Site; Building 2120A, B, C
4. USA Material Command, Intelligence Mat Act (IMA); Building 2501, 4554

Table 9

Quantities of Hazardous Wastes Generated at IMSS*

Wastes	IMSS # 1	2	3	4
Degreasing solvent (trichloroethylene)			0	
Degreasing solvent (1,1,1-trichloroethane)				0
Paint thinners				170
Surface Cleaners				
Paint wastes				
Lube oil				
Hydraulic/cutting fluids				
Corrosive chemicals (caustic soda)				
Corrosive chemicals (phosphoric acid)				
Corrosive chemicals (chromic acid)				
Corrosive chemicals (phosphate solution)				
Tank bottoms				
Paint/sand wastes				
Steam cleaning compound (alkali wastes)				
Radioactive wastes			10	
Radioactive sources (UDM-2)				
Batteries (lead-acid, NICAD)				

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*Quantities are reported in pounds per year.

Table 10

Paint Shops

1. DOL Maintenance Division - Allied Trades Section; Building 2283, 2286, 2287
2. DEH Paint Shop; Building 2213
3. NSGA Fort Meade - Barracks Upkeep/Maintenance

Table 11

Quantities of Hazardous Wastes Generated at PS*

Wastes	PS #	1	2	3
Old/used paint cans				
Old/used paint				
Paint thinner, equipment cleaner		1651		
Shellac thinner				
Paint stripper				
Caustic wastes				
Detergent solution from floor wash				
Oily dirt with heavy metals				
Spent sorbent				
Dirty rags				
Solvent tank-bottom sludges				
Contaminated water				
Filters from paint booths				
Sludges from water-wall booths				

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*Quantities are reported in pounds per year.

Table 12

Hospitals, Clinics, and Laboratories (HCL)

1. Kimbrough Army Community Hospital (KACH); Building 2840
2. Veterinary Activities; Building 2442
3. Dental Activity; Building 2455
4. EPES Dental Clinic; Building 8472
5. Walter Reed Army Medical Center, Medical Laboratory; Building 2490
6. U.S. Army Institute of Dental Research (IDR); Buildings 2801, 2802, 2804, 2805, 2810, 2811, 2832

Table 13

Quantities of Hazardous Wastes Generated at HCL

Wastes	HCL #	1	2	3	4	5	6
Pathological wastes							
Medical Infectious wastes		5400 (bags)					
Pharmaceutical wastes							
Chemical wastes							
Radioactive wastes							
Photographic wastes							

Table 14

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

1. ACS Arts and Crafts, Building 6530
2. DPTMS Training/Audiovisual SPT CTR (TASC); Buildings 4406, 504, T544
3. USARCS, OTJAG - Micrographic Equipment Operation
4. CPD - Photography
5. 902D MI Group - Visual Information Section; Building 4554
6. USAISC Micrographics

Table 15

Fort Meade Hazardous Waste Generation

General Description	Haz. Char.	USEPA Hazard Code	Annual Generation (lbs) 1984	1985	1986	1987	1988
Spent paint thinner	ignitable	D001	9062	2125	459	9800	
Mineral spirits	ignitable	D001					
Paint, oil base	ignitable	D001	3550		6180		
Lacquer	ignitable	D001	80				
Epoxy coating	ignitable	D001					
Polyurethane	ignitable	D001					
Asphalt primer	ignitable	D001					
Sealant	ignitable	D001					
Cement, rubber	ignitable	D001	2420				
Supertropical bleach	ignitable	D001					
Waste petroleum solvent	ignitable	D001			1463	3700	
Cleaning solvent	ignitable	D001	280	1416			
Isopropyl alcohol	ignitable	D001					
Ink	ignitable	D001					
Adhesives	ignitable	D001					
Miscellaneous chemicals							
Amyl nitrite	ignitable	D001	5	58			
Others	ignitable	D001	573	1	62		
Replenisher developer	corrosive	D002	4696				
Sodium hydroxide soln.(spent)	corrosive	D002	1560	1275	1990		
Sulfuric acid	corrosive	D002	30	30			
Potassium hydroxide	corrosive	D002					
Battery acid	corrosive	D002					
Acetic acid	corrosive	D002					
Miscellaneous chemicals							
Batteries (acid, storage)	corrosive	D002			101		
Others	corrosive	D002	2574		3582	4400	
Miscellaneous chemicals							
Chemical agent training set	reactive	D003	28	20			
Caustic decon. agent	reactive	D003	78	78			
Others	reactive	D003			270		
Arsenic compounds	toxic	D004	143				
Barium compounds	toxic	D005					
Nickel-cadmium batteries	toxic	D006	125	489	829		
Chromate solutions	toxic	D007	33				
Lead	toxic	D008	15				
Mercury	toxic	D009	283	48	57		
Selenium	toxic	D010					
Silver	toxic	D011	16				
Endrin	toxic	D012					
Lindane	toxic	D013					
Methoxychlor	toxic	D014	200	200			
Toxaphene	toxic	D015					
2,4-Dichlorophenoxyacetic acid	toxic	D016					
Silvex	toxic	D017					

Table 15 (Cont'd)

General Description	Haz. Char.	USEPA Hazard Code	Annual Generation (lbs)				
			1984	1985	1986	1987	1988
Trichloroethylene	toxic	F001					
Methylene chloride	toxic	F001					
Perchloroethylene	toxic	F001					
Carbon tetrachloride	toxic	F001					
1,1,1-trichloroethane	toxic	F001					
Spent halogenated solvents	toxic	F002					
Spent nonhalogenated solvents	toxic, ignitable	F003	795	160			
Spent nonhalogenated solvents	toxic, ignitable	F005	120	45			
Aldrin	toxic	P004					
Arsenic acid	toxic	P010					
Cyanides	toxic	P030					
Dieldrin	toxic	P037					
DURSBAN	toxic	P040	225	225			
3,4-dihydroxy-alpha-methyl benzyl alcohol	toxic	P042					
Endrin	toxic	P051					
Fluorine	toxic	P056					
Heptachlor	toxic	P059					
p-Nitroaniline	toxic	P077					
Pentachlorophenol	toxic	P090					
Malathion	toxic	P097	612	400			
3,4-Hydroxycoumarin & salts	toxic	P001					
Acetaldehyde	toxic	U001					
Acetone	ignitable	U002					
Acetonitrile	toxic, ignitable	U003					
Asbestos	toxic	U013					
Benzene	toxic	U019					
Chlorodane	toxic	U036					
Chloroform	toxic, ignitable	U044	48				
DDT	toxic	U061					
Dichloromethane	toxic	U080	45				
Dioxane	toxic	U108					
Ethyl acetate	toxic, ignitable	U112					
Ethyl ether	toxic, ignitable	U117					
Formaldehyde	toxic	U122	1				
Iodomethane	toxic	U138					
Iron dextran	toxic	U139					
Methanol	toxic	U154					
Methyl ethyl ketone (MEK)	toxic, ignitable	U159					
Phenol	toxic	U188					
Toluene	toxic	U220					
1,1,1-Trichloroethane	toxic	U226	3				
Xylene	toxic	U239					
Dichlorobenzene	toxic	U070					
PCB & PCB contaminated items	toxic	U248	8079	6720	1055		
Miscellaneous chemicals		U0XX		3841	1860	683	

Table 16

Fort Meade Hazardous Waste Generation Summary

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate lb/yr (mean)	lb/yr/unit (range, mean)	Hazardous Waste Stream Unit
Photographic and print	1	21	0 - 50, 21	Acetone
Reproduction facilities	6	703	0 - 671, 250	Hydroquinone
			0 - 900, 225	Uraine
			0 - 297, 134	Photographic processing chemicals
	8	4	0 - 17, 4	Acetic acid
	12	94	0 - 46, 12	Silver nitrate
			0 - 178, 82	Miscellaneous chemicals
Motor pools (excluding DEH & DOL)	1	193	0 - 38, 10	Aromatic hydrocarbons
			0 - 718, 180	Cleaning solvent
			0 - 10, 3	PD - 680
	2	98	0 - 58, 15	Trichloroethane
			0 - 40, 10	Perchloroethylene
			0 - 290, 73	Freon
	4	194	0 - 496, 194	Waste oils
	5	152	0 - 513, 152	Ethylene glycol
	8	1070	0 - 1565, 342	Cresylic acid
			185 - 1276, 728	Caustic soda
	12	29	0 - 90, 23	Batteries
			0 - 25, 6	Absorbent
DEH shops	3	909	0 - 2535, 909	Paint thinner
	7	1484	0 55, 14	Polyurethane
			97 - 1669, 627	Enamel paint

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*1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontaminated agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table 16 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate lb/yr (mean)	lb/yr/unit (range, mean)	Hazardous Waste Stream Unit
DEH shops (cont'd)			57 - 3000, 790	Sealing compound
			0 - 250, 63	Driveway sealant
	8	29	0 - 70, 22	Cresylic acid
			0 - 9, 3	Sodium hydroxide
			0 - 14, 4	Anhydrous ammonia
	9	4	0 - 15, 4	DS-2
	10	178	0 - 563, 178	Insecticide
	12	57	0 - 15, 4	Plating solution
			0 - 17, 6	Etchant
			0 - 23, 6	Batteries
			0 - 63, 41	Miscellaneous chemicals
DOL shops	1	100	0 - 300, 100	Toluene
	2	82	0 - 30, 8	Freon
			12 - 162, 66	Methylene chloride
			0 - 33, 8	Blanket hardener
	3	5600	536 - 9510, 5600	Thinner
	7	7804	335 - 6367, 3935	Paint
			0 - 654, 164	Polyurethane
			207 - 11201, 2936	Sealing compound
			0 - 382, 176	Lead contaminated filters
			0 - 1594, 585	Rust proofer
			0 - 30, 8	Adhesive
	8	74	0 - 225, 74	Sulfuric acid
	12	486	0 - 165, 41	Contaminated fuels

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*1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontaminated agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table 16 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate		Hazardous Waste Stream Unit
		lb/yr (mean)	lb/yr/unit (range, mean)	
DOL shops (cont'd)			0 - 1664, 416	Batteries
			0 - 34, 9	Plating solution
			0 - 56, 14	Copper etchant
			0 - 24, 6	Ammonium persulfate
			0 - 24, 8	Benzene
			0 - 1080, 474	Ethyl acetate
Hospitals, clinics and laboratories	1	930	7 - 45, 27	Acetone
			0 - 151, 38	Acetonitrile
			0 - 426, 126	Ethyl ether
			0 - 110, 28	Hexane
			0 - 160, 40	Cyclopropane
			0 - 420, 129	Toluene
			0 - 106, 60	Xylene
	2	309	0 - 25, 9	Chloroform
			0 - 1200, 300	Thionyl chloride
	5	188	0 - 476, 119	Propylene glycol
			0 - 18, 5	Butanol
			0 - 18, 5	Methanol
			0 - 75, 19	Propanol
			0 - 102, 40	Reagent alcohol
	8	107	0 - 35, 20	Sulfuric acid
			0 - 36, 14	Hydrochloric acid
			0 - 16, 4	Nitric acid
			0 - 40, 10	Acetic acid

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*1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontaminated agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table 16 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate		Hazardous Waste Stream Unit
		lb/yr (mean)	lb/yr/unit (range, mean)	
			0 - 17, 4	Formic acid
			0 - 42, 16	Miscellaneous acids
			0 - 40, 14	Sodium hydroxide
			0 - 40, 10	Ammonium hydroxide
			0 - 48, 12	Calcium hydroxide
			0 - 13, 3	Miscellaneous bases
	9	70	0 - 279, 70	DS-2
	11	346	68 - 762, 346	Waste pharmaceuticals
	12	390	7 - 31, 22	Mercury
			4 - 18, 10	Formaldehyde
			0 - 25, 15	Sodium metal
			110 - 651, 343	Miscellaneous chemicals
Troop units	9	456	0 - 810, 225	DS-2
			61 - 425, 230	STB
			0 - 3, 1	Decontamination kit
	12	17	0 - 27, 7	Batteries
			0 - 40, 10	Bore cleaning kit
Naval security group	3	20	0 - 35, 20	Paint thinner
	7	29	0 - 83, 21	Methylene chloride
			0 - 30, 8	Paint
Aviation maintenance facilities	2	26	0 - 61, 26	Methylene chloride
	4	112	0 - 446, 112	Aviation lube oil
	12	59	0 - 74, 19	Contaminated fuel
			0 - 65, 24	Nickel cadmium batteries
			0 - 25, 6	Carbon remover
			0 - 41, 10	Corrosion preventative

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*1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontaminated agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table 16 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Total Approximate Annual Generation Rate	Generator Ranking by Waste Volume Generated
Photographic and printing shops	822 lb/yr	5
Motor pools	1736 lb/yr	4
DEH shops	2661 lb/yr	2
DOL shops	14146 lb/yr	1
Hospitals, clinics, and labs	2340 lb/yr	3
Troop units	473 lb/yr	6
Naval security group	49 lb/yr	8
Aviation maintenance facilities	197 lb/yr	7

Table 17

Total Waste Generation Rates Sorted By Waste Categories

Hazardous Wastes Categories		Photographic and Print Shops	Motor Pools	DEH Shops	DOL Shops	Hospitals, Clinics, and Laboratories	Troop Units	Naval Security Group	Aviation Maintenance Facilities
Number	Total								
1	1244	21	193	-	100	930	-	-	-
2	515	-	98	-	82	309	-	-	26
3	6529	-	-	909	5600	-	-	20	-
4	306	-	194	-	-	-	-	-	112
5	340	-	152	-	-	188	-	-	-
6	703	703	-	-	-	-	-	-	-
7	9317	-	-	1484	7804	-	-	29	-
8	1284	4	1070	29	74	107	-	-	-
9	530	-	-	4	-	70	456	-	-
10	178	-	-	178	-	-	-	-	-
11	346	-	-	-	-	346	-	-	-
12	1132	94	29	57	486	390	17	-	59
TOTAL	22424	822	1736	2661	14146	2340	473	49	197

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; rust removal; and solution replacement. Table 18 lists the operations, the corresponding materials used, and the wastes generated. Table 19 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*,[35] and other references.[36]

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.[37] 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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[35] W.M. Toy, *Waste Audit Study - Automotive Repairs* (Prepared for the California Department of Health Services, Sacramento, CA, 1987).

[36] *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).

[37] 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.[38] 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.[39] 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.[40] Several standard methods are available for minimizing emissions from immersion cleaning, wipe cleaning, and spray cleaning operations.[41]

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

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

[40] 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.

[41] 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 is less from solvent sinks than from dip tanks or buckets. Equipment leasing services (see Table 20) 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 21). 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 22 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.[42] 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 23. 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 23 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.[43] 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.[44] 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[45] 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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[42] 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).

[43] W.M. Toy, pp A-1 - A-23.

[44] W.M. Toy, p 20.

[45] 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.[46]

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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[46] *Management/Equipment Evaluation Program*, Report H82-1B (1st Space Support Group, U.S. . -- 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.[47] 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.[48] 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.[49]

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[50] 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).[51] 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").

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

[48] 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).

[49] 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.

[50] 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).

[51] 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[52], developed by the U.S. Army Research and Development Center, Fort Belvoir, VA, allows the use of antifreeze (MIL-A-46153[53]) whose inhibitor system has reached a marginal condition.[54] 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).[55] 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 24 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.[56]

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.[57] Table 20 lists some of the equipment leasing and service companies.

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[52] Military Specification MIL-A-53009, *Additive, Antifreeze Extender, Liquid Cooling System* (Department of Defense [DOD], 6 August 1982).

[53] Military Specification MIL-A-46153, *Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package* (DOD, 31 July 1979).

[54] 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.

[55] R.H. Salvesen Associates, pp 35-36.

[56] 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).

[57] 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 20) 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 20.

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[58] 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,[59] 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.[60] More recent studies have placed the cost of such a qualification procedure at $75,000.[61]

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

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[58] 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.

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

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

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

of selling or disposing of used oil includes sampling and testing the oil, storage b ie sale, 55-gal drums for sale/disposal, inventorying expenses, advertising for bid solicitations, b iluation, bid letting, and accounting. Draft USEPA regulations, when finalized, could increase 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 2 years ($3 to $8/gal) and it is in short supply. A simple recycling method is available.[a] 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 20 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 21). 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,

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[a] *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.

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.[63]

Used Oil - Onsite Treatment - Blending/Burning

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.[64]

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.[65] 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.[66] Current Navy regulations limit the amount of used oil in fuel oil blends to 1 percent.[67] 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.[68]

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,[69] 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.

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

[64] 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.

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

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

[67] 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).

[68] 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.

[69] W.M. Toy, p 27.

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 25 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.[70] 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.[71] 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 20) 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.

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.

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[70] W.M. Toy, pp 25-27.
[71] W.M. Toy, pp 31-32.

Table 18

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

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

Table 19

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	Warte 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

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

Table 20

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. 97 Branston 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		

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*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 20 (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		
Petrex 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 manufacturer		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 986	(503) 286-8352 Rerefiner			X		
Gibson Oil & Refining [illegible] 3121 Standard Street Bakersfield, CA 93308	(805) 327-0413 [illegible]ssor			X		
GNB, Inc. - Metals Division 2700 South Indiana Street Los Angeles, CA 90023	(213) 2[illegible] [illegible] Lead-acid battery proce[illegible] 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 20 (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 Recycli 'orp. 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 20 (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 21

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

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

Table 22

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

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

Table 23

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 24

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 Blakeslees, 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/hr	--	--
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 24 (Cont'd)

Supplier	Model	Capacity	Temperature limits	Approximate cost
Finish Engineering Company	LS-Jr.	3-5 gal/8h	<320 °F	$2,995
921 Greengarden Road	LS-15	15 gal/8h	<320 °F	$5,895
Erie, PA 16501	LS-15V	15 gal/8h	<320 °F	$9,390
(814)455-4478, (415)821-4154				
(Hazardous waste solvents)				
Garden Machinery Corp.	#50	50-60 gal/h	--	$4,950
700 N. Summit Avenue				
Charlotte, NC 28233				
(Petroleum solvents and oils)				
Hoyt Corporation	EP8	4-8 gal/h	<330 °F	$14,500
Westport, MA 02790	EP20	<20 gal/h	<330 °F	$76,945
Hazardous waste solvents)				
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	$ [illegible].000
South San Francisco, CA 94080	RS-35AF	6-8 gal/h (2)	<375 °F	$[illegible]1,000
(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 25

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 gallons	$ 1,995
Nordale Fluid Eliminator 990 Xylite Ave., N.E. Minneapolis, MN 55434 (603) 668-7111 (714) 885-0691	FE-150	150 gallons	$ 8,000 - $13,000
Wastewater Treatment Systems 440 N. Central Ave. Campbell, CA 95008 (408) 374-3030	BM-50	50 gallons	$15,000 - $18,000

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*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 26. 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.[71] 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;

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[71] 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.

ventilation equipment; and drying equipment such as ovens, air heaters, fans, and compressors.[73] 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.

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.

Since Fort Meade does not conduct any vapor degreasing, only the following four categories of processes are discussed in this chapter: alkaline cleaning, dry media blasting, phosphatizing, and cutting and threading.

Treatment - Alkaline Cleaning

Cleaning metal substrates using alkaline cleaners generates a corrosive waste that must be neutralized. In addition to neutralization, removing grease and heavy metals may also be necessary. Batch treatment units are commercially available. A precipitation/neutralization system can also be designed for onsite use.

Source Reduction - Dry Media Blasting

Dry Wastes - Product Substitution - Plastic Media Blasting

Plastic media blasting (PMB) is a relatively new method to remove 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 MC and other toxic compounds) and abrasive blasting with sand, glass beads, or agricultural media (walnut shells, rice hulls, corn cobs, etc.).

Agricultural media blasting has several drawbacks such as high explosion potential, poor paint/rust removal, high contamination, low recycle rate, and generation of large quantities of wastes. Comparatively, sand and glass beads are better for blast cleaning because of good performance and low explosion potential, however they also have a very low recycle rate. Some of the advantages of PMB are: (1) it is aggressive and requires less operating time (compared to agricultural media only); (2) the plastic maintains its size and hardness; (3) the plastic does not break up and thus can be recycled 10 to 20 times,[74] resulting in lower replacement and disposal costs; and (4) overall, the method is economically favorable.

PMB is slower than sand or glass bead blasting, however it produces a better quality finish. Also, the amount of waste produced in 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.[75]

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

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

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

Suppliers of plastic media including: Aerolyte Systems, 1657 Rollins Rd., Burlingame, CA 94010, (415) 570-6000; E.I. du Pont de Nemours & 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 per pound.

Dry Wastes - Process Change - Plastic Media Blasting

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

Source Reduction - Phosphatizing

Wastewater - Better Operating Practices - Process Controls

Process controls, if implemented, not only minimize the quantities of wastes generated but also optimize the phosphate coating process.[74] A draining time of 5 to 15 seconds is recommended to allow the solution to run off the parts suspended on hooks, racks, or in barrels. A transfer time of less than 30 seconds between emergence and reimmersion must be maintained to avoid evaporation and drying-up between stages. Hollow components require special handling to ensure that the solution completely drains into the tank to reduce drag-out losses. If tumbling barrels are used, a work depth over 6 in. must be avoided and the turning speed must be maintained between 2 to 5 ft/min. A clearance of 6 to 12 in. must be allowed between the part and the phosphate tank bottom to prevent the part from passing through the sludge that accumulates on the bottom. The immersion tank volume must be at least 2.5 gal for every square foot of work to be coated. If the work load increases beyond the design capacity of the tank, a larger tank must be used. Optimal operation of the coating process increases the production efficiency, reduces reject parts, and minimizes waste generation.

Wastewater - Process Change - Reducing Water Use

If multiple rinse tanks are used, they must be configured in a countercurrent arrangement. The rinsewater must flow (or be transferred) in a direction counter to the movement of the parts. This process change will result in a tremendous reduction in quantities of rinsewater used. Adding spray nozzles and other such equipment to rinse the coating solutions off the parts reduces the amount of drag-out losses.

Emissions - Process Change - Proper Ventilation

Phosphate coating processes generate steam, acidic sprays, vapors, and small amounts of gases (nitrogen oxides, hydrogen, etc.). Adequate air exchange must be provided in confined areas to reduce worker discomfort. Efforts must be undertaken to minimize emission of toxic contaminants and fumes into the work space or ambient air by using lids, condensing devices, etc. If the concentrations of gaseous emissions are high, proper air pollution control devices (e.g., scrubbers) must be installed.

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

Phosphate Sludge/Coating Solution - Process Change - Bath Loading

Bath loading is defined as the area (square feet) of work to be coated per hour per gallon of solution.[77] A lower bath loading requires less frequent analysis of the coating solution and less frequent sludge removal. The minimum working volume for the phosphatizing process is 2.5 gal/sq ft.

All Wastes - Better Operating Practices - Proper Maintenance/Control

Proper maintenance of equipment used in the phosphatizing process is required for optimal operation. Insoluble phosphate coatings accumulate on heating coils. Descaling of heating coils must be done frequently. Accurate thermostatic controllers must be installed to reduce fluctuations in solution temperature. These fluctuations destroy work quality and degrade the solutions, thus increasing waste generation.

All Wastes - Product Substitution

Very low temperature phosphating systems, nonchromated sealing solutions, and solvent based systems have been developed for use in the phosphatizing process.[78] The equipment requirements are similar. However, use of these new solutions reduces the quantities of wastes produced and results in an economical use of fuel.

Treatment - Phosphatizing

Phosphate Sludge - Treatment

The phosphatizing process generates a sludge consisting of precipitates. Depending on the volume of sludge generated and its solids content, volume reduction techniques such as filtration (with plate and frame press) or centrifugation must be used. Although the sludge is not a listed hazardous waste, it must be tested for hazardous characteristics (heavy metal content, toxicity, etc.) and disposed of properly.

Source Reduction - Cutting and Threading

Cooling/Cutting Oils - Better Operating Practices - Material Conservation

The application of cooling/cutting oils in metalworking 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 amount of oil purchased and wastes generated.

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

The coolant performance 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.

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

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

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 also be trained about the hazards of mixing oils and chlorinated/nonchlorinated solvents and the associated disposal problems.

Cooling/Cutting Oils - Better Operating Practices - Chemical Purchase

When purchasing oils, screen them 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 the sump and at 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 (belts or disks) 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.[79]

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.

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

Cooling/Cutting Oils - Process Change - Control Bacterial Growth

Bacterial growth in coolants can be controlled by: cleaning the sump whenever the coolant is replaced, using biocides, adjusting the pH, and adequately circulating the coolant.[80] 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. Measuring the 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.

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 discharged directly to the sewer system.[81] 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 accumulated during use can thus be removed. The blend ratio of recycled oil to new oil is determined before use with a refractometer.

Cooling/Cutting Oils - Offsite Treatment

Several offsite treatment and recovery techniques are 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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[80] *Prolonging Machine Coolant Life.*

[81] Fred C. Hart Associates, *Aerospace Waste Minimization Report* (California Department of Health Services, 1987).

Table 26

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

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

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.[62] 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.[63]

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. 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.[64] 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 27 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. Excess powder that does not cling to the surface can be recycled. Heating in the curing oven ensures

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[62] ICF Associates, Inc.

[63] P.L. Layman, "Paints and Coatings: the Global Challenge," *Chemical and Engineering News* (September 30, 1985), pp 27-68.

[64] ICF Associates, Inc.

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 [illegible] 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.[85]

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.[86]

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.[87] 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 installating a drying unit. Surface treatment procedures may need extensive modification to convert to a water-based coating method.[88]

One company that unsucessfully 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 amount of surface cleaning before the water-based coating could be applied. The time and cost

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[85] ICF Associates, Inc.
[86] ICF Associates, Inc.
[87] ICF Associates, Inc.
[88] ICF Associates, Inc.

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.[89]

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.[90] Substituting two-component catalyzed coatings for solvent-based formulations is not justified because of the toxicity of the [illegible]

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.[91]

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.[92] 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.[93]

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[89] ICF Associates, Inc.

[90] 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).

[91] M.E. Campbell and W.M. Glenn.

[92] J. Kohl, P. Moses, and B. Triplett, *Managing and Recycling Solvents: North Carolina Practices, Facilities, and Regulations* (North Carolina State University, Raleigh, NC, 1984).

[93] 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.[94]

Solvent Wastes - Better Operating Practices - Maintain Equipment Properly

Proper equipment maintenance is critical to reducing the number of reject products and improving productivity.[95] 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.[96]

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.[97]

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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[94] ICF Associates, Inc.

[95] ICF Associates, Inc.

[96] ICF Associates, Inc.

[97] 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.[98] 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.[99] 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

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[98] L.J. Durney.
[99] J. Kohl, P. Moses, and B. Triplett.

of a Navy study[100] 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.[101]

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 24 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.[102] 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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[100] Acurex Corporation, *Navy Paint Booth Conversion Feasibility Study*, CR 89.004 (Prepared for the Naval Civil Engineering Laboratory [NCEL], Port Hueneme, CA, 1989).

[101] 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.

[102] 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.[103]

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 27

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

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[103] SCS Engineers, Inc.

8 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.[104] Detailed definitions and classifications of infectious wastes can be obtained from USEPA's *Guide to Infectious Waste Management.*[105]

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.[106]

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: ^{99m}Technetium, ^{51}Chromium, ^{32}Phosphorus, and ^{131}Iodine.[107] Most of the radioactive wastes that require special handling and disposal are generated by the use of radionuclides such as ^{14}Carbon, ^{3}Hydrogen, and ^{131}Iodine, in clinical laboratories.

A number of different types of hazardous wastes are generated in HCL, although in small quantities. Table 28 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.

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[104] Army Regulation (AR) 40-5, *Preventive Medicine* (HQDA, 30 August 1986).

[105] *Guide to Infectious Waste Management*, EPA/530-SW-86-014 (USEPA, Washington, D.C., 1986).

[106] 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.

[107] 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*,[108] and *Waste Audit Study - General Medical and Surgical Hospitals*.[109] The minimization of photographic wastes is discussed in Chapter 9.

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).[110] 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.[111] 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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[108] *Protocol Health Care Facility Waste Management Surveys* (USAEHA, 1987).

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

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

[111] *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 Proctices - Collection/Transportation

Sufficient numbers of IW/PW containers must be provided and conveniently located in all rooms where the wastes are generated. They should also be located in such a way as to minimize patients/personnel exposure to the wastes. The containers must be cleaned and disinfected every time they are emptied. All the containers should have tight-fitting lids and the lids should be in place when the containers are not in use. To minimize exposure for patients and staff, 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[112] 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

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

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.

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.*[113]

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[114] 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:[115] flash point, Btu value, viscosity, halogen content (e.g., chlorine), and water content. Segregating wastes as individual chemicals (with minimal contamination) simplifies waste management.

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[113] *Infectious Hazardous Waste Handling and Disposal*, Technical Guide Number 147 (USAEHA, 1986).

[114] 40 CFR 262.34, *Onsite Accumulation Requirements.*

[115] Ecology and Environment, Inc., pp 5-1 to 5-3.

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 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.[116] 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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[116] 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.[117]

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).[118] 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 acohol and decontaminated weekly with an alkaline solution.[119] 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.

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[117] Ecology and Environment, Inc.
[118] Ecology and Environment, Inc.
[119] 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.[120]

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 24 lists manufacturers of industrial distillation equipment. For laboratories, stills made of glassware (process-spinning band distillation[121]) 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 20 lists some of them.

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[120] Ecology and Environment, Inc.

[121] 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.[122] 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.[123] 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.[124]

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.

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[122] National Research Council, pp 44-55.

[123] National Research Council, Chapter 4.

[124] National Research Council, Chapter 9, pp 111-125.

Table 28

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,	Nonhalogenated solvents:	F003	Waste acetone	Flammable liquid	UN1090
Pathology,	Acetone	D001	Waste acetonitrile	Flammable liquid	UN1648
Histology,	Acetonitrile	[illegible]	Waste ethyl alcohol	Flammable liquid	UN1170
Embalming,	Ethanol	F003	Waste ethyl acetate	Flammable liquid	UN1173
Sterile processing,	Ethyl acetate	D001	Waste isopropyl alcohol	Flammable liquid	UN1219
Facilities maintenance,	Isopropanol	F003	Waste methanol	Flammable liquid	UN1230
Laundry,	Methanol	F005	Waste toluene	Flammable liquid	UN1294
	Toluene	F003	Waste xylene	Flammable liquid	UN1307
	Xylene			ORM-A	UN1888
	Halogenated solvents:	F001	Waste chloroform	ORM-A	UN1888
	Chloroform	F001	Hazardous waste liquid, NOS	ORM-A	UN9195
	Freon	F001	Waste methylene chloride	ORM-A	UN1593
	Methylene chloride	F001	Waste 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 acids	D002	Waste nitric acid, > 40%	Oxidizer	UN2031
	Nitric acid	D002	Waste nitric acid ≤ 40%	Corrosive material	UN1760
		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,	Corrosive material > 12% < 44%	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	UN1479
	Mercury		Waste oxidizer, NOS	Oxidizer	NA9193
	Oxidizers		Waste oxidizer, corrosive liquid, NOS	Oxidizer	NA9194
			Waste Oxidizer, corrosive, solid, NOS	Oxidizer	
	Poisons		Waste poison B, liquid, NOS	Poison B	UN2810
			Waste poison B, solid, NOS	Poison B	UN2811
			Waste poison B, solid NOS	Poison B	UN2922
			Waste corrosive liquid, poisonous, NOS	Corrosive material	UN2928

Table 28 (Cont'd)

Waste Classification for HCL

Process Description		Waste Description			
Typical process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
	Poisonous, oxidizers		Waste poisonous solid, corrosive, NOS	Oxidizer	NA9200
	Nonspecific hazardous Wastes		Waste oxidizer, poisonous, liquid, NOS	ORM-E	NA9189
			Wastes oxidizer, poisonous, solid, NOS	ORM-E	NA9189
Chemotherapy, pharmacy, clinics	Antineoplastics Cytotoxic drugs		Hazardous waste solid, NOS		UN2209
Radiology	Photographic chemicals:				
	Fixer			ORM-A	
	Developer			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				

9 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.[125] 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.[126]

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.[127]

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 29 and 30.

Most of the waste minimization options discussed in this chapter have been extracted from *Waste Audit Study - Commercial Printing Industry*.[128]

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[125] Jacobs Engineering Group, Inc., *Waste Audit Study - Commercial Printing Industry* (California Department of Health Services, Sacramento, CA, May 1988).
[126] Jacobs Engineering Group, Inc.
[127] Jacobs Engineering Group, Inc.
[128] 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.[139] 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

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[139] 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.[130] 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:[131]

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.[132] 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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[130] Jacobs Engineering Group, Inc.

[131] Jacobs Engineering Group, Inc.

[132] 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.[133] 3M has also developed a platemaking system that eliminates the need for photoprocessing, and has been found to be economical for large plating operations.[134]

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.[135] 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.[136] Water-based inks are not available for lithographic printing operations.

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[133] M.E. Campbell and W.M. Glenn.
[134] M.E. Campbell and W.M. Glenn.
[135] Jacobs Engineering Group, Inc.
[136] Jacobs Engineering Group, Inc.

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:[137]

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.

Disadvantages of UV inks include:[138]

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.

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[137] Jacobs Engineering Group, Inc.

[138] Jacobs Engineering Group, Inc.

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.

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:[139] 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

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[139] Jacobs Engineering Group, Inc.

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.*[140]

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.[141] These films must be sold to recyclers for silver recovery.

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.[142]

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.

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[140] *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.

[141] *Defense Utilization and Disposal Manual.*

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

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.

Table 29

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, manganese 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

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

Table 30

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

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:[143] 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 31). Used oil that meets the specifications can be burned in any burner (space heater, nonindustrial boiler, industrial boiler, utility boilers, and industrial furnaces),[144] whereas

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

[144] 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.

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 Vaiclene™ (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 32). Table 33 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 naptha must be explored. As is obvious from Table 32, 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 34 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 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 35 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.[145] Treatment methods include destruction with chlorine or lime, incineration, and carbon adsorption.[146] 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 36. OB/OD is the simplest and has been the primary method of demilitarization used at Army installations.[147] 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 37 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.

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.[148] 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

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

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

[147] 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).

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

propellants by such reclamation techniques[149] 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[150] 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.[151] 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) associated with the data base has been devised to indicate the likelihood of individual tank leakage.[152] 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.

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

[150] 40 CFR Parts 280-281, *Underground Storage Tanks: Technical Requirements and State Program Approval; Final Rule*, pp 37081 - 37247.

[151] 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).

[152] 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.

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.[133] 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 31

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	4,000 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."

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[133] J. Makwinski and P.N. Cheremisinoff, "Special Report: Underground Storage Tanks," *Pollution Engineering*, Vol 20 (1988), pp 60-69.

Table 32

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	[***]

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[*] 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 33

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

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[*] 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 34

Wastes Classification: Woodworking and Preserving Operations*

Process/ operation	Materials used	Waste Description: HW code	Waste Description: DOT shipping name	Waste Description: Hazard class	Waste Description: 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	UN2553
				ORM-A	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
					UN1993
Staining	Stains (mineral spirits, alcohols, pigments)	D001	Waste flammable liquid	Flammable liquid	
					UN1263
Painting	Paints (enamels, lacquers, epoxy, alkyds, acrylics)	D001	Waste paint or enamel liquid	Flammable liquid	UN1993
					NA9189
	Varnish, shellac, lacquer	D001	Waste flammable liquid, NOS	Flammable liquid	
Finishing					NA2020
	Creosote	K001	Hazardous waste liquid or solid, NOS	ORM-E	
Preserving					UN1557
	Pentachlorophenol	K001	Waste pentachlorophenol, liquid or solid	ORM-E	
					UN1556
	Chromated copper arsenate	D004/ D007	Waste arsenical compounds, liquids	Poison B	
			Waste arsenical compounds, solids		UN1557
	Ammoniacal copper arsenate	D004	Waste arsenical compounds, liquids	Poison B	
			Waste arsenical compounds, solids		UN1556
		Varies	Hazardous waste liquid or solid, NOS	Poison B	NA9189
	Other wood preservatives			Poison B	
				ORM-E	

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

Table 35

Waste Classification: Pesticides[*]

		Waste Description		
Process/operation	**Materials used**	**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	Waste arsenical pesticide, solid, NOS[3]	Poison B	UN2759
	Dimethylarsinic acid	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Phytar	Waste arsenical pesticide, liquid, NOS	Flammable liquid	UN2760
Monosodium Methanearsonate	MSMA	Waste arsenical pesticide, solid, NOS	Poison B	UN2759
	Ansar 170 H.C. and 529 H.C.			
	Arsanote liquid	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Bueno 6			
	Daconate 6	Waste arsenical pesticide, liquid, NOS	Flammable liquid	UN2760
	Dal-E-Rad Herb-All Merge 823 Mesamate Monate Trans-Vert Weed-E-Rad Weed-Hoe			
Disodium Monomethanearsonate	DSMA	Waste arsenical pesticide, solid, NOS	Poison B	UN2759
	Ansar 8100	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Arrhenal	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Arsinyl Dinate Di-Tac DMA Methar 30 Sodar Versar DSMA-LQ			

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[*] Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), p. 144.

Table 35 (Cont'd)

Process/operation	Materials used	Waste Description		
		DOT shipping name	Hazard class	Number
Weed-E-Rad				
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 Agallol	Waste mercury based pesticide, solid, NOS	Poison B	UN2777
	Cekusil Universal-C Ceresan-Universal-*Nassbeize*	Waste mercury based pesticide, liquid, NOS	Poison B	UN2777
	Emisan 6	Waste mercury based pesticide, liquid, NOS	Flammable liquid	UN2778
Phenylmercuric acetate	PMA PMAS	Waste mercury based pesticide, solid, NOS	Poison B	UN2777
	Agrosan Cekusil	Waste mercury based pesticide, liquid, NOS	Poison B	UN2777
	Celmer Gallotox	Waste mercury based pesticide, liquid, NOS	Flammable liquid	
	Hong Nien			
	Liquidphene			
	Mersolite			
	Pamisan			
	Phix			
	Seedtox			
	Shimmer-ex			
	Tag HL 331			
Pesticides Containing Substituted Nitrophenols:				
Dinitrocresol	DNC DNOC	Waste substituted nitrophenol pesticide, solid, NOS	Poison B	UN2779
	Chemset Detal	Waste substituted nitrophenol pesticide, liquid, NOS	Poison B	UN2779
	Elgetol 30	Waste substituted nitrophenol pesticide,	Flammable liquid	UN2780

Table 35 (Cont'd)

Process/operation	Materials used	Waste Description DOT shipping name	Hazard class	Number
	Nitrador	liquid, NOS		
	Selinon			
	Sinox			
	Trifocide			
	Trifrina			
Dinoseb	DNBP	Waste substituted nitrophenol pesticide,	Poison B	
	Basanite	solid, NOS		UN2779
	Caldon	Waste substituted nitrophenol pesticide,	Poison B	
	Chemox general	liquid, NOS		UN7890
	Chemox PE	Waste substituted nitrophenol pesticide,	Flammable liquid	
	Dinitro	liquid, NOS		UN2780
	Dinitro general			
	Dynamite			
	Elgetol 318			
	Gebutox			
	Hel-Fire			
	Nitropone C			
	Premerge 3			
	Sinox general			
	Subitex			
	Vertac general weed killer			
	Vertac selective weed killer			
Organophosphate pesticides:				
Dimethoate	AC-12880	Waste organophosphorous pesticide,	Poison B	UN2783
	Bi 58 EC	solid, NOS		
	Cekuthoate	Waste organophosphorous pesticide,		
	Cygon	liquid, NOS	Poison B	UN2783
	Daphene	Waste organophosphorous pesticide,		
	De-Fend	liquid, NOS	Flammable liquid	UN2784
	Demos-L40			
	Devigon			
	Dimet			
	Dimethogen			
	Perfekthion			
	Rebelate			
	Rogdial			
	Rogor			
	Roxion			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
	Trimetion			
Disulfoton	Bay 19639 and S276	Waste disolfoton	Poison B	NA2783
	Dithiodemeton	Waste disulfoton mixture, dry	Poison B	NA2783
	Dithiosystox	Waste disulfoton mixture, liquid	Poison B	NA2783
	Di-Syston	Waste organophosphorous pesticide,	Flammable liquid	UN2784
	Ethylthiodemeton	liquid, NOS		
	Frumin AL			
	M-74			
	Solvirex			
	Thiodemeton			
Famphur	Bash	Waste organophosphorous pesticide,	Poison B	UN2783
	Bo-Ana	solid, NOS		
	Dovip	Waste organophosphorous pesticide,	Poison B	UN2783
	Famfos	liquid, NOS		
	Warbex	Waste organophosphorous pesticide,	Flammable liquid	UN2784
		liquid, NOS		
Methylparathion	Cekumethion	Waste methyl parathion, liquid	Poison B	NA2783
	E-601	Waste methyl parathion mixture, dry	Poison B	NA2783
	Devithion	Waste methyl parathion mixture,	Poison B	
NA2783				
	Folidon M	liquid, (containing 25% or less		
	Fosferno M50	methylparathion)		
	Gearphos	Waste methyl parathion mixture,	Poison B	NA2783
	Methacide	liquid, (containing more than 25%		
	Metaphos	methylparation)		
	Nitrox 80	Waste organophosphorous pesticide,	Flammable liquid	UN2784
	Parataf	liquid, NOS		
	Paratox			
	Partron M			
Methylparathion (Cont'd)	Penncap-M			
	Wofatox			
Parathion	AC-3422	Waste parathion, liquid	Poison B	NA2783
	Alkron	Waste parathion mixture, dry	Poison B	NA2783
	Alleron	Waste parathion mixture, liquid	Poison B	NA2783
	Aphamite	Waste organophosphorous pesticide,	Flammable liquid	UN2784
	Bladan	liquid, NOS		
	Corothion			
	E-605			
	ENT 15108			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
	Ethyl parathion			
	Etilon			
	Folidol E-605			
	Fostarno 50			
	Niran			
	Orthophos			
	Panthion			
	Paramar			
	Paraphos			
	Parathene			
	Parawet			
	Phoskil			
	Rhodiatox			
	Soprathion			
	Stathion			
	Thiophos			
Strychnine Pesticides:				
Strychnine	Strychnine salts	Waste strychnine, solid	Poison B	UN1692
		Waste strychnine salt, solid	Poison B	UN1692
Thallium Sulfate Pesticides:				
Thallium sulfate	Thallous sulfate	Waste thallium sulfate, solid	Poison B	NA1707
	Ratox	Waste flammable liquid, poisonous, NOS	Flammable liquid	UN1992
	Zelio			
Triazine Pesticides:				
Amitrole	Amarol	Waste triazine pesticide, solid, NOS	Poison B	UN2763
	Amino triazol weedkiller 90	Waste triazine pesticide, liquid, NOS	Poison B	UN2763
	Amizol	Waste triazine pesticide, liquid, NOS	Flammable liquid	UN2764
	AT-90			
	AT liquid			
	Azolan			
	Azole			
	Cytrol			
	Diurol			
	Farmco			
	Herbizole			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
	Simazol Weedazol Weedazol TL			
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	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

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
	Rhodia			
	Salvo			
	Super-D Weedone			
	Verton			
	Visko-Rhap			
	Weed Tox			
	Weed-B-Gone			
	Weed-Rhap			
	Weedar			
	Weedone			
	Weedtrol			
2,4,5-T	Brush-Rhap	Waste 2,4,5-trichlorophenoxyacetic acid	ORM-A	NA2765
	Decamine			
	Ded-Weedon	Waste 2,4,5-trichlorophenoxyacetic acid (amine, ester, or salt)	ORM-E	NA2765
	Esteron			
	Farmco Fence Rider	Waste phenoxy pesticide, liquid, NOS	Flammable liquid	UN2766
	Forron			
	Inverton 245			
	Line Rider			
	Super D Weedone			
	Tormona			
	Transamine			
	U 46			
	Veon 245			
	Weedar			
	Weedone			
Silvex	2,4,5-TP	Waste 2-(2,4,5-trichlorophenoxy) propionic acid	ORMA-A	NA2765
	Fenoprop			
	AquaVex	Waste 2-(2,4,5-trichlorophenoxy) propionic acid ester	ORM-E	NA2765
	Double Strength			
	Fruitone T	Waste phenoxy pesticide, liquid, NOS	Flammable liquid	UN2766
	Kuron			
	Kurosal			
	Silver-Rhap			
	Weed-B-Gone			

Table 35 (Cont'd)

Process/operation	Materials used	Waste Description		
		DOT shipping name	Hazard class	Number
Organochlorine Pesticides:				
Aldrin	HHDN	Waste aldrin	Poison B	NA2761
	Aldrex 30			
	Aldrite	Waste aldrin mixture, dry (with more than 65% aldrin)	Poison B	NA2761
	Aldrosol			
	Altox	Waste aldrin mixture, liquid (with or less aldrin)	ORM-A	NA2761
	Drinox			
	Octalene	Waste aldrin mixture, liquid (with more than 60% aldrin)	Poison B	NA2762
	Seedrin liquid			
		Waste aldrin mixture, liquid (with 60% or less aldrin)	ORM-A	NA2762
		Waste organchlorine pesticide, liquid, NOS	Flammable liquid	UN2762
Chlordan	Belt	Waste chlordane, liquid	Flammable liquid	NA2762
	Chlordan			
	ChlorKil	Waste chlordane, liquid	Combustible liquid	NA2762
	Chlortox			
	Corodane			
	Gold Crest C-100			
	Kypchlor			
	Vesicol 1068			
	Topiclor 20			
	Niran			
	Octachlor			
	Octa-Klor			
	Ortho-Klor			
	Synklor			
	Termi-Ded			
DDT	Dedelo	Waste DDT	ORM-A	NA2761
	Didimac			
	Digmar	Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762
	Genitox			
	Gyron			
	Gildit			
	Kopsol			
	Neocid			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	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

Table 35 (Cont'd)

Process/operation	Materials used	Waste Description DOT shipping name	Hazard class	Number
Kepone	Exagama	Waste Kepone	ORM-E	NA2761
	Forlin	Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762
Lindane	Gallogama	Waste Lindane	ORM-A	NA2761
	Gamaphex	Waste organochlorine pesticide, liquid, NOS		
	Gammex		Flammable liquid	UN2762
	Inexn			
	Isotox			
	Lindafor			
	Lindagam			
	Lindagrain			
	Lindagranox			
	Lindalo			
	Lindamul			
	Lindapoudre			
	Lindaterra			
	Novigam			
	Silvanol			
Methoxychlor	Flo Pro McSeed Protectant	Waste Methoxychlor	ORM-E	NA2761
	Marlate	Waste organochlorine pesticide, solid, NOS	Poison B	UN2761
		Waste organochlorine pesticide, liquid, NOS	Poison B	UN2761
		Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762
Propylene Dichloride dichloride	Flammable liquid	1,2-dichloropropane UN1279	Waste	propylene
Toxaphene	Attac 4-2, 4-4, 6, 6-3, 8	Waste toxaphene	ORM-A	NA2761
	Camphochlor	Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762
	Motox			
	Phenacide			
	Phenatox			
	Strobane T-90			
	Toxakil			
	Toxon			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	DOT shipping name	Hazard class	Number
Other Pesticides:				
Thiram	TMTD	Waste Thiram	ORM-A	NA2771
	AAtack	Waste flammable liquid, poisonous, NOS	Flammable liquid	UN1992
	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			
Warfarin	Co-Rax	Hazardous waste solid, NOS	ORM-E	NA9189
	Cov-R-Tox			
	Kypfarin	Hazardous waste liquid, NOS	ORM-E	NA9189
	Liqua-Tox			

Table 35 (Cont'd)

		Waste Description		
Process/operation	Materials used	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			
	Tritisan			
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 36

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

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

Table 37

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		

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

11 WASTE MINIMIZATION FOR MISCELLANEOUS WASTES

Polychlorinated Biphenyls (PCBs)

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.[154] 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, appropriate actions must be taken.

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[154] P.N. Cheremisinoff, "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 38 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 39 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.

Ordnance

A number of hazardous ordnance materials are used on Army installations. Ingredients contained in some of them were listed in Table 36. Further details are available in Technical Manual (TM) 9-1300-214.[155] 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.

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* For information, contact Bernard Donahue or Keturah Reinbold at USACERL-EN, P.O. Box 4005, Champaign, IL 61824-4005, or telephone 800-USACERL (outside Illinois) 800-252-7122 (within Illinois).

[155] Technical Manual (TM) 9-1300-214, *Military Explosives* (Headquarters Department of the Army, 20 September 1984).

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.[156] 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 hazardous 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 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.[157] 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:[158] 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

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[156] *Standard Handbook of Hazardous Waste Treatment and Disposal.*
[157] Ventura County Environmental Health, p 3-2.
[158] *Managing Empty Containers*, Fact Sheet (Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

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.

Table 38

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 39

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 ANALYSIS FOR HAZARDOUS WASTE MINIMIZATION

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[139] 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.

Paint Thinner Waste

Paint thinner waste is generated from cleaning painting equipment as discussed in Chapter 7. Onsite distillation and contract recycling/disposal were the two options examined and compared with the current practice of purchasing fresh thinners and offsite disposal of waste thinners.

Investment costs are assumed to be incurred in the first year. A 10-year 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,

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

- logistics and procurement - 7 percent of installed equipment costs,
- contingencies - 10 percent of installed equipment costs,
- labor rate (manager) - $16.00/h,
- labor rate (laborer) - $11.00/h,
- labor rate (laborer) - $11.00/h,
- 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 per pound, and,
- annual logistics and procurement - 1.6 percent of other Operation and Maintenance (O&M) costs.

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

- An annual escalation of 4 percent was applied to raw materials and replacement materials, maintenance and repair, other materials and supplies, and utilities.
- An escalation rate of 8 to 10 percent was assumed for disposal costs.
- Liability costs were assumed as follows: onsite distillation and reuse, $0.03/gal; offsite disposal, $0.08/gal; and contract recycle, $0.01/gal.
- In the recycling process, it is assumed that 20 percent of the material is replaced with new material in each cycle. Ten percent of the material evaporates and 10 percent is disposed of with residue. Residue and thinner make up 20 percent of the original volume for disposal purposes.
- Repair and maintenance costs are annual costs at 5.75 percent of the original cost of the equipment and are based on 2080 hours of use per year. If the equipment is used less, the costs are adjusted.
- Laboratory analysis costs are estimated as a 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 $50.00 is assumed.
- Transportation and warehousing costs depend on the volume of waste handled.
- The disposal cost of thinner waste is $1.00/gal (1989 price by DRMO).

- Purchase cost of new paint thinner is $4.16/gal (General Services Administration [GSA] Schedule).

- Distillation stills are available with and without vacuum attachments. If the boiling point of the solvent is below 300 or 350 °F, a still without a vacuum attachment is considered. For recovery of solvents with boiling points between 300 and 500 °F, a vacuum attachment is necessary. Most of the dope lacquer thinners (NSN 8010-00-160-5787) have a boiling point of less than 300 °F.

- 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, $3.65/gal is assumed.

- Labor costs for loading and unloading the still, especially for 5-gal or 15-gal sizes, will be less than 2 hours (default value in the model). The labor requirement for operating a 55-gal still is reported by the manufacturers to be about 1/4 to 1/2 hour per batch.

- 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 $0.06 to $0.12.

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

With the above assumptions, net present assumptions, net present values (NPVs) of the total 10-year costs were calculated for each of the following management options: (1) offsite disposal and purchase of fresh thinner (status quo); (2) contract, closed-loop recycling; (3) onsite distillation with a 5-gal still; and (4) onsite distillation with a 15-gal still. Calculations were based on generation rates ranging between 100 gal/yr and 1000 gal/yr. The results of this analysis are presented in Figure 5.

No investment costs are associated with options 1 and 2. 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 40). Since Finish Engineering currently has a GSA contract, the corresponding GSA prices for stills were used. For the reported generation rate (870 gal/yr), purchase and use of a 5-gal still (Option 3) represents the least cost management option for minimizing paint thinner waste and is expected to remain cost effective throughout the generation range anticipated for FGGM.

The costs associated with each of the four management options are provided in Table 41. Variable labor requirements associated with different capacity distillation equipment are presented in Table 42. Purchase and installation of a 5-gal still to recycle paint thinner waste onsite is recommended. The estimated investment cost for implementing this option, which includes the price of the equipment and an initial purchase of fresh thinner, is $6021. Annual operating costs for this option are expected to be approximately $1970. Compared to the current operating practice, use of a 5-gal still provides a savings to investment ratio (SIR) of 2.50 and discounted payback period (DPP) of 5.32 years.

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. An economic analysis was performed to compare the current practice of periodically purchasing fresh solvent and offsite disposal of waste with recycling solvent by onsite distillation and offsite recycling by contract.

Investment costs are assumed to be incurred in the first year. A 10-year economic life and midyear discounting at a rate of 10 percent is assumed for all the options. The model's 12 default values (listed under paint thinner waste) were retained for this analysis.

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, and liability.
- Escalation rates of 8 and 6 percent were used for 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 to evaporate because of open lids and other poor operating practices.
- The volume of the still bottoms is assumed to be 10 percent of the original volume.
- Fresh solvent is expected to be 30 percent of the original 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 a minimum of $50.00.
- Transportation and warehousing costs are based on the volume of wastes generated.
- Cost of cooling water is $0.70/1000 gal.
- Cost of electricity is $0.05/kWh.
- The used cleaning solvent (assumed nonhazardous) disposal cost is $1.65/gal.
- The still bottom (assumed hazardous) disposal cost is $5.30/gal.
- Cost of new solvent (NSN 6850-00-285-8011) is $1.60/gal.
- A vacuum attachment is used if the boiling point of the solvent is above 325 or 350 °F.

- Labor cost for loading and unloading the still will be less than 2 hours (default value in the model). According to manufacturers, loading and unloading a 55-gal still varies from 1/4 to 1/2 hours per batch.

- Utility costs are often provided by still manufacturers based on their estimates of machine performance. Typical utility costs range from $0.06 to $0.12/gal of solvent distilled.

- The still prices on the GSA schedule (by Finish Engineering, Table 40) were used in the analysis. Shipping costs for equipment are not included in the price.

- Seventy percent of the initial cost of raw materials is included in the investment cost. The remaining 30 percent is included in the annual O&M costs.

- The same amount of waste generated is assumed for owned equipment and disposal and contract recycling.

With the above assumptions, net present values (NPVs) of total 10-year costs were calculated for each of the following management options: (1) purchase of fresh solvent and offsite disposal of generated wastes (status quo); (2) contract, closed-loop recycling with owned equipment (OE); (3) contract, closed-loop recycling with leased equipment (LE); (4) onsite distrillation with a 15-gal still; and (5) onsite distillation with a 55-gal still. Calculations were based on generation rates ranging between 1000 gal/yr and 5000 gal/yr. The results of this analysis are presented in Figure 6.

There are no investment costs associated with options 1 and 2. A one-time installation charge of $154 is associated with option 3 and considered an investment. The investment costs required for the two onsite distillation options vary with still capacity and the cost of fresh solvent. The costs for each of the five management options are presented in Table 43. Variable labor requirements associated with different capacity distillation equipment are presented in Table 44. Options 2 and 3 are cost effective at a generation rate of 1000 gal/yr. Option 3 (LE) is the least cost management option throughout the generation range examined in this analysis and recommended for implementation on FGGM. Option 4 is the most costly management option beyond a generation rate of 2200 gal/yr and requires the purchase of a second still to accomodate larger waste volumes. Beyond generation rates of 5000 gal/yr, distillation with a 55-gal still (Option 5) is the least cost management option.

The use of cleaning solvent at Fort Meade is estimated to be about 3000 gal/yr. Most of it is lost because of evaporation. Therefore, the reported waste generation is low. At the above rate, contract recycling with leased equipment is the best alternative. The present value of the 10-year operating expenses is estimated at $61,702. The annual operating cost is approximately $6170.

A typical contract recycling firm is Safety-Kleen (on GSA schedule through June 1991). They offer two types of contracts. With the second type of contract only the solvent, equivalent to PD680-II, is supplied and recycled by the vendor. The user is responsible for the purcahse and maintenance of equipment (i.e., solvent dip tanks).

Used Oil

Approximately 35,000 gal/yr of used oil, primarily engine lubricating oil, are generated on FGGM. Lubricating oil is drained from wheeled and tracked vehicles by the traditional drip-pan method and collected in 55-gal 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 vehicles based on the AOAP test.

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 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 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. Some of the assumptions made were:

- 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 cost of a small FLOC unit is $2260 (site preparation, etc. = $1530 and personnel training = $1235). Costs of larger units vary 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 45 lists the SIR and DPP for numbers of vehicles ranging from 100 to 5000. The SIR is 0.39 (not economical) in almost every case and the DPP is greater than the assumed economic life of 10 years. Varying the number of oil changes from 2 to 6 per year, a comparison can be made of the SIR and DPP, as shown in Table 46 for 1000 vehicles. Only when more than six oil changes per year, per vehicle are conducted does the FLOC system become cost-effective and a payback of less than 10 years is achieved.

Other options analyzed for management of used oil include: (1) no segregation and burning in the existing boilers (status quo); (2) segregate solvents and other contaminants from oils and burn the oils in an existing facility (no additional investment) (3) offsite disposal (burning in an industrial boiler), and (4) blend and burn with minimal processing (with additional investment). Hazardous oil, when burned in a boiler without permits is subject to fines. Operating without a permit or violating a permit will cause the facility to be shut down by the regulating agency.

The major assumptions made in the analysis were:

- Nonsegregated oil may be considered hazardous depending on the concentration of halogens and heavy metals.
- The cost of oil is $3.25/gal.
- Processing time is 40 h/1000 gal for options 1 and 4, and 60 h/1000 gal for option 2.
- Transport cost is the same for all options within the installation.
- Sampling and testing costs ($21.00) are assumed to be the same for all options.
- Liability costs are $0.002/gal for options 1, 2, and 4, and $0.008/gal for option 3.
- Fuel to oil ratio is assumed to be 10 to 1. At Fort Meade it is between 14 and 16 to 1 during the normal operating period of 6 to 7 months.
- The disposal cost of filters, residues, etc. is $25/100 gal for options 1, 2, and 4, and $0.35/gal (Chemical Waste Management Price) for option 3.
- Transportation cost from Fort Meade to an industrial boiler (in Ohio) is $500/1000 gal.
- Escalation of raw materials, repair and maintenance, and liability costs is assumed to be 4 percent. Disposal costs are escalated by 6 percent and the transport cost for option 3 is escalated by 4 percent.
- Repair and maintenance for options 1 and 2 is assumed to be 1 percent of investment costs in option 4.
- Labor requirement for disposal of 1000 gal is assumed to be 8 hours for laborers and 1 hour for managers.
- When the oil volume exceeds 25,000 gal, two boilers will be necessary for burning throughout the year.

Figure 7 shows the comparison between the NPVs of the life cycle (10-yr) costs for the four used oil management options analyzed. From an economical perspective, the current procedure (Option 1) of blending with heating fuel and burning is the least expensive. However, the poor segregation of used oil from other waste streams at sites of generation and absence of an adequate characterization testing program have led to uncertainties concerning the legality of this management option. Used oil destined for blending and burning must be continually screened for halogenated contaminates and other hazardous compounds. The blending and burning of hazardous used oil constitutes a disposal activity for which FGGM is not permitted. The penalties associated with non-regulatory compliance far exceed the benefits of this option as it is currently being managed. Simple improvements in waste stream segregation and storage procedures and the implementation of a used oil testing program (Option 2) would enhance the quality of this waste stream as a boiler fuel additive and alleviate the concern for being cited as an illegal hazardous waste disposal operation. With the implementation of a comprehensive used oil testing program and improvements in segregation and storage procedures, the continued blending and burning of used oil generated on FGGM is recommended.

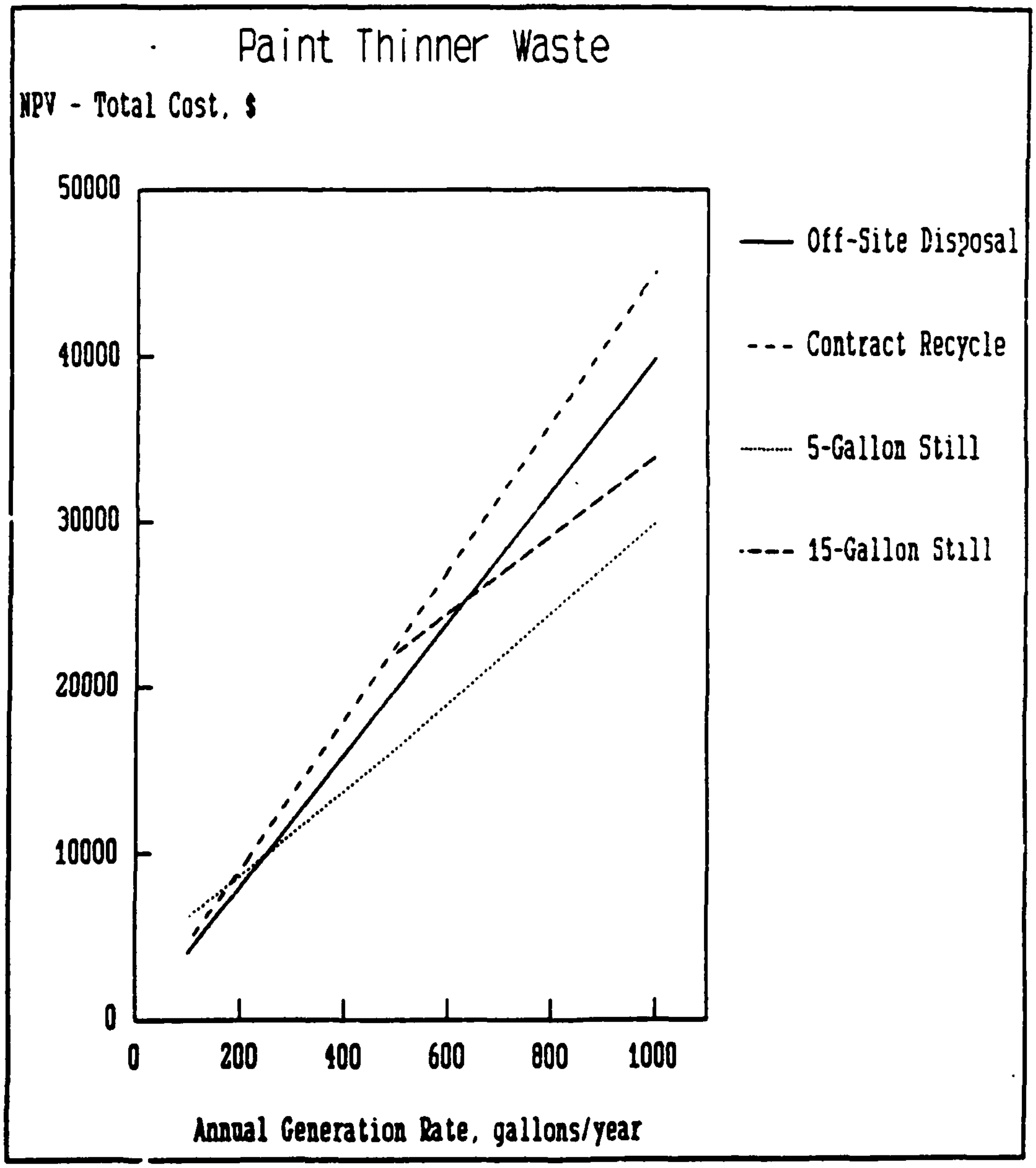

Figure 5. Comparison of net present values for paint thinner waste minimization options. Offsite disposal defines the status quo.

Table 40

Purchase Cost of Distillation Stills (In 1989 dollars)

Manufacturer	Model	Capacity (gal)	Price ($) no vacuum attachment	Price ($) vacuum attachment
Finish Engineering	LS-Jr	5	2770	4338
	LS-15HD	15	10,128	13,361
	LS-55HD	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 41

Comparison of Options for Minimization of Paint Thinner Waste

Option Name	PV Investment Costs $	PV O&M Costs $/10 years ($/year)	SIR	DPP (years)
Offsite disposal (status quo)	0	34,703 (3470)	-	-
Contract closed-loop recycle	0	39,225 (3923)	-	-
5-gal still	6,021	19,639 (1964)	2.50	5.32
15-gal still	14,233	15,255 (1526)	1.37	8.98

Table 42

Variable Labor Requirements Associated With the Use of Distillation Equipment for the Minimization of Paint Thinner Waste (870 gal/yr)

Still Capacity (gallons)	No. Batches per year	Labor hrs per batch	Total Labor hrs per year
5	174	0.50	87
15	58	0.75	44

Table 43

Comparison of Options for Minimization of Solvent Waste at the Actual Generation Rate Reported for FGGM (3000 gal/yr)

Option Name	PV Investment Costs $	PV O & M Costs' $/10 years	SIR ($year)	DPP (years)
Off-site Disposal (status quo)	0	72,522 (7,252)	-	-
Contract Recycle (OE)	0	68,560 (6,856)	-	-
Contract Recycle (LE)	154	61,702 (6,170)	70.26	1.16
(2) 15-Gallon Distillation Units	34,567	46,834 (4,683)	0.74	>10
55-Gallon Distillation Unit	34,787	42,493 (4,249)	0.86	>10

Table 44

Variable Labor Requirements Associated With the Use of Distillation Equipment for the Minimization of Solvent Waste (3000 gal/yr)

Still Capacity (gallons)	No. Batches per year	Labor hrs per batch	Total Labor hrs per year
15	200	0.75	150
55	55	1.00	55

Table 45

SIRs and DPPs From a Comparison of the Costs of Gravity Drain With FLOCS

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 46

SIRs and DPPs From a Comparison of the Costs of Gravity Drain With FLOCS 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

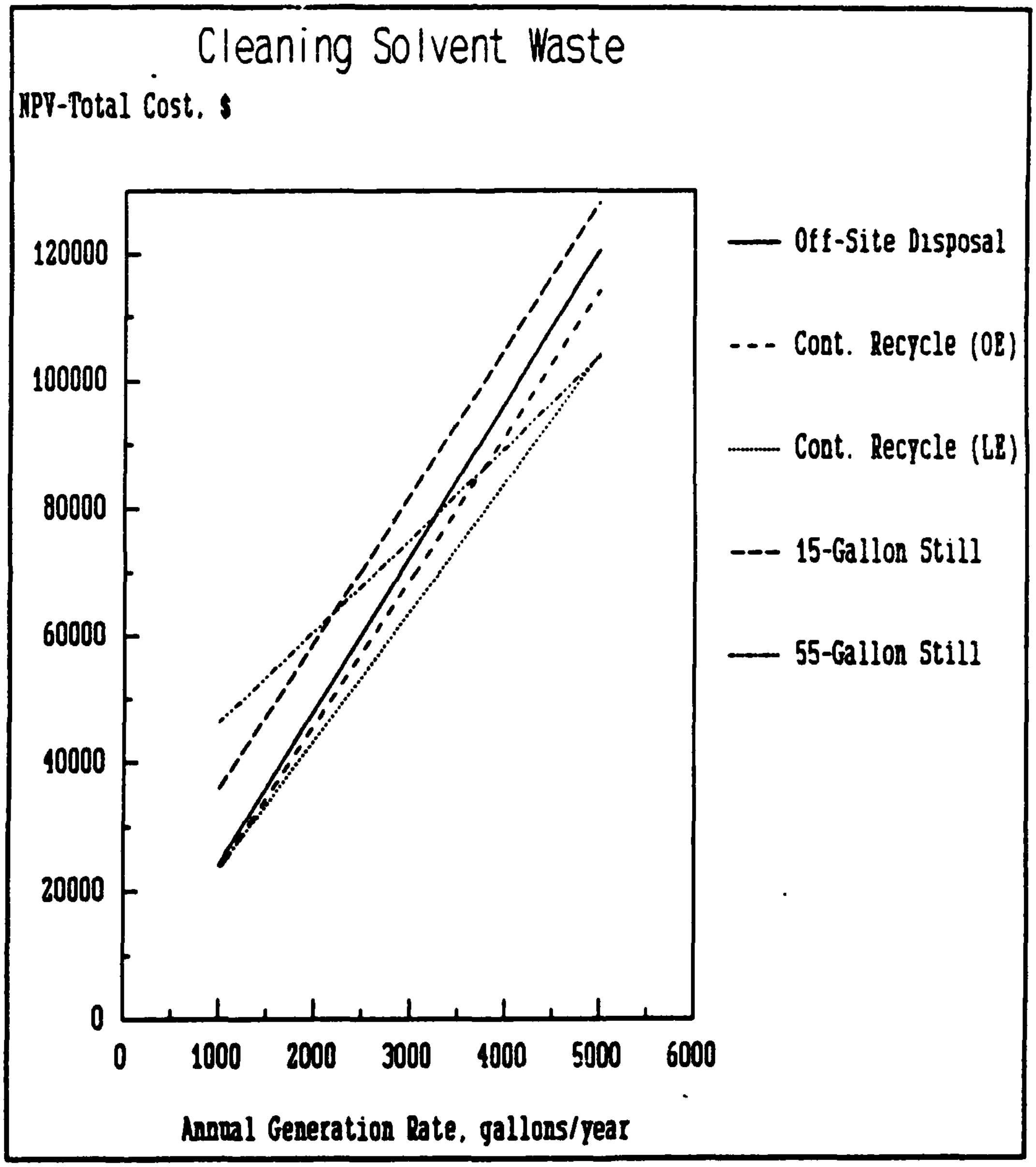

Figure 6. Comparison of net present values for cleaning solvent waste minimization options. Offsite disposal defines the status quo.

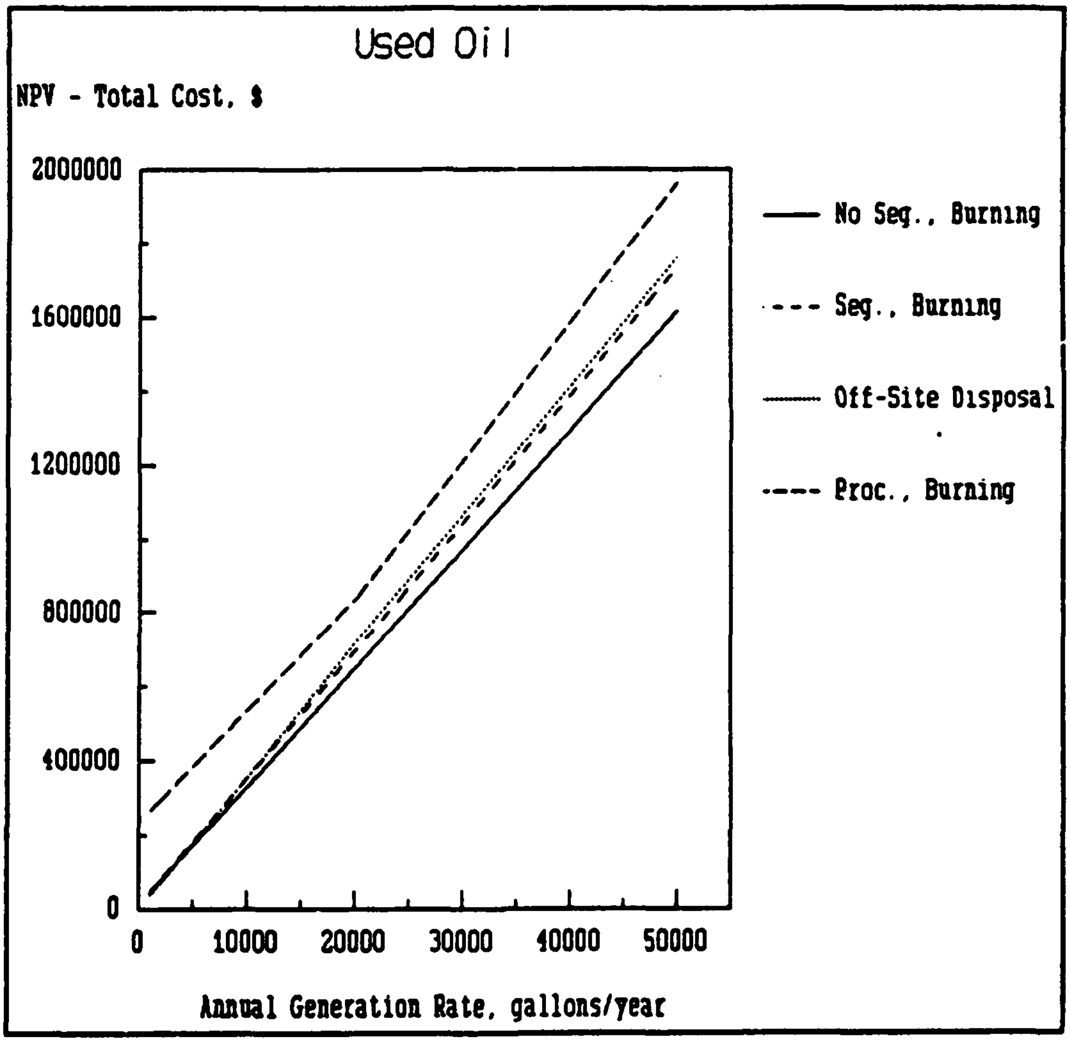

Figure 7. Comparison of the Net Present Values for used oil minimization of the total 10-year costs of implementing options. No segregation and burning defines the status quo.

13 SUMMARY AND RECOMMENDATIONS

Summary

All Army installations that are generators or small quantity generators (according to RCRA definitions) are required to implement programs to reduce hazardous waste generation. Waste minimization is a method of preventing pollution with the primary focus on reducing waste generation. 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 best 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.

Analysis of annual waste disposal data (Table 16) for Fort Meade, obtained from DRMS, indicates that DOL shops generate the largest amount (14,146 lb/yr), followed by DEH shops (2661 lb/yr), hospitals, clinics, and laboratories (2340 lb/yr), other motor pools (1736 lb/yr), and other sources (1541 lb/yr). This analysis does not include PCB transformer wastes. Paint-related materials (9317 lb/yr) and paint thinner waste (6529 lb/yr) are generated in the largest quantities. Spent nonhalogenated cleaning solvents and spent acids and bases are the other two wastes turned in for disposal. Lead-acid batteries, although generated in large quantities, are all recycled. Used oil (that may be a hazardous waste) generated at a rate of 35,000 gal/yr is currently being burned in a boiler plant.

Paint thinner, cleaning solvent, and used oil were considered for detailed technical and economic evaluation. The options examined include current practices (offsite disposal, burning, etc.), onsite distillation, contract recycling, and segregation/processing. Most of the other wastes can be minimized by implementing simple source reduction techniques, and/or elementary treatment (neutralization for acids and bases from laboratories).

Recommendations

A program to train military and civilian employees to handle hazardous material and manage and dispose of hazardous wastes must be implemented to ensure compliance with 40 CFR 264.16.[160] A qualified environmental engineer in the EECO should direct the program. EECO personnel must conduct monthly inspections, minimization audits, and periodic training classes in recognition, handling, and storage of hazardous materials and wastes.

A waste analysis program to characterize and define all (air, water, liquid, and solid) wastes from all the generators should be developed to ensure compliance with Federal and State of Maryland

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[160] 40 CFR 264.16, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, 1985.

laws. 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 tracking HW from the generators to final storage before disposal, will provide a mass balance and improve minimization opportunities.

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 military and civilian employees. An example of a policy statement is provided in Appendix D.

The installation command heirarchy and 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 Chief, EECO) 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:[161] (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 current practice of recycling lead-acid batteries must be continued. Burning of used oil may be continued only after implementation of proper segregation practices and periodic testing and laboratory analyses. The feasible options, discussed in Chapter 12, for minimization of cleaning

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[161] National Association of Manufacturers, *Waste Minimization: Manufacturers' Strategies for Success* (ENSR Consulting and Engineering, 1989).

solvent waste, paint thinner waste, and waste oil must be funded and implemented. For cleaning solvents, a change in management practice to utilize the services offered by a commercial recycler is recommended. With an initial investment of $154 for equipment installation and at an estimated annual operating cost of $6,170, the predicted payback period for this option would be 1.16 years. For paint thinner waste, it is recommended that a small 5-gal distillation still be purchased at a total investment cost of $6021 and an annual operating cost of $1970. The estimated payback period is expected to be 5 years.

The Fort Meade Hazardous Waste Management Board, chaired by the Commander, 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.

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 in. = 25.4 mm
1 ft. = 0.305 m
1 psi = 6.89 kPa
1 lb = 0.453 kg
1 cu ft = 0.028 m^3
1 mi = 1.61 km
1 sq ft = 0.093 m^2
1 m = 1x10^{-6}m
1 gal = 3,78 L
°F = (°C + 17.78) x 1.8
°C = 0.55(°F-32)
1 yd = 0.9144 m

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APPENDIX A:

FORT MEADE HAZMIN PLAN

1. PURPOSE The purpose of the Fort Meade 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.

2. 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 Ammendments (HSWA), and Subtitle 13 (Disposal of Controlled Hazardous Substances) of the Code of Maryland (COMAR) Regulations.

3. BACKGROUND

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 maintainance	30
Fueling operations	30
Battery shop operations	50
Painting	50
Sand blasting	60
Metalworking	15
Graphic Arts	40
Electrical maintenance	60
Waste treatment sludges	60

Percent HW reduction for any calender year (CY) =

$$\frac{\text{(Baseline Year HW Generation - CY HW Generation)} * 100}{\text{Baseline Year HW Generation}}$$

4.2 Fort Meade HAZMIN Goals

Same as DA HAZMIN goals.

5. PROGRAM MANAGEMENT

5.1 Fort Meade will manage the HAZMIN program according to 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 Garrison Commander and consists of the following members:

Commander
Civilian Executive Assistant
Director of Logistics
Director of Engineering and Housing
Chief, Energy and Environmental Affairs Office
Chief, Defense Reutilization and Marketing Office
Safety Officer
Industrial Hygienist
Environmental Coordinators (tenant activities)
Environmental Coordinators (troop units, and generators)

5.2 The following activities are generators of hazardous waste, used oil, and miscellaneous toxic wastes at Fort Meade:

Motor Pools/Vehicle Maintenance Facilities
Aviation Maintenance Facilities
Industrial Maintenance, Small Arms Shops, etc.
Paint Shops
Hospitals, Clinics, and Laboratories
Photography and Printing Operations

6. TRAINING

6.1 Personnel Training

A training program will be developed by the Chief, EECO for personnel involved in handling of hazardous material 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 training courses. The formal courses must be designed similar to the program offered by the U.S. Army Environmental Hygiene Agency. Refresher courses must be taught by the Environmental Personnel from the DEH Energy and Environmental Office.

The objective of a formal (or refresher) course must be to provide each student with the following abilities to:[162]

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, and

5. 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 (of Directorate of Plans, Training, Mobilization, and Security) will direct a training program designed by the Chief of the Energy and Environmental Office (Directorate of Engineering and Housing). 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 Meade and tenant activities) will maintain records pertaining to job experience and the training completion requirements. The records must include a description of the type/nature of initial and continuing training each person receives.

6.4.2 Fort Meade will maintain records of all current personnel until closure of the tenant activity or the entire base. 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 <u>Command Initiatives</u>. For the HAZMIN program to be successful, the Commander and the chain of command for all the troops and tenants must make a committment to all the goals (section 2) and establish specific goals at the generator (or activity) level.

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[162] *Defense Hazardous Materials Handling Course (DHMHC)*, U.S. Army Logistics Management Center (ALMC), Fort Lee, Virginia.

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 (e.g., in the installation newspaper) regarding the command committment 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 (Anne Arundel 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 Meade (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 Environmental (and Hazardous Waste) Management Board Meetings. Proper coverage must be provided in the installation newspaper to ensure wide acceptance among personnel.

7.1.6 Chief, EECO, Installation Safety Officer, and Industrial Hygienist 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, EECO, will develop a waste analysis program to characterize and define all (air, water, liquid, and solid) waste streams from all generators to ensure compliance with Federal and State laws.

7.1.8 DRMO and the Chief, EECO, will examine the use of waste exchange programs as a proper recycle methodology for some of the hazardous wastes.

7.1.9 The environmental engineer 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 All environmental coordinators will maintain proper records (logbooks) of materials procured and wastes generated.

7.2.4 All generators will include HAZMIN requirements in their standard operating procedures (SOPs).

7.3 Current HAZMIN Projects

7.3.1 Used Oil Burning. Used oil is collected from all the generators and burned in a DEH Boiler Plant (Building 268). About 35,000 gallons per year of used oil is burned in the boiler.

Proper segregation of waste oil is required at all the generators. Chlorine detection kits (e.g., CLOR-D-TECT™1000 and CLOR-D-TECT™Q4000)[163] must be used to detect the level of chlorinated solvent contamination of oil at the generators before the oil is transported to the boiler for burning. If oil samples are found to contain chloride, a complete laboratory analysis is required to determine the flash point and the total halogens and heavy metals (As, Cd, Cr, Pb) content. If the halogen content is less than 1000 ppm and the heavy metals are within specifications, the oil can be blended and burned.

Additional operation and maintenance costs for segregation and testing is expected to be $9,100 per year.

7.3.2 Spent Lead-Acid Batteries. Lead-acid batteries (sealed and unsealed) are accumulated at the generators (e.g., motor pools) on pallets. These batteries, bound securely to the pallets, are turned in to DRMO for reclamation. Since the batteries are being reclaimed, they do not require the reporting and manifesting paperwork necessary for other hazardous wastes.

7.4 Future HAZMIN Projects

7.4.1 Cleaning Solvent - Recycle Onsite/Offsite - Contract Recycling. A used solvent recycling program will be designed to collect and recycle used cleaning solvent (PD 680 -Type II) used in motor pools, vehicle/aviation maintenance facilities, and all other current and future locations.

From the economics of solvent use, it is determined that closed-loop contract recycling (e.g., SAFETY KLEEN™)[164] is the most economical option for minimizing cleaning solvent wastes.

Estimated Cost: Investment = $154; Annual O&M - $6,170

Estimated Payback Period: 1.16 years

7.4.2 Paint Thinner/Residue - Recycle Onsite/Offsite - Distillation. The paint shop belonging to the Allied Trades Section (of the Directorate of Logistics) will purchase a 5-gal distillation still for recycling paint thinner wastes. The still will be shared by other thinner waste

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[163] 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.

[164] Safety-Kleen, Inc., is a commercial solvent recycling contractor.

generators. Permit requirements, if any, will be reviewed by the environmental office before the installation and operation of the still.

Estimated Costs: Investment - $ 6021; Annual O&M - $ 1970

Estimated Payback Period: 5.32 years

8. HAZMIN REPORTS

8.1 A summary of Fort Meade HW generation data is given in Table A1.

8.2 This plan is part of the *Hazardous Waste Minimization Assessment of Fort George G. Meade.*

9. IMPLEMENTATION

Estimated Implementation Date: September 30, 1990.

10. RESPONSIBILITIES

10.1 The duties and responsibilities of persons directly responsible for implementing this plan and for the success of the HAZMIN program are described in this section. The following personnel will form the Fort Meade HAZMIN committee, which will oversee the implementation of this plan and keep it revised and updated in the future.

Job Title	HAZMIN Activity
Chief, Environmental & Energy Control Office	Overview of the entire program; chair the committee.
Environmental Engineer	Establish a hazardous materials/waste training program; establish waste analysis contract; establish waste inventory and inspection program; coordinate with Safety Officer, Fire Chief, DRMO and all the environmental coordinators.
Safety Officer	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 & Marketing Office	Establish proper waste turn-in procedures; waste contract management; explore offsite reclamation and waste exchange options.

Chief, DEH Operations Division	Inventory control of materials and wastes; vehicle/equipment maintenance, painting and laboratory wastes minimization; pesticides management; PCB transformer inventory management.
Chief, DEH Fire Prevention & Protection Division	Develop spill contingency plan; coordinate with safety office; inventory flammable/ toxic materials on Fort Meade; SARA Title III compliance.
Chief, DOL Transportation Division	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DOL Maintenance Division	Inventory control of materials and wastes; painting, parkerizing, machining, and nuclear weapons cleaning wastes minimization.
Chief, DOL Supply & Services Division	Flag and control procurement of hazardous materials; coordinate with Safety and EECO; establish chemical use inventory and demand history by each generator.
Chief, DPCA Arts & Crafts and Auto Crafts	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DPCA Training & Audiovisual Support Center	Inventory control of materials and wastes; photographic and printing wastes minimization.
Environmental Engineer, National Security Agency	Inventory hazardous materials/wastes; quantify and minimize process specific wastes. Coordinate with DEH Environmental Office.
Industrial Hygienist, Kimbrough Army Community Hospital	Establish inventory of hazardous materials/wastes; establish waste generator monitoring program; coordinate minimization and proper disposal practices (infectious, hazardous, and radioactive wastes) with environmental office.
Airfield Commander, Tipton Army Airfield	Inventory control of materials and wastes; aviation maintenance wastes minimization.
General Foreman, USAR Equipment Concentration Site	Inventory control of materials and wastes; vehicle maintenance, small arms repair, and general cleaning wastes minimization.

Director, USAMC Intelligence Material Activity	Inventory control of materials and wastes; photographic, printed circuit board fabrication, plating, cleaning, and machining wastes minimization.
Commander, 11th Engineer Company C	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
BMO, 85th Medical Battalion	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Commander, 99th ASA Co.	Inventory control of materials and wastes; aviation maintenance wastes minimization.
Commander, 144th Ordnance Detachment	Inventory control of materials and wastes; vehicle maintenance, ordnance wastes minimization.
Commander, 209th Military Police Co.	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Commander, 293rd Military Police Co.	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Commander, 31st Aviation Group	Inventory control of materials and wastes; aviation wastes minimization.
BMO, 902nd Military Intelligence Group	Inventory control of materials and wastes; vehicle maintenance wastes minimization.

10.2 Responsibilities of all HAZMIN Committee Members (except Chief, EEO)

10.2.1 Identify and prioritize goals necessary for achieving the goals outlined in this plan.

10.2.2 Provide information on HAZMIN techniques to 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, Energy and Environmental Office, regularly.

10.2.5 Assist the Chief, Energy and Environmental Office, in preparing an Annual HAZMIN status report.

10.3 Responsibilities of the Chief, Energy and Environmental Office

10.3.1 Oversee and provide resources (including technological assistance) to conduct the annual HAZMIN assessments. Report the state of the HAZMIN program to the commander.

10.3.1 Revise and update this plan annually.

10.3.2 Prepare a HAZMIN status report when requested by HQ FORSCOM or HQ DA.

10.3.3 Program funds necessary to accomplish HAZMIN goals.

10.3.4 Chair the HAZMIN Committee.

10.3.5 Conceive, develop, and implement HAZMIN techniques consistent with this plan.

10.4 Responsibilities of Environmental Coordinators

10.4.1 Establish goals for minimizing all forms environmental pollution (air, water, solid, and hazardous waste).

10.4.2 Obtain training (organized by EECO) 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 engineers at EECO.

Table A1

Summary of Fort Meade Hazardous Waste Generation

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate		Hazardous Waste Stream Unit
		lb/yr (mean)	lb/yr/unit (range, mean)	
Photographic and print	1	1	0 - 50, 21	Acetone
Reproduction facilities	6	03	0 - 671, 250	Hydroquinone
			0 - 900, 225	Uralite
			0 - 297, 134	Photographic processing chemicals
	8	4	0 - 17, 4	Acetic acid
	12	94	0 - 46, 12	Silver nitrate
			0 - 178, 82	Miscellaneous chemicals
Motor pools (excluding DEH & DOL)	1	193	0 - 38, 10	Aromatic hydrocarbons
			0 - 718, 180	Cleaning solvent
			0 - 10, 3	PD - 680
	2	98	0 - 58, 15	Trichloroethane
			0 - 40, 10	Perchloroethylene
			0 - 290, 73	Freon
	4	194	0 - 496, 194	Waste oils
	5	152	0 - 513, 152	Ethylene glycol
	8	1070	0 - 1365, 342	Cresylic acid
			185 - 1278, 728	Caustic soda
	12	29	0 - 90, 23	Batteries
			0 - 25, 6	Absorbent
DEH shops	3	909	0 - 2535, 909	Paint thinner
	7	1484	0 - 55, 14	Polyurethane
			97 - 1669, 617	Enamel paint
			57 - 3000, 790	Sealing compound
			0 - 250, 63	Driveway sealant
	8	29	0 - 70, 22	Cresylic acid
			0 - 9, 3	Sodium hydroxide

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* 1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontamination agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate lb/yr (mean)	Approximate Hazardous Waste Generation Rate lb/yr/unit (range, mean)	Hazardous Waste Stream Unit
DEH shops (cont'd)			0 - 14, 4	Anhydrous ammonia
	9	4	0 - 15, 4	DS-2
	10	178	0 - 563, 178	Insecticide
	12	57	0 - 15, 4	Plating solution
			0 - 17, 6	Etchant
			0 - 23, 6	Batteries
			0 - 63, 41	Miscellaneous chemicals
DOL shops	1	100	0 - 300, 100	Toluene
	2	82	0 - 30, 8	Freon
			12 - 162, 66	Methylene chloride
			0 - 33, 8	Blanket hardener
	3	5600	536 - 9510, 5600	Thinner
	7	7804	335 - 6367, 3935	Paint
			0 - 654, 164	Polyurethane
			207 - 11201, 2936	Sealing compound
			0 - 382, 176	Lead contaminated filters
			0 - 1594, 585	Rust proofer
			0 - 30, 8	Adhesive
	8	74	0 - 225, 74	Sulfuric acid
	12	486	0 - 165, 41	Contaminated fuels
			0 - 1664, 416	Batteries
			0 - 34, 9	Plating solution
			0 - 56, 14	Copper etchant
			0 - 24, 6	Ammonium persulfate
Hospitals, clinics and laboratories	1	930	7 - 45, 27	Acetone
			0 - 151, 38	Acetonitrile
			0 - 24, 8	Benzene
			0 - 1080, 474	Ethyl acetate
			0 - 426, 126	Ethyl ether

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* 1: spent cleaning solvents (nonhalogentatd), 2: spent cleaning solvents (halogenated), 3: spent paint thinner, 4: used oils, 5: spent alcohol, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontamination agents, 10: insecticides or herbicides, 11: pharmaceutical wates, 12: miscellanous wastes (small volume wastes)

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate		Hazardous Waste Stream Unit
		lb/yr (mean)	lb/yr/unit (range, mean)	
Hospitals, clinics and laboratories (cont'd)			0 - 160, 40	Cyclopropane
			0 - 110, 28	Hexane
			0 - 420, 129	Toluene
			0 - 106, 60	Xylene
	2	309	0 - 25, 9	Chloroform
			0 - 1200, 300	Thionyl chloride
	5	188	0 - 476, 119	Propylene glycol
			0 - 18, 5	Butanol
			0 - 18, 5	Methanol
			0 - 75, 19	Propanol
			0 - 102, 40	Reagent alcohol
	8	107	0 - 35, 20	Sulfuric acid
			0 - 36, 14	Hydrochloric acid
			0 - 16, 4	Nitric acid
			0 - 40, 10	Acetic acid
			0 - 17, 4	Formic acid
			0 - 42, 16	Miscellaneous acids
			0 - 40, 14	Sodium hydroxide
			0 - 40, 10	Ammonium hydroxide
			0 - 48, 12	Calcium hydroxide
			0 - 13, 3	Miscellaneous bases
	9	70	0 - 279, 70	DS-2
	11	346	68 - 762, 346	Waste pharmaceuticals
	12	390	7 - 31, 22	Mercury
			4 - 18, 10	Formaldehyde
			0 - 25, 15	Sodium metal
			110 - 651, 343	Miscellaneous chemicals
Troop units	9	456	0 - 810, 225	DS-2
			61 - 425, 230	STB
			0 - 3, 1	Decontamination kit
	12	17	0 - 27, 7	Batteries

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* 1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontamination agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	Approximate Hazardous Waste Generation Rate lb/yr (mean)	Approximate Hazardous Waste Generation Rate lb/yr/unit (range, mean)	Hazardous Waste Stream Unit
Troop units (Cont'd)			0 - 40, 10	Bore cleaning kit
Naval security group	3	20	0 - 35, 20	Paint thinner
	7	29	0 - 83, 21	Methylene chloride
			0 - 30, 8	Paint
Aviation maintenance facilities	2	26	0 - 61, 26	Methylene chloride
	4	112	0 - 446, 112	Aviation lube oil
	12	59	0 - 74, 19	Contaminated fuel
			0 - 65, 24	Nickel cadmium batteries
			0 - 25, 6	Carbon remover
			0 - 41, 10	Corrosion preventative

Hazardous Wastes Generating Operations, Processes, or Conditions	Total Approximate Annual Generation Rate	Generator Ranking by Waste Volume Generated
Photographic and printing shops	822 lb/yr	5
Motor pools	1736 lb/yr	4
DEH shops	2661 lb/yr	2
DOL shops	14146 lb/yr	1
Hospitals, clinics, and labs	2340 lb/yr	3
Troop units	473 lb/yr	6
Naval security group	49 lb/yr	8
Aviation maintenance facilities	197 lb/yr	7

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* 1: spent cleaning solvents (nonhalogenated), 2: spent cleaning solvents (halogenated), 3: spent paint thinners, 4: used oils, 5: spent alcohols, 6: spent photographic processing and printing chemicals, 7: paint related materials (PRM), 8: spent acids or bases, 9: decontamination agents, 10: insecticides or herbicides, 11: pharmaceutical wastes, 12: miscellaneous wastes (small volume wastes)

Table A2

Total Waste Generation Rates Sorted by Waste Categories

Hazardous Wastes Categories		Photographic and Print Shops	Motor Pools	DEH Shops	DOL Shops	Hospitals, Clinics, and Laboratories	Troop Units	Naval Security Group	Aviation Maintenance Facilities
Number	Total								
1	1244	21	193	-	100	930	-	-	-
2	515	-	98	-	82	309	-	-	26
3	6529	-	-	909	5600	-	-	20	-
4	306	-	194	-	-	-	-	-	112
5	340	-	152	-	-	188	-	-	-
6	703	703	-	-	-	-	-	-	-
7	9317	-	-	1484	7804	-	-	29	-
8	1284	4	1070	29	74	107	-	-	-
9	530	-	-	4	-	70	456	-	-
10	178	-	-	178	-	-	-	-	-
11	346	-	-	-	-	346	-	-	-
12	1132	94	29	57	486	390	17	-	59
TOTAL	22424	822	1736	2661	14146	2340	473	49	197

APPENDIX B:

HAZMIN PROTOCOL AND SURVEY FORMS

HAZMIN Protocol

<u>Goals</u>

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.

<u>Approach</u>

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 <u>each waste stream</u>.

V. Identify minimization options for <u>each waste stream</u>.

VI. Evaluate and rate options (preliminary or first screen) for <u>each waste stream</u>.

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 on-site 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.

HAZMIN Protocol

V. Identify minimization options for each waste stream.

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

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

HAZMIN Protocol

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 and 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 (potassium 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

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

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			
Infectidious wastes			
Ordnance			
Fire-fighting foam		Fire fighting foam	
Miscellaneous (specify)		Miscellaneous (specify)	

APPENDIX C:

FORT MEADE - LIST OF TENANTS

Named Tenants

1. Armed Forces Courier Service; Building 144 (JM4401; W8033K)
2. Army Frequency Coordinator; Building 1978
3. CAP Liaison Office (USAF); Building 2034
4. Central Clearance Facility; Building 4552A, 4571, 8611
5. CID, HQ, 1st Region, USACIDC; Building 2835, 2812
6. Corps of Engineers - Bay Area Office; Building T2844
7. Corps of Engineers - NSA Area Office; Building 8902
8. Defense Investigative Service; Building 4406
9. Defense Reutilization & Marketing Office (DRMO); Building T6297 (SX1213)
10. Dental Activity; Building 2455
11. EPES Dental Clinic; Building 8472
12. DC #3 KAH; Building 2480
13. Field Support Activity: Entomology Sciency Division, Environmental Health Division; Building 4411 (W23SH1)
14. District of Columbia National Guard, Building 2825
15. Equipment Concentration Site, USAR (ECS); Building 2120A, B, C - Maintenance Branch, Support Branch, Supply Branch, E & C Shop, Small Arms Shop (W23HAP)
16. Field Band USA; Building 4700 (W23A57)
17. FORSCOM Manpower Standards Activity; Building T383 (W807Y0)
18. Fort Meade Commissary Office; Building 2786 (W23VKV)
19. Command Aviation Company (COMP); Building P80
20. HQ, Eastern Sector, Military Entrance Processing Command; Building 2845, 2837
21. HQ. CONUS MI GP; Building 9805, 9802 (W23A7P)

22. Intelligence Mat Act, USA Material Command (IMA); Building 4544, 2501: Electronics, Special Fabrication, Maintenance Branch, Supply & Services Branch (W23BFK)

23. Marine Support Battalion, Co A; Building 9804, 9803 (M54032)

24. Medical Laboratory, Dept of Pathology; Building 2490 (W23A7S)

25. Military Intelligence Detachment (CI) (SPT); Building 2842

26. National Security Agency (HNS004; H98230; H98236; H98237; H98241

27. Naval Security Group Activity (NSGA); Building 9803, 9804, 9805 (N62936)

28. Northeast Commissary Region (USATSA); Building 563, 2813, 2814

29. Northeast Region Recruiting Command; Building 582, 603, 605, 618

30. Personnel Support Detachment; Building 9805

31. Program Manager - Army Combat Identification Systems; Building 2424

32. Readiness Group Meade; Building 4553C

33. *SATCOM Station (USAISC); Building 9801*

34. Training Concepts Development Group; Building 6226

35. U.S. Army Claims Service (office of JAG); Building 4411 (W23NXN)

36. U.S. Army Pictorial Detachment; Building 606

37. U.S. Army Information Systems Command Fort Meade; Building 1978, 4554 (W23A7D)

38. Administrative Services Division; Building 4215A

39. U.S. Army Institute of Dental Research (USAIDR); Building 2832, 2801, 2804, 2805, 2810, 2811

40. U.S. Army Regional Support Activity; Building 2018

41. U.S. Army Recruiting Battalion Baltimore; Building 3179 (W23BDC)

42. U.S. Army TMDE Support Operation (AMC)-(TSO); Building 2220 (W80RD3)

Numbered Tenants

43. 5th Infantry Platoon Pathfinder Airborne; Building 926, 939 (W23BCB)

44. 5th Weather Sq Detachment 2, OL-A; Building P81

45. 10th Combat Support Hospital; Building 6507 (W23A5W)

46. 10th Mobile Army Surgical Hospital; Building 8543
47. 11th Engineer Battalion, Company D; Building 8610, Building 8492: Motor Pool (W23A5T)
48. 11th Special Forces Group (Airborne); Building 938, 939 (W23R6E; W23R6G)
49. 11th Signal Company; Building 922 (W23R6D)
50. 31st Aviation Group HHD; ASF 85 (W81D33)
51. 31st Combat Aviation Group (W81EDE; W81EUY)
52. 60th Aviation Battalion; ASF 85 (W81D31; W81EDC; W81EUW)
53. 75th Medical Detachment Dispensary (W23KE2)
54. 82nd Chemical Detachment; Building 8605 (W23A6Q)
55. 85th Medical Battalion; Building 8542, 8543, 8545, Building 72: Motor Pool, Building T60F: Grounds Maintenance (W23BBV)
56. 97th Army Reserve Command; Building 1251 (W80TSM)
57. Avn Spt Facility (ASF 85); Building 85 (W81D31; W81D33)
58. 99th Army Security Agency Co. (C&P); Building 934, Building 2125: Motor Pool (W23A08)
59. 138th Medical Detachment Anesthesiology; Building 2040 (W23KL4)
60. 144th Ordnance Detachment; Building 6359 (W23A52)
61. 173rd FIN SEC DISB; Building 2240 (W23A6G)
62. 209th Military Police Company; Building 8479, Building 8487: Motor Pool (W23A6W)
63. 212th Medical Detachment General Dispensary; Building 2240 (W23KFE)
64. 249th Medical Detachment; Building 8541 (W23A6E)
65. 250th Medical Detachment Orthopedic; Building 2240 (W23A6E)
66. 252th Medical Detachment Thoracic; Building 2240 (W23KLY)
67. 293d Military Police Company; Building 8478, Building 8486: Motor Pool (W23A6X)
68. 299th Maintenance Detachment; Building T918 (W81C7T)
69. 327th Aviation Company; Building 90 (W80REB)
70. 342d Army Security Agency Company; Building 935, 936 (W23A17)
71. 356th Public Information Detachment; Building P1551 (W23RL3)

72. 362 MI Det (CRF); Building 913 (W80GU6)

73. 407th Personnel Services Company; Building 905 (W80GQU)

74. 416th Engineer Command; Building 4551

75. 426 Chemical Detachment; Building 926 (W23XLF)

76. 440th Medical Detachment; Building 8545, 6208 (W23RJC)

77. 451st Military Police Detachment; Building 979 (W23RL5)

78. 519th Military Police Battalion; Building 8476, 8477, 8478, 8479, 8487, 8544 (W23A6P)

79. 549th Ordnance Detachment (EODCC); Building 2231 (W23A54)

80. 630th Medical Detachment; Building 8541 (W23A6N)

81. 641st Military Intelligence Detachment; Building 2240 (W23LE3)

82. 702nd Medical Detachment; Building 8545, Building 71: Motor Pool (W23A6D)

83. 808th Chemical Detachment CBR STF SF, 11th SFG (W80GQC)

84. 818th Maintenance Company; Building T918: Maint. Shop (W80PLE; W80Y0H; W81C7U)

85. 860th Maintenance Detachment; Building T918 (W81C7W)

86. 902nd Military Intelligency Group, HQS; Building 4553, 4554, 8607, Building 4662: Motor Pool (W23ACZ)

87. 941st Maintenance Detachment; Building T918 (W81C7X)

88. 1006th General Supply Company; Building 579, 4201 (W81C7N)

89. 1100th Resource Management Group det 2; Building 9805

90. 1100th Training Evaluation Comm (RTU); Building 569

91. 6940th Electronic Security Wing (ESC); Building 9800, 9801, 9804, 9805, 9827 (FY1336; FY9166)

92. 6994th Electronic Security S (FX7025; FY1403)

93. 8830th USA OSUT BDE MP; Building 949, 978, 998 (W23RMT)

APPENDIX D:

EXAMPLE OF INSTALLATION ENVIRONMENTAL POLICY

MEMORANDUM FOR DISTRIBUTION

SUBJECT: <u>INSTALLATION ENVIRONMENTAL POLICY</u>[165]

1. Fort George G. Meade 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[166] (see enclosure), and must be adopted and implemented throughout the installation.

Encl Garrison Commander

DISTRIBUTION

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[165] *The EPA Manual for Waste Minimization Opportunity Assessments* (U.S. Environmental Protection Agency, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, 1988).

[166] *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

AEHA	U.S. Army Environmental Hygiene Agency
AFB	Air Force Base
AFFF	Aqueous Film Forming Foam
AMF	Aviation Maintenance Facilities
AOAP	Army Oil Analysis Program
AR	Army Regulation
ASTM	American Society of Testing and Materials
BOD	Biological oxygen demand
Btu	British thermal unit
CARC	Chemical agent resistant coating
CFR	Code of Federal Regulations
DEH	Directorate of Engineering and Housing
DERA	Defense Environmental Restoration Account
DESR	Defense Environmental Status Report
DLA	Defense Logistics Agency
DO	Dissolved oxygen
DOD	Department of Defense
DODAAC	Department of Defense Address Activity Code
DOHS	State of California, Department of Health Services
DOL	Directorate of Logistics
DOT	Department of Transportation
DPCA	Directorate of Personnel and Community Activities
DPP	Discounted Payback Period
DRMO	Defense Reutilization and Marketing Office
DRMS	Defense Reutilization and Marketing Service

EECO	Energy and Environmental Control Office
EOD	144th Ordnance Detachment
FLOCS	Fast Lube Oil Change System
FORSCOM	U.S. Army Forces Command
FUSA	First U.S. Army
FY	Fiscal Year
GSA	General Services Administration
HAZMIN	Hazardous Waste Minimization
HCL	Hospitals, Clinics, and Laboratories
HMTC	Hazardous Materials Technical Center
HQDA	Headquarters, Department of the Army
HSWA	Hazardous and Solid Waste Ammendments
HW	Hazardous Waste
IMA	Intelligence Materiel Activity
IMSS	Industrial Maintenance and Small Arms Shops
INSCOM	U.S. Army Intelligence and Security Command
JLC	Joint Logistics Commanders
KACH	Kimbrough Army Community Hospital
MC	Methylene Chloride
MEK	Methyl ethyl ketone
MPRSA	Marine Protection, Research, and Sanctuaries Act
MPVM	Motor Pools and Vehicle Maintenance Facilities
MSDS	Material Safety Data Sheet
MWSA	Medical Waste Sanctions Act of 1988
NICAD	Nickel cadmium
NIPER	National Institute for Petroleum and Energy Research
NPDES	National Pollution Discharge Elimination System

NPV	Net Present Value
NSA	National Security Agency
O&M	Operation and Maintenance
OB/OD	Open Burning/Open Detonation
PC	Perchloroethane
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PECI	Productivity Enhancing Capital Investment
PERC	Perchloroethylene
PMB	Plastic media blasting
POL	Petroleum, Oils, and Lubricants
PPAS	Photography, Printing, and Arts/Crafts Shop
PS	Paint Shops
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SIR	Savings to Investment Ratio
SQG	Small Quantity Generator
SS	Suspended solids
TASC	Training and Audiovisual Support Center
TCE	Trichloroethylene
TDS	Total dissolved solids
TM	Technical Manual
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
USACERL	U.S. Army Construction Engineering Research Laboratory
USAIDR	U.S. Army Institute of Dental Research
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

USE	Used Solvent Elimination
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
WRAMC	Walter Reed Army Medical Center
WWTP	Waste Water Treatment Plant

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DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LP (2)
ATTN: CEHEC-IM-LH (2)
ATTN: CERD-L

HQ FORSCOM (6)
ATTN: FCEN/CDE/E

Fort Belvoir, VA 22060
ATTN: CECC-R

TRADOC
ATTN: DEH

Commander, U.S. Army Environmental Hygiene Agency
ATTN: HSHB-ME-SH

HQ USATHAMA
Aberdeen Proving Ground, MD

Defense Technical Info. Center 22314
ATTN: DDA (2)