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Hazardous Waste Minimization Assessment: Fort Carson, CO

by
Seshasayi Dharmavaram
Douglas A. Knowlton
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 (HQ, FORSCOM), under an interagency reimburseable order IAO 3788, dated 25 July 1988. The FORSCOM technical monitor was Rudy Stine.

The work was done by the Environmental Engineering Team of the Environmental Division (EN), U.S Army Construction Engineering Research Laboratory (USACERL). Mr. Bernard Donahue is the Acting Team Leader and Mr. Walter Mikucki is the Team Leader. Dr. Edward W. Novak is the Acting Chief of EN Division. 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 Technical Director.

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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

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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 157.
[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.

by Army installations.[5] The DLA, through its Defense Reutilization and Marketing Offices (DRMOs) located in several regions, was responsible for disposal of most categories of hazardous waste generated by the installations. The installations do not have a separate funding account for waste disposal and 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 our 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 plan.

Objective

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

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[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.

[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 the U.S. Army Construction Engineering Research Laboratory (USACERL).

2. Conduct a survey of all possible waste generated at Fort Carson from 22 through 25 January 1989, 5 through 24 March 1989; and 27 August through 2 September 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 Carson, 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 Carson 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 Carson 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.

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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.

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.

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.

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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).

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], 1,1,1-trichloroethane) 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

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

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 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,

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

coagulation, decantation, encapsulation, filtration, flocculation, flotation, foaming, sedimentation, thickening, a. ' 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.

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 CERL was involved in. FORSCOM recognized the need for the development of a HAMZMIN program and did the initial planning and organization.

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

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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.

(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 Carson 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.

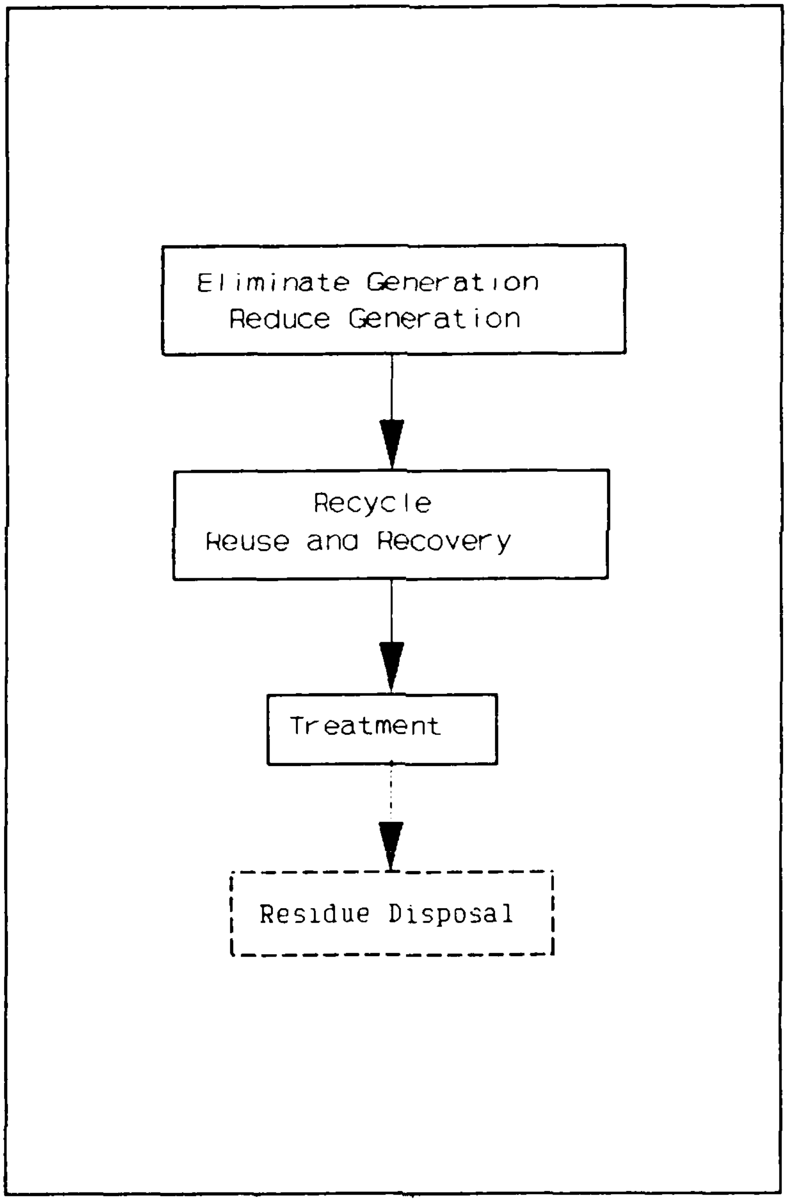

Figure 1. Waste minimization hierarchy.

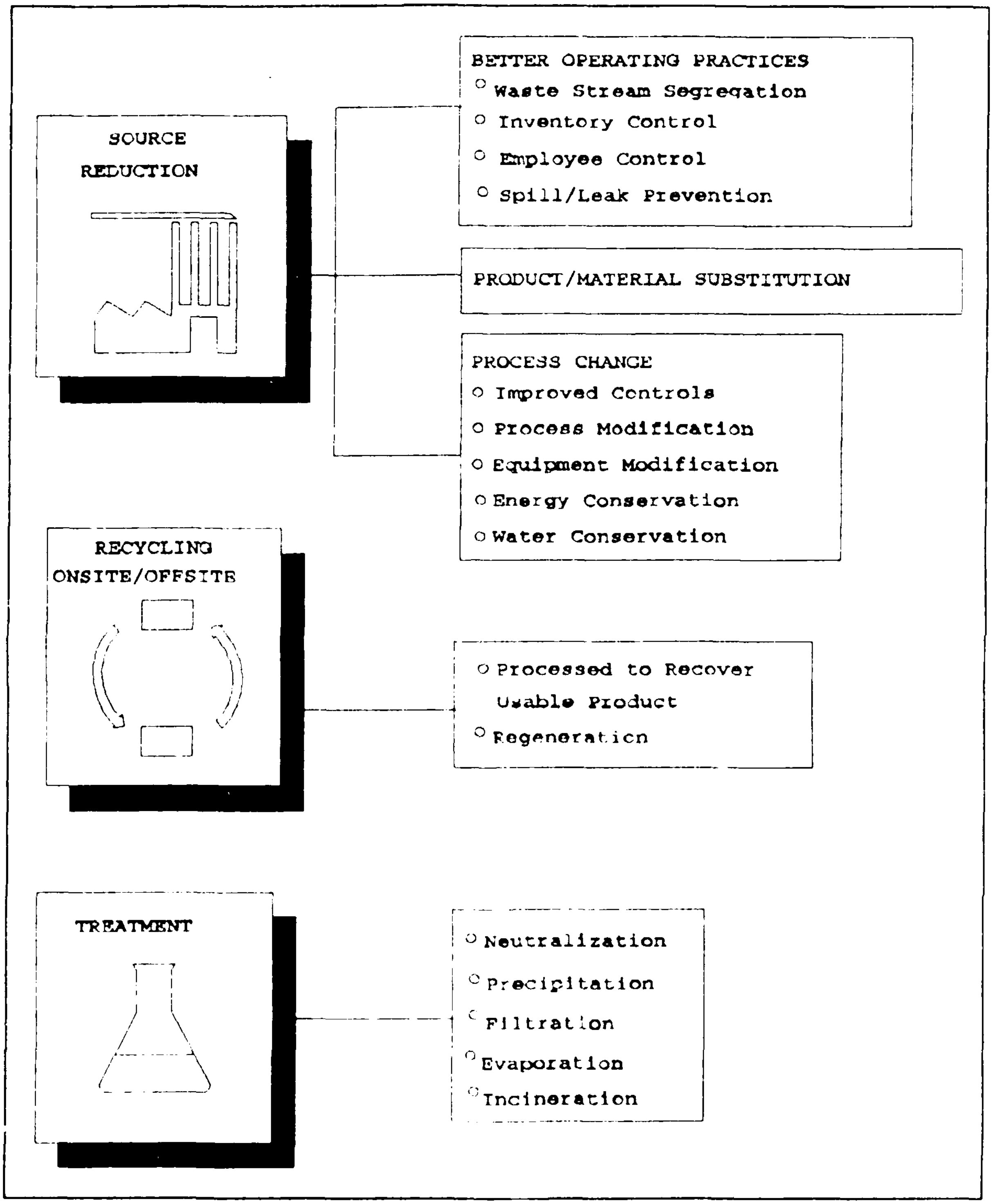

Figure 2. Waste minimization techniques.

Table 1

List of Waste Exchanges

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

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

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

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

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

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

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

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

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

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

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

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

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

Resource Recovery of America**
P.O. Box 75283
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(813) 248-9000

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

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

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

Wastelink, Division of Tenecon Associates*
P.O. Box 12
Cincinnati, OH 45174
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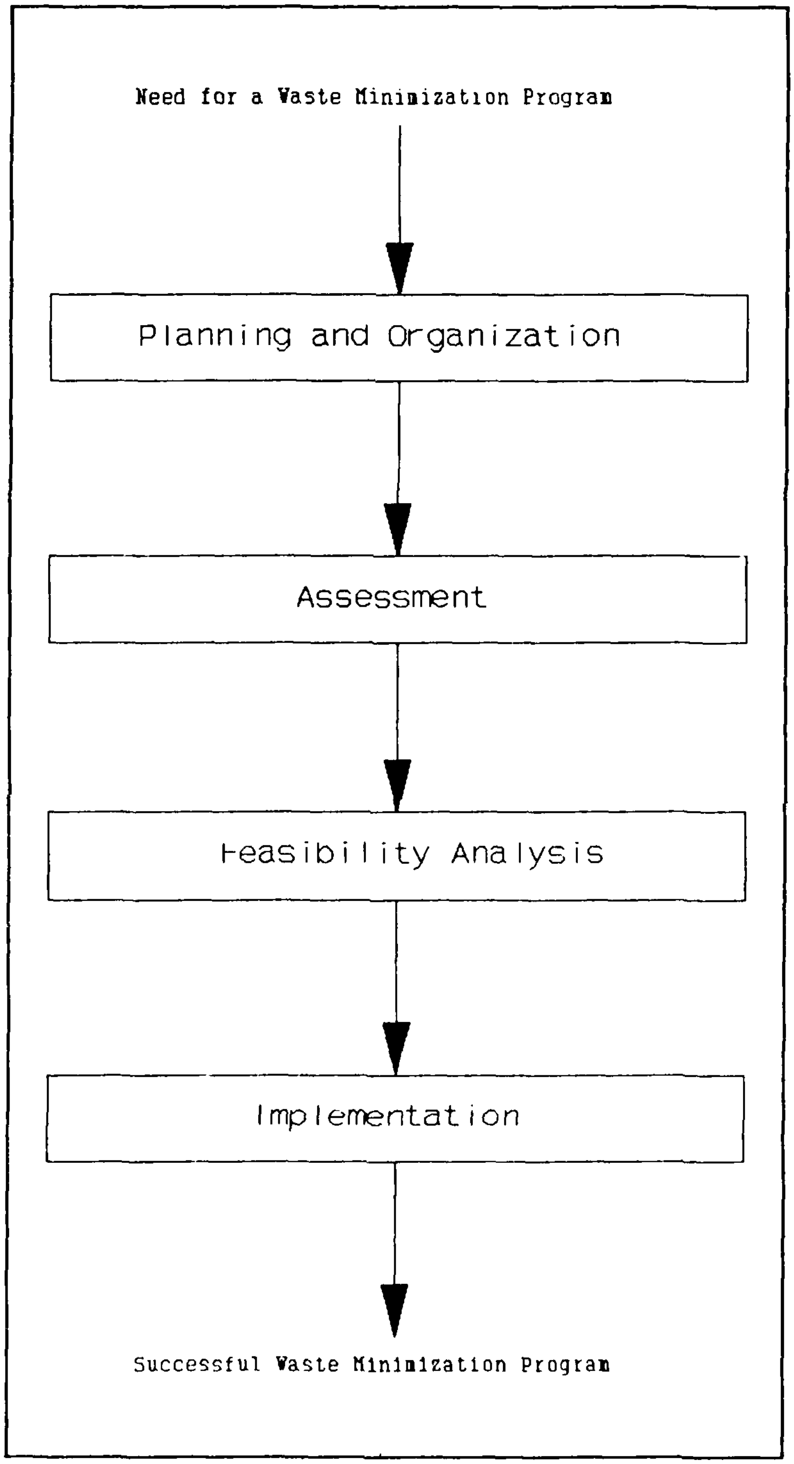

Figure 3. Hazardous waste minimization program development procedure.

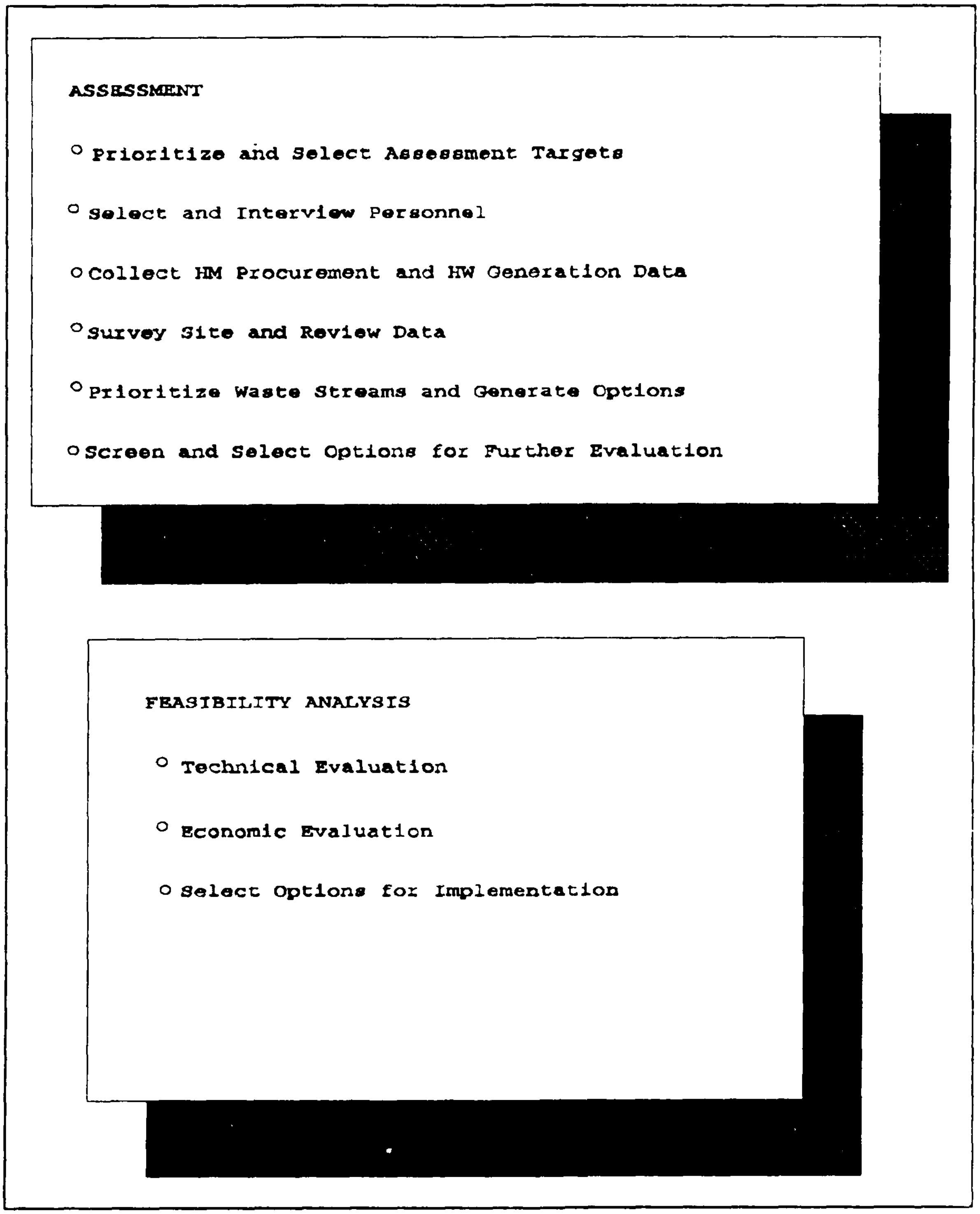

Figure 4. Hazardous waste minimization assessment and feasibility analysis procedure.

3 FORT CARSON

History/Geography

Fort Carson, named in honor of Brigadier General Christopher "Kit" Carson, a former frontiersman, is home of the 4th Infantry Division (Mechanized). It is located in eastern Colorado, near Colorado Springs, on rolling plains that border the Rocky Mountains. Military commanders and officials in Washington, DC, chose Colorado Springs as the site of an Army camp on January 6, 1942. The original camp consisted of 60,048 acres of land. Colorado Springs donated 5533 acres, 29,676 acres were purchased from private owners, and 262 acres were purchased from the Department of Interior. The State of Colorado leased 24,577 acres to the Army.

More land was deemed necessary to train a mechanized division. Therefore, an additional 78,741 acres of land was acquired south of the original reservation in 1965 and 1966 from private owners, the State of Colorado, the Colorado School of Mines, and the Department of Interior. With those additions, the total area amounted to the current size of 138,789 acres.

Because of the immediate need for a place to train soldiers, round-the-clock construction at Camp Carson began in early 1942. To avoid grading, the camp was built to conform to the shape of the land, thus providing it with a "banana" belt look. Facilities were built for 35,173 enlisted men, 1818 officers, and 592 nurses. A semipermanent hospital with space for 1726 beds, a prisoner of war internment camp, and barns to house horses and mules were also built.

During World War II (WW II), about 104,165 soldiers were trained at Camp Carson. Three infantry divisions (71st, 104th, and 10th Mountain) and more than 125 other units were activated. Additionally, more than 100 units were transferred from other installations to train at this mountain post. Use of mules in the Army stopped in 1956 and the associated Field Artillery Batallion (pack) was deactivated when helicopters arrived. The 10th Mountain Division was formed and trained at Camp Hale (20 miles west of Leadville, CO) to move weapons over mountainous terrain in any kind of weather. This division was deactivated in 1946 and a Mountain Cold Weather Training Detachment was created and then transferred to Fort Greeley, Alaska, in 1957. In 1965, the Army traded Camp Hale to acquire land on Fort Carson's southern border.

A prisoner of war internment camp was opened in 1943; approximately 9000 German, Italian, and Japanese prisoners of war were interned. These prisoners were repatriated following the end of the war.

The strength of the post after WW II dropped drastically, to only 600 personnel and 320 patients by April 4, 1946. Many units were deactivated and Camp Carson was ready for closure. However, with the advent of military activity in Korea, many reserve units were called for active duty. A Camp Carson Separation Center was established in 1951 to separate Korean Conflict veterans from the service; approximately 100,000 soldiers were processed there. Camp Carson became Fort Carson in 1954. The Cuban Missile Crisis and the Berlin Blockade lead to the activation of the 5th Infantry Division at Fort Carson.

During the Vietnam Conflict (1965 to 1968), approximately 29,000 soldiers in 61 units were trained at Fort Carson and transferred to Vietnam. By July 1967, the number of military personnel and civilians rose to 24,735 and 2445, respectively. Following the conflict, cutbacks were ordered and the number of military personnel dropped to 20,400 while civilian strength rose to 2860 and has remained relatively stable since 1973. The 4th Infantry Division was ordered to locate at Fort Carson in 1970.

In 1974, an additional 245,000 acres of land was acquired at Piñon Canyon, 100 miles southeast of Fort Carson. The Pinon Canyon Maneuver Site was opened for training in 1985. Each brigade of the 4th Infantry Division trains at Piñon Canyon before training at the National Training Center at Fort Irwin, CA. A number of permanent buildings (including the Evans U.S. Army Community Hospital) were constructed at Fort Carson to replace the WW II structures.

Since deployment of the 4th Infantry Division at Fort Carson, it was reorganized into its current form of a mechanized infantry division with the nickname "The Ironhorse Division." It has three maneuver brigades, a combat aviation brigade, four field artillery battalions, and many combat support and combat service support units. This "Ivy" division, as it is also known, has a long history of successful participation in several wars. It is a training division that is a combat-ready "fire brigade" ready to quell aggression wherever and whenever required.

Tenants

The tenants at Fort Carson that generate, handle, or dispose of hazardous materials/waste are:

1. U.S. Army Medical Department Activity (MEDDAC),

2. U.S. Army Dental Activity (DENTAC), and

3. Defense Reutilization and Marketing Office.

Other tenants also located at Fort Carson are: 902nd Military Intelligence (MI) group, Logistics Assistance Office (LAO), U.S. Army Criminal Investigation Command (USACIC), U.S. Army Legal Service Agency, Maintenance Assistance and Instruction Team (MAIT) No. 20, Air Force Air Weather Service Unit, U.S. Army Commissary, U.S. Army Calibration, U.S. Army Audit Agency, U.S. Army Reserve 3rd Battalion 87th Infantry, and Naval Reserve Center.

Environmental Programs

This section provides a description of the status of environmental quality as affected by the number of pollution sources at Fort Carson. The information has been extracted from an *Environmental Operations Review*[24] conducted by AEHA, other assessments,[25] discussion with the Environment, Energy, and Natural (EENR) Office personnel, and the survey conducted during the course of this study.

Air Pollution Control

Fort Carson is required to comply with Federal Clean Air Act Amendments of 1977 and Colorado Air Quality Control Act regulations. These regulations are enforced by the Air Pollution

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[24] *Environmental Operations Review - 4th Infantry Division (Mechanized) and Fort Carson, Colorado Springs, CO*, Study No. 37-26-1385-87, (U.S. Army Enviromental Hygiene Agency, August 1986).

[25] B.N. McMaster, J.D. Bonds, L.C. Carter, W.G. Fraser, J.B. Holly, E.A. Knauft, J.B. Sosebee, J.H. Wiese, and K.A. Civitarese, *Installation Assessment of the Headquarters, Fort Carson and 4th Infantry Division (Mechanized), Fort Carson, Colo., and its Subinstallations Headquarters, Fort Douglas and U.S. Army Support Detachment, Fort Douglas, Utah, and Headquarters, Fort Missoula, Fort Missoula, Mont.*, Report No. DRXTH-AS-IA-82330 (Prepared for the Commander, Headquarters, Fort Carson and 4th Infantry Divsion (Mechanized), Fort Carson, CO, and U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD, 1983); *Multimedia Inspection Nov. 30 - Dec. 7 1987; Fort Carson, Colorado; Final Inspection Report* (U.S. Environmental Protection Agency, Region VIII, Denver, Colorado, 1988).

Control Division (APCD) of the Colorado Department of Health and the El Paso County Health Department. Fort Carson and Piñon Canyon are located in the San Isabel Intrastate Air Quality Control Region (AQCR) (Colorado AQCR Nos. 4 and 7). AQCR 4, which encompasses most of Fort Carson, has been classified as "better than National Ambient Air Quality Standard (NAAQS)" for sulfur dioxide (SO_2), "cannot be classified or better than NAAQS" for ozone (O_3) and nitrogen oxide (NO_2), and "does not meet primary NAAQS" for carbon monoxide (CO), total suspended particulates (TSP), and particulate matter less than 10 microns (PM10). AQCR 7, which includes the southern portion of Fort Carson and Piñon Canyon has been classified as "better than NAAQS" for SO_2, TSP, and PM10; and "cannot be classified or better than NAAQS" for O_3, CO, and NO_2.

The EENR at Fort Carson maintains a listing of all the air pollution sources. Stationary sources of air pollution include: boilers/minor combustion sources, incinerators, open burning/open detonation (OB/OD), fuel storage/dispensing, painting, metal cleaning, and miscellaneous (woodworking, building demolition, training exercises, construction/land development projects, etc.) operations. In addition, there are a number of mobile sources (tactical and nontactical vehicles, aircraft, etc.) of emissions that are maintained in compliance through an inspection and maintenance program, a transportation control plan, and a smoking vehicle program.

A majority of Fort Carson's boilers/minor combustion sources, located throughout the post, are exempt from Colorado permitting requirements based on size and/or date of installation. They have all been in compliance with Colorado standards for visible emissions. The permits required have been obtained and updated for installation and modification of boilers in buildings 1860, 6290, 633, 635, and 636; the industrial wastewater treatment plant (IWTP) steam sludge heater; boilers at some of the vehicle and aircraft maintenance facilities; and several boilers at Piñon Canyon.

Only "specification used oil" is occasionally burned in one of the three natural gas/No. 6 fuel oil-fired, high temperature boilers at the Central High Temperature Hot Water Plant (Bldg 1860). The current air emissions permit for these boilers limits the quantities of fuel oil burned annually to 137,000 lb and the sulfur content of the backup fuel to 0.5 percent. The visible emissions must be limited to 0.5 percent. Burning of used or waste oil is not addressed in the permit (although the boiler may qualify as a utility boiler), and may be illegal.

Three stationary engine test cells located in the DOL industrial maintenance shop (Bldg 8000) are used to test engines from wheeled and tracked vehicles. Emissions of less than 5 tons/yr from these cells are exhausted to the atmosphere. Although exempt from permit requirements, filing of an APEN is probably required.

A new pathological incinerator (Consumat Model C-75P rated at 200 lb/hr) was purchased in 1986 to replace the old one (Shenandoah Model G-71/JTC) located in the veterinary clinic (Bldg 6000). Its operation is in compliance with the APCD regulations. In the past, solvents were illegally burned at a firefighter training pit at the Butts Army Air Field. That practice has been stopped and a RCRA (Part B) permit has been obtained for open burning/open detonation of ordnance at Ranges 1, 1A, 121, and 123. A permit is required for open burning of building structures at Piñon Canyon.

The vehicle paint booth in Bldg 8000 was modified in the mid-1980's to accommodate Chemical Agent Resistant Coating (CARC) painting operations. CARC paints contain hexamethylene diisocyanate (HDI) and a number of other methyl isocyanates that are moderately to highly toxic air pollutants. Two other paint booths are located in the autocraft shop (Bldg 2427) and a fourth one is located at the training aids fabrication center (Bldg 6054). The potential of toxic emissions exists from all these booths.

A number of large fuel storage tanks are located throughout Fort Carson. Most of them require permits. However, none of them are regulated as sources of volatile organic carbon (VOC) emissions. A major source of VOC emissions is the vapor degreaser, in Bldg 8000, which is exempt from permitting requirements based on the date of installation. Degreasers containing 1,1,1-trichloroethane are specifically exempt from Colorado VOC regulations since 1,1,1-trichloroethane is considered a "low toxicity air contaminant," and because Fort Carson is in an O_3 attainment area.

Woodworking operations (Bldg 2426 and 210) generate very small quantities of emissions and therefore do not require a permit. There are, however, a number of sources of fugitive dust (e.g., unpaved roads, coal piles, etc.) for which permits have been obtained and a particulate control plan has been developed.

Fort Carson has a number of WW II era buildings that have asbestos insulation. Friable asbestos is being removed or encapsulated in all the buildings that are in use or in the ones that are burned. A proper asbestos management plan has been developed and implemented.[26]

Emissions testing, instrumentation, and mechanic certification are commonly conducted at the Adjustment, Inspection, and Realignment stations. Vehicles built before 1968 and all emergency response vehicles are routinely tested for emissions. Emissions testing may also be required for privately owned vehicles in the future.

Fort Carson does not have an air pollution emergency episode plan. However, it has an excellent ambient air quality monitoring network for both the main post and Piñon Canyon which must be fully developed and maintained. A comprehensive review of all the sources of toxic emissions should also be conducted to comply with the forthcoming ammendments to the Clean Air Act and changes in the State of Colorado VOC and air pollution regulations.

Water Pollution Control

Fort Carson purchases water from the city of Colorado Springs. No contingency/emergency plan exists to cope with a possible shortage of potable water. Although the water distribution system dates back to the early 1940's, no significant problems have been noted. A regular monitoring, inspection, and maintenance program, however, is lacking. The back-flow prevention and cathodic protection systems must be inspected and maintained.

A sanitary wastewater treatment plant (WWTP) at Fort Carson, that was designed in the 1940's and slightly modified in the 1980's, has a capacity of 3 to 4 million gallons per day (MGD). In addition to the municipal wastewaters, the sewer system receives influent from the industrial wastewater treatment plant (IWTP) and from the laundry, photographic shop, painting shops, boiler plants, vehicle wash racks with oil/water separators, and other minor industrial sources. The capacity is exceeded every other day and flows of 6 to 7 MGD are generated at the head of the plant when there are major storms. An increase in waste load, cold weather over an extended period of time, and more stringent discharge standards may cause a noncompliance with the National Pollutant Discharge Elimination System (NPDES) permit.

An IWTP was designed in 1981 as an integral part of the centralized vehicle washrack and consisted of sedimentation, oil skimming, biological (aerobic) treatment, chemical addition, flocculation, and multimedia filtration. Because of problems with filtration system capacity, operation of the facility

[26] *Fort Carson Asbestos Control Program - Asbestos Management Plan*, Draft Report (Directorate of Engineering and Housing, Fort Carson, Colorado Springs, CO, 16 February 1989).

was halted. A system redesign has not yet been completed. In the meantime, wastewater from the collection system (lift stations and gravity flow sewers) and the "birdbaths" flows into an equalization pond and is then pumped to the two surface aerated biological ponds. The overflow bypasses the remaining IWTP and flows into the WWTP.

Both the Spill Prevention Control and Countermeasures Plan (SPCCP) and the Installation Spill Contingency Plan (ISCP) are currently being updated.

Solid Waste Management

Fort Carson has more than 600 dumpsters located throughout the post for collection of solid waste. A contractor collects the trash from all the dumpsters and transports it to a landfill onpost. No waste is transported offpost. The major generators are the mess and dining facilities, and the commissary; followed by the billeting and family housing areas. The dumpsters are not washed regularly.

Only one landfill (260 acres) is currently active and being operated by General Electric (GE) contractor personnel. It has been in operation since 1978 and is regulated by the Colorado Department of Health and the El Paso County Health Department according to the Colorado Solid Waste Regulations. The landfill has 5 water quality monitoring wells to record the depth and condition of the groundwater around the landfill. Groundwater is monitored for leaching of pollutants.

Although a standing operating procedure (SOP) exists and the landfill is inspected monthly by EENR personnel, several violations have been noted in previous studies. Access to the landfill is not limited and illegal dumping is prevalent. A barrier must be built to secure the facility.

A grit/oil pit is located in a 1/2-acre lagoon near the active landfill. This pit contains grit from the installation's oil/water separators and grit interceptors. In the Environmental Operations Review (EOR) study,[27] a number of other wastes such as aerosol cans, empty drums, and typical vehicle maintenance wastes were also observed in the pit. Presence of HW (e.g., solvents) in the pit makes it an illegal HW disposal facility and Fort Carson is most probably in violation of HW regulations. Additionally, the site has a very high potential for groundwater contamination.

The inactive landfills (No. 2, 5, and 6) are also potential sources of groundwater contamination. Monitoring of groundwater beneath these landfills is also necessary. AEHA conducted a hydrogeologic investigation of these sites in 1988 and recommended expansion of the existing landfill (No. 1) by 114 acres. Some of the corrective actions required for the other landfills include: improving the landfill cover, revegetation of the surfaces, and cleanup of groundwater when required.

A solid waste recycling program has been developed and is successful in segregating paper products, brass, and other metallic products. Aluminum is not recycled.

Hazardous Materials and Waste Management

The USEPA has authorized the State of Colorado to operate its own HW management program. Therefore, HW generators such as Fort Carson are regulated by Colorado HW regulations 5 CCR, parts 2, 99, 100, and 260 through 267,[28] which are very similar to Federal HW regulations.[29] Fort Carson

[27] *Environmental Operations Review.*
[28] *Title 5, Code of Colorado Regulations (CCR),* Parts 2, 99, 100, 260-267, 1985.

is classified as a "generator," and as owner and operator of a HW Treatment, Storage, or Disposal Facility (TSDF).

A HW storage facility (Building 9248) is currently authorized to operate under interim status regulations, awaiting approval of a Part B permit. It was originally an ammunition storage bunker that has been refurbished to accommodate different types of wastes (ignitable, corrosive, reactive, toxic, etc.). The facility is in compliance with all the general facility standards and specific requirements for the use and management of containers.

At one time, there were 4 OB/OD sites (Ranges 1, 1A, 121, and 123) used for burning and detonation of small arms ammunition and other reactive wastes. An application has been made to include Ranges 1 and 121 on the Fort Carson's Part A HW TSDF permit to maintain compliance with specific standards for thermal treatment facilities. The other two ranges have been closed. AEHA has conducted a detailed study[30] of the OB/OD ranges and made detailed recommendations for proper operation and compliance with regulatory requirements.

Use of the grit/oil pit, next to Landfill 1, for disposal of the wastes from the oil-water separators is not a good practice. It is also used for illegal dumping by some of the troop units. When tested in 1987, the waste was found to be nonhazardous. The disposal practice continues, while awaiting the construction of a drying bed. The construction was requested in 1987 and has yet to begin.

The open burning of solvents and oils mixed with contaminated fuel at the Butts Army Airfield's Fire Training Pit used to be commonplace. Such a practice would constitute illegal hazardous waste treatment. However, only contaminated fuel is used for fire training and it is constantly monitored for halogen content.

The Commander has the overall responsibility for proper maintenance and operation of the HW management program and is the "owner" of the above TSDF. DRMO, an installation tenant, operates the HW storage facility. The EENR office is assigned the responsibility of maintaining the HW management program and, therefore, shares some of the responsibility for proper operation of the storage facility.

Fort Carson is in complete compliance with generator requirements such as obtaining an EPA identification number (#CO 2210020150); establishing a sampling and analysis program; providing for accummulation, packaging, labeling, and marking; placarding of vehicles used for transportation; submission of annual reports and exception reports; and recordkeeping.

Fort Carson has a good HW management program. An HW inventory was developed in accordance with Army Regulation (AR) 420-47; however, it is not comprehensive and should be updated. A training program was established, in 1988 by EENR to train personnel from each unit. It concentrates on petroleum, oils, and lubricants (POL) management and should be updated to include proper HW management (including packaging, labeling, storage, transport, etc.) and minimization. An HW management plan was written in early 1980 and revised in 1984. It includes forming a hazardous waste management board (HWMB) from the original Environmental Quality Control Committee that used to discuss all forms of environment protection. It also identifies all individual generators, and

[29] *Title 40, Code of Federal Regulations (CFR)*, Parts 260-266, 270-271, 1985; 40 CFR, Part 761, 1986; 49 CFR, Part 171-173, 178-179, 1985.

[30] *Investigation of Soil Contamination at the Open-Burning/Open-Detonation Grounds*, Hazardous Waste Study No. 37-26-0552-86 (U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Maryland, 1986).

provides guidance for handling, management, and proper disposal of HW. A contractor is revising the plan.

Fort Carson needs to establish a detailed inventory of wastes generated by all the units (including generation rates) and a tracking program for all the major HWs. The management of hazardous materials (HM) always has a direct impact on generation and management of HWs. A proper HM management program should be established. This program should include flagging of incoming materials, tracking of materials to their users, proper inventory of materials used, and their use rates. HMs must not be stored in unlabeled drums, and unused materials must be turned in for resale or disposal.

A number of underground storage tanks (USTs) are located throughout Fort Carson. All of them have been located. USEPA has been notified. A program of leak testing and remediation of leaking underground storage tanks is currently underway.

Some of the specific HWs and their management practices at the unit level will be discussed below. Additional discussion of wastes generated and materials used at Fort Carson is in Chapter 4. Used oil, unserviceable lead-acid batteries/battery acid, painting wastes, oil analysis wastes, vehicle radiator cleaning wastes, engine coolant, and PCB transformers/oils are the major wastes at Fort Carson.

Used/Waste Oil. Used oil is generated in a large quantity by all the vehicle and aircraft maintenance activities. Fort Carson has a used oil treatment (energy recovery) program. A contractor collects the used oil from all the above ground and underground storage tanks and transports it to a tank farm located near Building 1860 where it is burned in one of the boilers. Only "specification" used oil can be burned in the boiler.

A major problem with the used oil at Fort Carson is that it becomes a HW because of poor management practices. Used solvents and other HW are mixed with the used oil at many of the activities. This practice creates large quantities of "hazardous" waste oil. Proper segregation of the wastes can alleviate this problem. Because there are stringent regulatory requirements concerning types of boilers, generators, and burners of HW fuel, proper testing is required before burning. A monitoring program, using colorimetric CLOR-D-TECT[31] kits, has been established to test used oil for chlorinated solvents. Used oil that tests positive for halogenated contamination with the use of CLOR-D-TECT kits are sent to a private laboratory for complete analysis of flashpoint, halogens, heavy metals, and sulfur content. Complete laboratory analyses are also performed prior to the transfer of used oil from oil-water separators at Building 1399 to 40,000 gallon storage tanks at Building 1860.

Segregation and proper management of used oil definitely reduces the quantity of hazardous waste generated. It can result in a major savings in disposal costs and would result in used oil suitable for offsite recycling, sale, or disposal to oil recyclers/rerefiners or any other commercial TSDF.

Lead-Acid Batteries/Electrolyte. Vehicle maintenance activities generate a large number of unserviceable lead-acid batteries. At one time, there were three battery neutralization shops (Bldgs 8000, 8030, and 8142) at Fort Carson. Currently, all batteries are drained and the acid neutralized at the DOL Battery Shop (Bldg 8000). The neutralized acid is released into the industrial waste treatment system; the drained batteries are strapped to wooden pallets and turned in to DRMO. The battery casings are sent to the Department of Energy, Idaho Falls, ID, office for recycling.

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[31] CLOR-D-TECT is a trade mark 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.

A number of operational problems were discovered at the shops; some have yet to be corrected. In Bldg 8000, the air exchange rate in the battery charging area has been increased and the pH meter repaired. However, the battery shop in Bldg 8030 (belonging to 204th Maint. Bn.) has been shut down with work orders pending for repairs. It is currently only a turn-in point. The battery shop in Bldg 8142, which is part of 183rd Maint. Co., was shut down because of plumbing problems with the neutralization sump, poor air exchange rate, and other ventilation problems. While a work order for repairs is pending, the electrolyte is drained and collected in 55-gal drums and transported to Bldg 8000 for neutralization. Once the repairs are completed, neutralization might resume at the two shops.

The acid is likely to be EP toxic for lead (which must be verified by testing). Therefore, the practice of neutralization and draining into the sewer may be illegal. This practice should be stopped and a proper treatment permit obtained before continuing to neutralize. The sump sediment (consisting of gravel and sludge) must also be tested frequently.

According to Federal and State Regulations, used lead-acid batteries (wet or dry) which are reclaimed are exempt from classification as a HW and, therefore, from requirements for storage, manifesting, and notification. Fort Carson does not have to include the weight of batteries in HW generation rate calculations. Not draining the batteries is the best alternative to current practice which generates a corrosive waste.

Painting Wastes. Two large painting booths in the DOL Consolidated Maintenance Building (Bldg 8000) are used for vehicle painting operations. Smaller paint booths are located in two other buildings, and small-scale painting operations are conducted throughout Fort Carson. Spent paint thinners, paint-contaminated coveralls, empty paint cans, partially full cans of paint, paint booth filters, and grinding residue from paint removal wastes are accumulated and turned in to DRMO for disposal as HW. Empty paint cans and grinding residue with dried paint can be treated as a solid waste and disposed of in the Fort Carson landfill. The filters must be turned in to DRMO if they contain heavy-metal-based paint particles. If not, they can also be treated as solid waste.

Hand sanding and grinding operations are commonly conducted in Bldg 8000. Large quantities of sanding/grinding residue accumulate on the walls and other surfaces. This residue is collected and disposed of as solid waste. Occasionally, it is tested to determine the heavy metal content. The recent installation of a new centralized sand-vacuum system, and the eventual installation of a grind-vacuum system, will alleviate the waste generation problem, reduce air pollution, and hasten the residue collection/disposal.

Oil Analysis Wastes. An oil analysis laboratory in Bldg 8000 is operated by a contractor for analysis of used engine oil under the Army Oil Analysis Program (AOAP). A single mixed waste stream, consisting of heptane, 2,2-butyliminodiethanol, isopropanol, 1,1,1-trichloroethane, and oil was continuously generated in the laboratory. This mixture was then poured into the large underground storage tank containing used oil from other vehicle maintenance operations in Bldg 8000 creating "hazardous" waste oil. Further mixing of this oil with the rest of the installation's used oil generated very large quantities of waste oil which had to be disposed of at a very high price. Segregating the oil analysis wastes into: (1) unused oil samples - which can be mixed with other used oil; (2) oil mixed with heptane, 2,2-butyliminodiethanol - that may be "hazardous" because of ignitability; and (3) oil mixed with 1,1,1-trichloroethane - a listed (F001) HW; is a key to minimizing the amount of waste oil generated.

Radiator Cleaning Wastes. A large hot caustic wash tank for cleaning radiators is located in the DOL Radiator Repair Shop (Bldg 8000). A solution of sodium hydroxide and water is used. This solution is periodically discharged into the sewer system. A testing and monitoring program must be established to comply with regulations. The wastewater could be corrosive and EP toxic for heavy metals. If EP toxic, it has to be handled as a HW.

A second tank in Bldg 250 belongs to the DPCA's Auto Crafts shop but has never been used.

Used Engine Coolant. The vehicle maintenance activities generate large quantities of used engine coolant. This antifreeze solution (50 percent mixture of ethylene glycol and water) is not a hazardous waste. It could be, and some of it is, discharged into the sewer. However, it is a good practice to collect it and recycle it onsite or through an offsite recycling contractor because of the increase in price ($4 to $8/gal) of new antifreeze.

PCB Management: GE's Exterior Electric Shop has compiled a comprehensive inventory of PCB transformers on Fort Carson. Included in the inventory are PCB concentrations for all the transformers in service. PCB transformers (> 50 parts per billion [ppb] and < 60,000 parts per million [ppm] of PCB) are inspected at least once a year and allowed to continue in operation till they fail. When they cannot be used anymore, they are disposed of as a HW. The oil is drained out of the out-of-service non-PCB transformers and the metal sold as scrap.

A rudimentary HAZMIN program has been started as part of the Used Solvent Elimination (USE) program at Fort Carson. A closed-loop contract recycling service (Safety-Kleen) is used to supply cleaning solvent (petroleum naptha) to most of the vehicle maintenance facilities. However, a hazardous (ignitable) solvent (flash point 105 °F) is being used. It should be replaced with a less hazardous solvent (flash point > 140 °F). The following HAZMIN elements were identified in the 1986 EOR:[32] (1) comprehensive HW inventory; (2) accurate HW identification; (3) segregation of HW and nonhazardous waste; (4) USE and HAZMIN program interface; (5) substitution of nonhazardous materials for hazardous materials; (6) inventory control of hazardous materials purchased; and (7) onsite treatment only under the elementary neutralization permitting[33] exclusion.

The above AEHA recommendations are further emphasized throughout this report. Other recommendations are made in Chapter 13 and in the HAZMIN plan (Appendix A).

Pesticide/Pest Management

Fort Carson has a good comprehensive pest management program and a plan for pesticide management has been prepared. Additional details and recommendations are available in the EOR.

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[32] *Environmental Operations Review.*
[33] 40 CFR 260, *Hazardous Waste Management System: General*, 1985.

4 SOURCES OF WASTE GENERATION AND TYPES OF WASTES

FORSCOM Installations

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 hazardous waste generated at 22 installations.[34] Fort Carson generated 41, 32, and 31 tons in 1985, 1986 and 1987, respectively, as reported in the survey and in their annual *Defense Environmental Status Reports*. These are wastes that were turned in to the DRMO for proper disposal; the numbers do not reflect quantities of: waste oil that is being recycled for heat recovery; acid drained and neutralized from lead-acid batteries; burning of gasoline, aviation fuel, at the fire training area; contaminated water treated at the wastewater treatment plant; hazardous air emissions; etc.

Table 2 does not show the actual quantities of wastes generated at Fort Carson. The data presented in this chapter were obtained from a survey of the various generators, offsite shipping manifests, and IDMS[35] data. An analysis of the data indicates that the average waste (including hazardous and nonhazardous) generation rate is 3,233,467 lb/yr (1621 tons/yr) not including PCB-contaminated equipment. Almost half of it consists of lead-acid battery casings, medical infectious waste, and boiler blowdown. Only 441 metric tons/yr of hazardous or "potentially" hazardous wastes are generated.

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

Three different criteria were used to determine the ranking of the different types of sources. The first is the number of such sources on an installation, which can vary depending on the 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.

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[34] V.J. Ciccone & Associates, Inc., p C-4.

[35] IDMS Database, Defense Reutilization and Marketing Service, Defense Logistics Agency, Battle Creek, Michigan.

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 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 Carson has a number of motor pools and vehicle maintenance (MVPM) 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 are: 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). For comparison, some of the hazardous and nonhazardous materials used that lead to the generation of wastes are listed in Table 6. The blanks in these tables (and similar tables throughout this report) do not represent zero generation, but rather that the data was not available.

MPVM #9 [2nd Battalion 77th Armor (HHC, A, B, C, and D Companies), Bldg 2492] is the largest volume generator of the MPVMs on Fort Carson. Ninety two-track and 78 wheeled vehicles are repaired and maintained there. It has 5 Safety Kleen solvent tanks and generates 100,800 lb/yr of used oil, which accounts for 73 percent of its wastes. This amount is 16 percent of the total used oil (635,507 lb/yr) generated throughout the fort. MPVMs #12 and #13 [5th Bn 29th Field Artillery (HHB, A, B, C, and Service Batteries), Bldg 1682 and 1368; and 3rd Bn 29 Field Artillery (HB, A, B, C, and Service Batteries), Bldg 1392] are attached to Division Artillery (DIVARTY). They are the second and third largest generators, respectively. Antifreeze solution is generated in the largest quantities (73,920 lb/yr or 63 percent) and (68,640 lb/yr or 59 percent), respectively, followed by other wastes. They have 3 and 5 solvent tanks each. Approximately 200 vehicles (70 tracked and 130 wheeled) are serviced at MPVM #12. Four waste and 1 POL storage areas are located at the MPVM. Some operational problems concerning recycling and oil segregation have been reported. Used lead-acid batteries are directly exchanged for new ones at this and most other MPVMs. MPVM #5 [2nd Bn 8th Inf (HC, A, B, C, D, and E Companies), Bldg 1982] is the fourth largest generator that also has 5 solvent tanks. Used oil accounts for 49 percent (49,000 lb/yr), lead-acid batteries, 15 percent (15,000 lb/yr), and sorbent wastes, 13 percent (13,000 lb/yr) of the wastes.

MPVM #26 [4th Engineering Bn (HC, A, B, C, D, and E Companies), Bldg 9072] is ranked fifth among MPVMs. It has 4 solvent tanks. Approximately 43 percent (41,250 lb/yr) and 33 percent (31,500 lb/yr) of its wastes consist of batteries and used oil, respectively. The 204th and 704th Support Bns (both direct support Command [DISCOM] units) are the direct support units for MPVM #26. Many engineering and construction vehicles (e.g., combat engineering vehicle, armored vehicle launcher bridge, etc.) are maintained here. There are two 800-gal underground storage tanks, located outside the maintenance bays, for storage of waste oil. Small scale painting activities (brush painting) are also conducted at this MPVM. CARC and architectural paints are used. No significant wastes are generated from the painting activities.

MPVM #6 [4th Bn 68th Armor (HHC, A, B, C, and D Companies), Bldg 1882] is the sixth largest generator. It has 5 solvent tanks and generates 25,200 lb/yr (33 percent) of used oil, 18,000 lb/yr (23 percent) of batteries, and 10,560 lb/yr (14 percent) of caustic wash. It is one of the newer motor pools where 100 tracked and 60 wheeled vehicles are maintained. Many different types of chemical coatings are applied on vehicles.

MPVMs #5 and #6 are attached to the 2nd Brigade. The 2nd Brigade was deactivated on December 31, 1989, but the facilities could be used by other units.

With used oil and batteries generation rates of 42,000 lb/yr (57 percent) and 18,750 (25 percent), MPVM #3 [3rd Bn 68th Armor (HC, A, B, C, and D companies), Bldg 3092] is the seventh largest generator. Oil is stored in two above ground pods of 600-gal capacity each. Eighty tracked and 100 wheeled vehicles are maintained here. MPVMs #24 [52nd Engineering Bn (HSC, A, and B Companies), Bldg 3292], #1 [1st Bn 10th Inf (HC, A, B, C, D, and E Companies), Bldg 2992], and #2 [1st Bn 12th Inf, Bldg 2792] are ranked eighth, ninth, and tenth, respectively. Used oil is generated at a rate of 42,000 lb/yr (67 percent), 48,650 lb/yr (81 percent), and 14,000 lb/yr (25 percent), at the three MPVMs. MPVM #24 has 4 solvent tanks that are used for cleaning parts. MPVM #1 repairs and maintains 113 tracked and 60 wheeled vehicles and has 5 solvent tanks. If a part does not fit into the tank, it is cleaned on the ground with MOGAS. The MPVMs have had a number of waste disposal problems including: intercompany theft of drip pans; lack of space for 55-gal barrels and full pods; nonavailablility of funnels for waste oil barrels; spill and slop; and no connection to an oil-water separator. About 37,268 lb/yr of antifreeze is used at MPVM #1. MPVM #2 also has 5 solvent tanks and 2 oil pods with locking oil/water separator. In addition to used oil, MPVM #2 also generates large amounts of antifreeze (17,600 lb/yr), and sorbent (10,000 lb/yr).

Ten other MPVMs (#28, #10, #20, #7, #19, #46, #47, #23, #31, and #11) generate between 35,000 and 55,000 lb/yr. Six MPVMs (#22, #32, #17, #14, #30, and #4) generate between 10,000 and 35,000 lb/yr. The remaining 18 MPVMs (#44, #8, #18, #38, #27, #41, #16, #15, #43, #45, #37, #21, #33, #40, #34, #36, #29, #35, and #39) generate less than 10,000 lb/yr.

MPVM #19 [64th Support Bn (HHC, A, and C Companies), Bldg T-1001] is under the command of the Division Support Command (DISCOM), and generates approximately 40,802 lb/yr. Fifty-eight wheeled and 3 tracked (M113 Armored) vehicles are maintained.

MPVM #46 is the maintenance section (number 1) in the DOL consolidated maintenance building (Bldg 8000). Combat (e.g., M60, M88, M113, M578, vehicles) and engineering construction equipment (e.g., bulldozers, cranes, forklifts, graders, etc.) are repaired and maintained here.

MPVM #23 (183rd Maintenance Company, Bldg 8142) is under the command of the 43rd Support Group. It has 4 solvent tanks and generates 35,647 lb/yr of wastes. This MPVM is a division direct support unit that houses a number of activities including: fuel/electrical repair, battery service/recovery, communication/electrical repair, engineering equipment repair, vehicle maintenance (organizational support), small arms cleaning, and supply warehouse. The battery service and repair shop is no longer functional because of its small size and poor ventilation. Battery acid used to be neutralized in a sump that was not connected to the sanitary sewer system. Repairs are underway to remedy the problem before resuming the neutralization practice. Currently, battery acid is drained and collected in 55-gal drums that are transported to the DOL consolidated maintenance facility (Bldg 8000) where the acid is neutralized.

MPVM #22 (DPCA Auto Skills Shop, Bldg 2427) is a relatively new MPVM that became operational in 1986. Although it has modern equipment, very little of it is used and only a small quantity of waste is generated. This MPVM is used by all the military and some civilian employees for maintenance of their privately owned vehicles (POVs). Some of the available equipment, such as hot caustic tank, radiator leak testing tank, etc., have never been used since installation. A discussion of the painting activities is in the *Paint Shops* section.

MPVM #4 is the Headquarters Company motor pool and MPVM #7 is attached to the 2nd Brigade. After deactivation of the 2nd Brigade, on December 31, 1989, the motor pool could be used by some other unit.

No information, other than the number of solvent recycling machines used, was available from MPVMs #8 [1st Bn 8th Inf, Bldg 2392] attached to 3rd Brigade, #21 [68th Transportation Bn, Bldg 8152] under the command of 43rd Support Group, #25 [19th MP Bn, Bldg 2840], attached to the 4th Inf Div HQ Command, and #27 [4th Bn 61st Air Defense Artillery, Bldg 639] attached to the 4th Inf Div Command.

Of the total wastes (1,546,200 lb/yr) generated, used oil is the largest volume (635,507 lb/yr), followed by antifreeze solution (247,501 lb/yr), lead-acid batteries (201,850 lb/yr), spent solvent (managed through Safety Kleen, 190,103 lb/yr), spent sorbent (120,680 lb/yr), and others (150,559 lb/yr).

Industrial Maintenance, Small Arms Shops (IMSS)

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

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 8 shows a list of wastes that may be generated from the industrial shops.

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

All of the IMSS listed in Table 7 are located in the DOL Consolidated Maintenance Building (Bldg 8000), which has five sections. IMSS #6 [Battery Service and Repair Shop], operated by C Company of the 704th Maintenance Bn (which is under the command of the 64th Support Group), is located in Section III of the building. It is the largest waste generator; 300,000 lb/yr of lead casings and 90,000 lb/yr of battery acid. Almost all the used lead-acid batteries generated at Fort Carson are brought to IMSS #6 for draining. Some of the battery acid from DISCOM units is brought here in 55-gal drums. All the batteries (open- and closed-cell) are drained. Puncturing closed-cell batteries with a hammer prevents the recycler/distributor, at the supply warehouse, from reissuing batteries to the units.

A sump is located in IMSS #6 for neutralization of the spent acid. The batteries are drained on the floor. The acid flows into the floor drains which are connected to the sump. All the cells are rinsed with distilled water which also flows into the sump. Sodium bicarbonate (purchased in 100-lb bags) is thrown into the sump untill the liquid stops effervescing. The neutralized liquid from the sump is flushed into the industrial sewer system. Approximately 200 lb of sodium bicarbonate are required to neutralize acid from 16 batteries in about 30 minutes. A recently repaired electronic pH probe connected to the sump effluent will sound an alarm when the pH drops below 6. The drained batteries are accumulated, strapped on pallets, and sent to DRMO for recycling. The spent acid (which may be EP toxic) and the neutralized water are not tested for heavy metals.

IMSS #1 (Tactical and Heavy Equipment Repair, and Steam Rack, Section II), is operated by personnel from the DOL's Maintenance Operations Branch (MOB). Approximately 92,328 lb/yr of wastes are generated. Contaminated fuel comprises almost half (46 percent) of the total wastes, followed by used oil (21 percent), spent solvent (14 percent), antifreeze (6 percent), and others (13 percent). IMSS #2 (Unit Overhaul, Fuel and Electrical Systems Repair, and Special Support, Section III) is also operated by MOB personnel. This IMSS is a large industrial-type operation consisting of a vapor degreaser, engine dynamo testing facility, etc. Used oil is the largest quantity waste, followed by spent cold-cleaning solvent, antifreeze, and spent TCA and TCA degreaser sludge. Table 9 shows that nearly 30,000 lb/year of TCA is used in the degreasing operations. Approximately 22,000 lb/yr is lost because of its volatility and poor operating practices. The degreaser (manufactured by DETREX Corp) is a large machine used to clean oversized (e.g., large engine blocks, barrels, turrets, etc.) and small parts. It was installed in late 1970's; because of its age, it is exempt from State of Colorado regulations for volatile organic carbon emissions. Three people, wearing respirators and other safety equipment, are required to clean the machine and replace the solvent, which is done for 2 days every 3 months.

Large quantities of other wastes, such as used oil (42,000 lb/yr), cleaning solvent (13,351 lb/yr), and antifreeze solution (11,440 lb/yr), are generated at IMSS #2. Several "hot tanks" are used to contain used oil generated throughout Bldg 8000. In the past, chlorinated motor oil and other solvent wastes were also mixed in this tank.

The next largest waste generator is IMSS #5 (Army Oil Analysis Program Laboratory) which is operated by a private contractor (Trowell, Inc.). An unknown amount of TCA and other halogenated solvents are used in chemical analysis of the used oil samples. A large quantity of used oil (12,580 lb/yr) and some chlorinated oil (1,600 lb/yr) is generated. In the past, all the oil and solvents were mixed to form a hazardous waste. Now the three types of wastes are segregated. IMSS #4 (Radiator Service and Machine Shop, Section V) has a hot caustic tank (257 gal) and a leak testing tank (350 gal) for cleaning and repair of radiators. The hot tank contains full strength sodium hydroxide (pH - 12 to 13) and is operated at 190 °F. It is gas-heated and has a lid to prevent evaporation. An automatic rack is used to lower radiators into the tank for approximately 1 hour. This tank is cleaned once a year and the waste sludge is drummed and disposed of as a hazardous waste. The leak detection tank contains water and a rust inhibitor. It is operated at room temperature and emptied once a year. The wastewater is drained into the sanitary sewer. About 2,500 lb/yr of caustic waste and 3,080 lb/yr of antifreeze waste is generated at this IMSS. The waste solution from the hot caustic tank is drained periodically into the sanitary sewer without testing for pH or heavy metals.

In addition to the wastes from the radiator shop, a very small amount of water-soluble cutting oil waste is generated at the machine shop. The cutting oil is mixed with water and applied through jet nozzles on the work that is being machined. It serves to cool the cutting tool and the work piece. As it drips from the machined area, the coolant is captured in a drip reservoir, filtered, and reused. Each machine is emptied once a year and the cutting oil disposed of in a hot tank in Section III. IMSS #3 (Communication and Electronic Equipment Repair, Section IV) is the smallest of all the IMSS. A solvent tank is located in the shop for cleaning electrical and electronic parts. Small numbers of other batteries (lithium, nickel-cadmium) are discarded here.

Lead-acid battery casings (300,000 lb/yr) and spent acid (90,000 lb/yr) drained from the batteries are the largest quantity wastes generated at the IMSS. The casings, and the acid if contained within them, are not a hazardous waste because they are recycled and are exempt from regulatory requirements. However, the acid that is drained is a hazardous waste because of corrosivity and, possibly, EP toxicity for lead. Elementary neutralization of corrosive wastes only is exempt from permitting requirements. A Part B treatment permit has to be obtained for treating wastes that are both corrosive and EP toxic. Other significant wastes generated at the IMSS are: used oil (73,590 lb/yr); contaminated fuel (42,700 lb/yr); spent cleaning solvent (29,057 lb/yr); antifreeze solution (20,416 lb/yr); spent TCA and tank bottom sludge (12,980 lb/yr); and others (16,666 lb/yr).

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. Included in the services are: periodic maintenance (e.g., fluids change, tune-up, etc.), engine repair, brake servicing, battery repair/servicing, and unique repairs (if required, for different aircraft). There are six AMF at Fort Carson as shown in Table 10.

The typical repair operations that use hazardous materials and generate hazardous wastes are: oil and grease removal, engine parts and equipment cleaning, solution replacement, paint stripping, and painting (discussed later under *Paint Shops*). AMF commonly use: solvent sinks (parts cleaning), hot tanks (for engine cleaning), and spraying equipment. Table 11 lists the wastes generated at the AMF. The last column in the table contains data obtained from the IDMS data base and is provided for comparison with the numbers reported by individual AMF.

Some general categories of hazardous materials used at AMF 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 hazardous materials and also generate hazardous wastes. The hazardous and nonhazardous materials used at the AMF are listed in Table 12.

AMF #1 [1st Bn 4th Aviation Regiment (HC, A, B, C, and D Companies); Bldgs 9604, 9620, 9621, 9623, 9624, and 9628] generates more wastes (6,335 lb/yr) than any other AMF. Spent solvent accounts for half of this amount and used oil accounts for 22 percent. Spent solvent, contaminated JP-4, and oil are the major wastes generated at AMF #2 [A Co 2-158 Avn Regiment, Bldg 9620] which is under the command of the 4th Aviation Brigade. AMF #5 [E Co 4th Avn Bde, Bldg 9604] and AMF #3 [F Co 4th Avn Bde, Bldg 9604] are the third and fourth largest generators. The aircraft maintenance bay belonging to DOL (AMF #6) and AMF #4 [Task Force, 4th Avn Bde] generate lesser amounts of wastes than all the other AMFs.

Paint Shops (PS)

A FORSCOM installation has painting operations ranging from spray painting with cans to painting 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.

There are two major paint shops at Fort Carson as listed in Table 13. The quantities of wastes generated and materials procured are shown in Table 14 and 15, respectively. PS #1 [Body and Paint Shop, Bldg 8000] is operated by DOL personnel. Two large, cross-draft, dry-filter, paint booths are operated for use in enamel and CARC painting of large tactical vehicles. Of the 7650 lb/yr of wastes generated, 56 percent of it consists of paint thinner. Small amounts of other wastes are generated.

PS #2 [Auto Skills Shop] operated by DPCA personnel is a relatively small quantity generator. Two smaller, dry-filter, cross-draft paint booths are located here. The operators are dissatisfied with one of the booths. Accumulation of large quantities of overspray and inadequate air flow were noticed during the survey conducted for this study.

An old paint booth is also located at the DPTM Devices Section (Bldg 6054). There are no air filters connected to the exhaust to capture the solvent and paint aerosol; it is vented directly to the ambient air. However, it is used rarely (6 h/week/yr) and approximately 15 lb/yr of thinner waste is generated. A new paint booth, procured in 1985, is located outside the building. It was never installed because the dimensions of the new booth exceed the internal dimensions of the room. Unsuccessful efforts have been made over the past 4 years to increase the room size.

Paint thinner is the largest quantity (4720 lb/yr) waste generated from the two shops. The last column in Table 14 lists the 1987 IDMS data for comparison. The amount of paint thinner waste disposed of through the DRMO was 7040 lb. Also 19,679 lb of wet paint wastes were generated.

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

FORSCOM installations have photography and print shops that conduct a wide range of printing operations including standard forms, brochures, pamphlets, newsletters, and circulars. The shops perform image and plate processing. Image processing is a method for preparing artwork that includes typesetting and photoprocessing. The photographic process produces a negative with the light portions of the photographed object filled with 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 PPAS at Fort Carson (Table 16). Four of them belong to DPTM and the other two are operated by DOIM and the Directorate of Personnel and Community Affairs (DPCA). PPAS #1 (DPTM, Photography Section, Bldg 6010) generates the most wastes consisting primarily of bleach, activator, developer, cleaner, and fixer. Silver is recovered, as part of a precious metal recovery program, from all the silver-containing waste solutions. DPTM's Training and Audiovisual Center, Production Shop (PPAS #4) is the second largest generator. Wastes from printing (solvent, inks, etc.) and photography are generated here.

The DPCA Photography Skill Center (PPAS #6) is the third largest generator of photographic wastes (film/paper developers, bleach/fix solutions, and other solutions). Solutions containing recoverable silver are turned in to the Evans Army Hospital for recovery and disposal. The remaining PPAS are smaller than the three discussed above.

Small quantities of a number of different wastes are generated by the PPAS. Developer and fixer solutions are generated in the largest quantities. Fixer solutions are recycled for silver recovery. The 1987 IDMS data (last column, Table 17) indicates that a large amount of toner is also generated. Other significant wastes are: bleach, uralite, electrostatic ink and solution, and adhesive. Table 18 lists the quantities of materials procured.

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 Carson are listed in Table 19.

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. The wastes generated and materials used by the HCLs are listed in Tables 20 and 21, respectively.

The Evans Army Community Hospital (HCL #1), located at Building 7500, generates nearly 360,000 lb/yr of infectious wastes. Other infectious wastes are generated by the dental clinics (HCL #2). Most of the pathological wastes are generated and incinerated at the veterinary hospital (HCL #3).

A double chamber, natural gas-fired pathological incinerator (100 lb/hr) is located at HCL #3. This incinerator is permitted under the State of Colorado air quality regulations. Some of the equipment operation criteria are: (1) visible emissions should not exceed 20 percent opacity, (2) particulate emissions should not exceed 0.10 grains per dry standard cubic foot corrected at 12 percent CO_2, (3) summarized monthly records of daily burning rates and hours of operation must be maintained, (4) preheating of the secondary zone is required before charging and operating the unit, (5) both the primary and secondary burners must be operated at design rate, (6) charging rate should not exceed 100 lb/hr, and (7) operation and maintenance should be performed according to the procedure prescribed by the manufacturer (Incinerator International Inc.).

HCL #1 has a silver recovery unit used to recover silver from fixer solution from throughout Fort Carson. Other precious metal wastes (e.g., gold fillings) from DENTAC are recycled through the precious metal recovery program. A number of chemicals such as xylene, formalin, etc. are used at all the HCLs. The survey data (wastes generated and materials used) were inadequate. However, the 1987 IDMS data (last column, Table 20) show the generation of various chemical wastes.

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.

Table 22 lists the heating and cooling plants at Fort Carson. The main boiler facility (Bldg 1860) (HCP #1) is used to burn waste oil (183,890 lb/yr), which is generated throughout the fort. Table 23 and 24 list the wastes generated (boiler blowdown) and materials used, respectively. Some spent cleaning solvent is also generated at HCP #2 (Bldg 403). The amount of fuel oil and natural gas used is 289,485 and 336,167 lb/yr, respectively. A number of other chemicals (cyclohexyl, caustic soda, tripolyphosphate, tannin, sodium sulfite, and morpholine) are used in day-to-day operations as shown in Table 24.

The laundry facility at Fort Carson is located in Bldg 1510. It is a pickup point for a contracted operation. All the clothes are laundered and drycleaned offsite at the contractor's (New Method Dry Cleaning & Laundry, Inc.) shop in Canyon City, CO.

Currently, there is only one active solid waste landfill located at Fort Carson. A 1/2-acre unlined pit near the landfill is used for disposal of grit from the oil/water separators located throughout the installation. This pit contains water, oil, oily sludge, solvents, aerosol cans, empty drums, etc. Because of the solvents and heavy metal contaminants likely to be present, this pit is probably an illegal facility in violation of regulations. Additionally, the site has a very high potential for groundwater contamination. An alternate method must be developed for minimization, treatment, or disposal of the oily grit.

A wastewater analysis laboratory is located in Bldg 3387 at the wastewater treatment plant. Water is analyzed for fecal coliform bacteria, residual chlorine, 5-day biochemical oxygen demand (BOD_5), suspended solids (SS), chemical oxygen demand (COD), and alkalinity. Used reagents are discarded into the sanitary sewer system. Many nonreagent chemicals such as hexane, acetone, 1,1,2-trichloro-1,2,2-trifluoroethane (freon) etc. are also stored in the laboratory.

Pesticides are stored and used by the GE entomology section, DPCA golf course, field sanitation teams, school district, and the post exchange to prevent pest-related problems in: household, structural, health-related, and nuisance insect and rodent control programs; weed control programs; and programs involving turf areas (e.g., golf courses), trees, and shrubs. The section stores insecticides and rodenticides in Bldg 212. Herbicides and algicides are stored in Bldg T-204. Mixing of these pesticides is conducted outside the building. The empty containers are triple rinsed and buried in the landfill. The rinseate is reused as a diluent in the mixing operations. A contractor applies herbicides for broadleaf control, algicides in the ponds, and fungicides on the greens of the golf course.

PCBs are found in capacitors and transformers. All the online transformers containing PCBs have been identified by the GE exterior electrical repair shop. They are inspected periodically and the out-of-service transformers are replaced with non-PCB transformers.

The 94th Explosive Ordnance Disposal (EOD) Detachment performs OB/OD of small ammunition in the EOD ranges. Fort Carson has applied to include two ranges (1 and 121) on the RCRA Part A TSDF permit. The ammunition destroyed at these ranges includes: small arms (cartridges), artillery/mortar, grenades, rockets, pyrotechnics, and other hazardous explosive/demolition materials. Hazardous items are typically destroyed at the rate of one to two items per month by surface detonation after being covered by high explosives (e.g., C-4, TNT, etc). Some of the trenches at these ranges are used for burning excess powder bags. These propellant items are directly handled by troops and not the EOD detachment. Soil residue at these ranges must be tested for its toxic/hazardous nature.

The DRMO maintains two areas for storage of hazardous wastes/materials. A yard located to the west of Bldg 318 is used to store materials that can be stored outside such as epoxies, hydraulic fluid, and flammables. Bldg 9248, which was originally an ammunition storage bunker, is a permitted (interim status) hazardous waste management facility used to store toxic, corrosive, ignitable, reactive, and miscellaneous hazardous wastes (e.g., PCB transformers) before disposal. No wastes are actually generated here.

A miscellaneous generator at Fort Carson is the multicrafts skill development center (Bldg 2200). Very small amounts of wastes (metal plating solution, stained glass petina, ceramic slip, paint thinner, saw dust, etc.) are generated during the skill training activities.

Wastes Selected for Technical/Economic Analysis

Table 25 summarizes the data presented in the previous section that were obtained during the HAZMIN survey. Also included are the totals according to waste disposal data obtained from manifests and the IDMS data base. It is difficult to allocate the IDMS waste disposal information to each of the individual generators. However, the totals (5th column) indicate the quantities that were disposed of in 1987. The fourth column in the table presents the totals according to the survey. The suggested generation rate as determined from all the available information is provided in column 6. The 13 different waste categories considered are listed on the last page of Table 25. Table 26 presents the total wastes generation rate according to each of the waste categories and waste types. PCB-contaminated equipment has not been included in the above summaries.

Table 26 shows that motor pools and vehicle maintenance facilities generate the largest quantity (1,701,968 lb/yr) of wastes consisting primarily of used oil (635,507 lb/yr), antifreeze (247,501 lb/yr), lead-acid batteries (201,850 lb/yr), cleaning solvents (191,861 lb/yr), spent sorbent (120,680 lb/yr), and contaminated soil (105,000 lb/yr). The industrial shops (Bldg 8000) generate the next highest quantity (585,409 lb/yr). Most of it is drained lead-acid batteries (300,000 lb/yr) and the battery acid (90,000 lb/yr) which is neutralized. The other wastes of concern are used oil (73,590 lb/yr), cleaning solvent (29,057 lb/yr), antifreeze (20,146 lb/yr), and 1,1,1 trichloroethane (7700 lb/yr), and degreaser tank-bottom sludge (5280 lb/yr). The hospital, veterinary, and dental clinics generate the next largest quantity (515,563 lb/yr), with medical infectious waste accounting for 99 percent of it. The remaining 1 percent consists of spent solvents (e.g., xylene), many other chemicals (e.g., mercury, formalin), and photographic wastes.

Boiler plants are a major generator (267,000 lb/yr) because of the boiler blowdown reported (265,600 lb/yr). This blowdown is discharged into the sanitary sewer. Occasional discharge of blowdown may not adversely affect the wastewater quality; it may still be within NPDES limits, but this can only be determined by proper testing. Aviation maintenance facilities are the next largest generator (52,809 lb/yr) of typical aircraft maintenance wastes such as spent solvent, synthetic oil, spent NICAD batteries, contaminated aircraft fuel, etc. Troop units are next, generating small quantities of expired or spoiled decontaminating agents (e.g., DS-2, STB), and batteries (e.g., lithium, mercury).

The seventh largest type of waste generator is paint shops that generate paint related materials (29,521 lb/yr) such as thinner, and unused paint. Printing, photography, and arts/crafts shops are next. They generate acids/bases, halogenated solvents, and spent photographic and printing chemicals. Some of the shops belonging to GE. Other miscellaneous sources are the smallest quantity waste generators.

In terms of total waste generation, used oil is the largest volume (797,399 lb/yr). It is followed by spent batteries (535,534 lb/yr), spent acids/bases (373,973 lb/yr), spent antifreeze solution (267,917 lb/yr), spent nonhalogenated solvents (237,071 lb/yr), contaminated fuels (77,630 lb/yr), paint related material (38,957 lb/yr), decontaminating agents (18,626 lb/yr), spent halogenated solvents (11,362 lb/yr), photographic/printing chemicals (6587 lb/yr), used alcohols (5646 lb/yr), pharmaceutical wastes (90 lb/yr), and miscellaneous wastes (862,655 lb/yr).

The wastes selected for technical and economic analysis are used oils (797,399 lb/yr), spent antifreeze solution (267,917 lb/yr), spent cleaning solvent (235,309 lb/yr), battery acid (93,744 lb/yr), TCA and TCA sludge (7700 and 5280 lb/yr), and paint thinner (7040 lb/yr).

Table 2

Hazardous Waste Generation at FORSCOM Installations[36]

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

[36]Source: V.J. Ciccone and Associates, Inc., p C-4.

Table 3

List of Sources Ranked in Order of Importance

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

Table 4

Motor Pools and Vehicle Maintenance (MPVM) Facilities

1 1st Battalion 10th Infantry - Motor Pool - Building 2992

2 1st Battalion 12th Infantry - Motor Pool - Building 2792

3 3rd Battalion 68th Armor - Motor Pool - Building 3092

4 2nd Brigade Headquarters - Headquarters Company - Motor Pool - Building 1852

5 2nd Battalion 8th Infantry - Motor Pool - Building 1982

6 4th Battalion 68th Armor - Motor Pool - Building 1882

7 1st Battalion 77th Armor - Motor Pool - Building 2082

8 1st Battalion 8th Infantry - Motor Pool - Building 2392

9 2nd Battalion 77th Armor - Motor Pool - Building 2492

10 2nd Battalion 35th Armor - Motor Pool - Building 2692

11 1st Battalion 27th Field Artillery - Motor Pool - Building 1682

12 5th Battalion 29th Field Artillery - Motor Pool - Building 1682

13 3rd Battalion 29th Field Artillery - Motor Pool - Building 1392

14 1st Battalion 29th Field Artillery - Motor Pool - Building 1692

15 4th Division Support Command (DISCOM) - Headquarters Company - Motor Pool - Building 8300

16 4th Support Battalion - Motor Pool - Building T-800

17 4th Support Battalion - Motor Pool - Building T-804; DSU - Building 8030

18 204th Support Battalion - Motor Pool - Building 8200; DSU - Building 8030

19 64th Support Battalion - Motor Pool - Building 1001; DSU - Building 8030

20 704th Support Battalion - Motor Pool - Building 8300; DSU - Building 8030, Building 8000

21 68th Transportation Battalion - Motor Pool - Building 8152

22 73rd Maintenance Company - Motor Pool - Building 8030; DSU - Building 8142

23 183rd Maintenance Company - Engineer and Ground Equipment Repair, Automotive and Armament Repair, Building 8142

24 52nd Engineer Battalion - Motor Pool - Building 3292

Table 4 (Cont'd)

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25 19th Military Police Battalion - Motor Pool - Building 2840

26 4th Engineer Battalion -Motor Pool - Building 9072

27 4th Battalion 61st Air Defense Artillery - Motor Pool - Building 639

28 2nd Sanadron 7th Cavalry - Motor Pool - Building 3192

29 104th Military Intelligence Battalion - Motor Pool - Building 749

30 DEH - Operations Division - Maintenance Facility - Building 1302

31 Colorado National Guard - Motor Pool - Building 8110

32 DPCA - Auto Crafts Shop, Skills Center - Building 2427

33 4th Aviation Brigade - Headquarters Service Company - Motor Pool - Building 9628

34 2-158 Aviation Regiment - Motor Pool - Building 9628

35 2-58 ATC - Motor Pool - Building 9628

36 4th Aviation Brigade Headquarters - Headquarters Company - Motor Pool - Building 9628

37 4th Aviation Brigade - E. Company - Motor Pool - Building 9628

38 4th Aviation Brigade - D. Company - Motor Pool - Building 9628

39 4th Aviation Brigade - F. Company - Motor Pool - Building 9628

40 571st Medical Detachment - Motor Pool - Building 8152

41 517 Medical Company - Motor Pool - Building 8152

42 10th MASH Headquarters - Headquarters Company - Motor Pool - Building 8162

43 DOL - Transportation Motor Pool - Building 301

44 DEH - Equipment Concentration Site #42 - Maintenance Facility - Building 8930

45 DPTM - Range Division - Motor Pool - Building 2740

46 DOL - Maintenance Operations Branch - Combat and Engineering Construction Equipment Repair - Maintenance Section I - Building 8000

47 AAFES Main Service Station - Building 1515

Table 5

Quantities of Wastes Generated at MPVM Facilities*

Wastes	MPVM #	1	2	3	4	5	6	7	8	9	10	11	12	13
Spent degreasing solvent**		7854	7854	7854	***	7854	7854	7854	7854	7854	7854	3142	4712	7854
Used oil		48650	14000	42000	7000	49000	25200	24500		100800	10800	8400	4200	6300
Antifreeze solution			17600	2112	1760	8800	2112	6160			5280		73920	68640
Lead-acid batteries		6000	18750	1000	15000	18000				18000	3000	7200	6600	
Sulfuric acid					500									
Caustic wash					50		10560			13728		1584		
Contaminated dirt							600			2000				
Contaminated fuel		2394	350	1680		2100		1400					5040	6300
Oily rags			500	600	500	4300	1000			1000		4000	6000	6120
Spent sorbent			10000	1200	500	13000	2400	3000		12000	6000	15000	16800	14400
Transmission fluid			350		700		9240	350						840
Hydraulic fluid											3500			
Brake fluid						70								
Empty containers					150									
Faulty Parts				120	50		120							
Carburator Cleaner														
Contaminated GAA Grease														
Carbon remover														
Chlorinated motor oil														
Asbestos materials														
Mixed miscellaneous														

*Quantities are reported in pounds per year.
**Low flash point solvent (105 °F) - Safety Kleen Recycle
***A blank in this and similar tables does not mean zero generation. Where data is unavailable, Fort Carson should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use in helping meet HAZMIN goals.

Table 5 (Cont'd)

Wastes	MPVM #		14	15	16	17	18	19	20	21	22	23	24	25
Spent degreasing solvent		7854	1570	3142	1570	4712	1570	4712	3142	7854	6283	6283	1570	
Used oil			5040	1050	1400	18900	1400	21420	34692		16800	6000	42000	
Antifreeze solution			10560	1320		440	264	10912	5368		2640	6336	2640	
Lead-acid batteries								3250				10000		6000
Sulfuric acid					20	140						3000[†]		
Caustic wash														
Contaminated dirt			1500		600	1600			450					
Contaminated fuel			3220					70			385		105	
Oily rags				100		1000	150	700	600		500		1800	
Spent sorbent			360	60		900	500	1200	1800		500	2400	4000	
Transmission fluid				420		1400	210	840			1400	1638		
Hydraulic fluid			336					140						
Brake fluid			336			3500					504			
Empty containers					90						450			
Faulty Parts								250			1000			
Carburator Cleaner														
Contaminated GAA Grease														
Carbon remover														
Chlorinated motor oil														
Asbestos materials														
Mixed miscellaneous														

[†] Drained sulfuric acid is drummed and transported to C Company, 704th MNT Bn. (Building 8000) for neutralization.

Table 5 (Cont'd)

Wastes	MPVM #		26	27	28	29	30	31	32	33	34	35	36	37
Spent degreasing solvent		6283	6283	7854	1570	3142	3142	3142	315	315	315	315	315	
Used oil			31500		25200		8400	1[illegible]0	28000	770	420	350	189	578
Antifreeze solution			1936		10560					968	616	44	493	132
Lead-acid batteries			41250		5000		1000	10000	N/A			400		1750
Sulfuric acid			N/A						N/A					
Caustic wash														
Contaminated dirt										20				
Contaminated fuel			1400		1400			2800					126	
Oily rags								2200		300	100	50	300	
Spent sorbent			4000		2000		120	6000		400	300	25	240	600
Transmission fluid			385		140							18		
Hydraulic fluid			8400		1008									
Brake fluid					140		84			10				35
Empty containers														
Faulty Parts														
Carburator cleaner (methylene chloride)								792						
Contaminated GAA Grease		300												
Carbon cleaner														
Chlorinated motor oil														
Asbestos materials														
Mixed miscellaneous														

Table 5 (Cont'd)

Wastes	MPVM #	38	39	40	41	42	43	44	45	46	47	Survey Total	IDMS Total
Spent degreasing solvent		315	315	196	1570	1570	1570	1570	1570	10210	1570	190103	137900
Used oil		420	11	1400	2660	1050		5600	1155	17252	9800	635507	105000
Antifreeze solution		440	26	176	246	264		1920		2200	616	247501	
Lead-acid batteries		4000	100	150	500	500	2400		1000		21000[ff]	201850	38301
Sulfuric acid					84							3744	
Caustic wash												25922	
Contaminated dirt												6770	105000
Contaminated fuel			35	175	70	105				3500		32655	20487
Oily rags		375		200	50	40				2100	240	34825	
Spent sorbent		500	25	200		50				200		120680	9500
Transmission fluid				28	196					686	4200	23041	
Hydraulic fluid				158						800		14342	4070
Brake fluid		30	1		5	8		10		86	84	4903	1148
Empty containers												690	
Faulty parts												1540	647
Carburator Cleaner												792	
Contaminated GAA Grease											300		
Carbon remover													81917
Chlorinated motor oil													1160
Asbestos materials										685		685	
Mixed miscellaneous		350										350	

'Private recycling contract (*American Battery Company, Colorado Springs, CO*).

Table 6

Quantities of Hazardous/Nonhazardous Materials Used at MPVM Facilities*

Wastes	MPVM#	1	2	3	4	5	6	7	8	9	10	11	12
Degreasing solvent		9032	9032	9032		9032	9032	9032	9032	9032	9032	3613	5419
Carburetor cleaner													
Engine oil		64295		33600	10500	52465	31227			151200		8400	5880
Antifreeze		37268		2112	2640	30087	9838				2640	528	36960
Lead-acid batteries				18750	1000	15000	18000				18000	3000	7200
Caustic wash												24	
Floor wash detergent					50		350				12		
Spent sorbent				600	500	11000	2000				6000	1500	16800
Diesel fuel				691509		2000000				49000	714000		
Mogas fuel					64379	141652						4200	16800
Dirty rags				600	500	4000	240			1000		4000	6000
Transmission fluid				700		567							
Brake fluid						588	840						
Hydraulic fluid						1568							
De-icer													
Lithium batteries													
Lacquer thinner													

*Quantities are reported in pounds per year.

Table 6 (Cont'd)

Wastes	MPVM #		13	14	15	16	17	18	19	20	21	22	23
Degreasing solvent		9032	9032	1806	3613	1806	5419	1806	5419	3613	9063	7226	
Carburetor cleaner													
Engine oil		6720	37800	2100			700	16030	36000		3500		
Antifreeze		36960	36960	1760		440	616	10560	8882		4400		
Lead-acid batteries		6600						250					
Caustic wash													
Floor wash detergent					20			1008		2016			
Spent sorbent		12000		100		900	500	1200			500	2400	
Diesel fuel		78750	840000	3500						350			
Mogas fuel			84000										
Dirty rags		4800		100		1000	150	700	450		500		
Transmission fluid		1260	756	420		1400					1400		
Brake fluid			1008			3500							
Hydraulic fluid			1008										
De-icer													
Lithium batteries													
Sulfuric acid													
Lacquer thinner													

Table 6 (Cont'd)

Wastes	MPVM #	24	25	26	27	28	29	30	31	32	33	34
Degreasing solvent		7226	1806	7226	7226	9032	1806	3613	3613	3613	362	362
Carburetor cleaner										792		
Engine oil							4620	8400	11550		1050	700
Antifreeze		1320					5280	4224	5280		968	616
Lead-acid batteries				41250			5000		1000	10000		
Caustic wash												
Floor wash detergent								55000		840		
Spent sorbent		4000		4000				5000	120	6020	400	300
Diesel fuel							1540	0	336000			
Mogas fuel									210000			
Dirty rags									2400		300	100
Transmission fluid							3640					
Brake fluid								84				
Hydraulic fluid												
De-icer												
Lithium batteries									20			
Sulfuric acid								9	2100			

Table 6 (Cont'd)

Wastes	MPVM #	35	36	37	38	39	40	41	42	43	44	45	46	47
Degreasing solvent		362	362	362	362	362	231	1806	1806	1806	1806	1806	12012	1806
Carburetor cleaner										275				795
Engine oil		539	210	875	700	49	2744	2660	1225	1500	7000	1540	3500	
Antifreeze		44	528	132	440	44	176	44	440	660		484	1100	
Lead-acid batteries		400		1750	4000	100	150	500	500	2400		1000		
Caustic wash														
Floor wash detergent							42							
Spent sorbent		25	240	600	500	25	200		150				200	
Diesel				20664			1750	70000		350000				3500
Mogas			420			35	3500							
Dirty rags			50	300		375		200	50	40				
Transmission fluid		18					105	196						
Brake fluid												8		
Hydraulic fluid							252					126	800	
De-icer														
Lithium batteries														
Sulfuric acid							42	84						

Table 7

Industrial Maintenance and Small Arms Shops (IMSS)

1. DOL - Maintenance Operations Branch - Tactical and MHE repair - Maintenance Section II - Building 8000
2. DOL - MOB - Unit overhaul, fuel and electrical systems repair, and special support - Maintenance Section III - Building 8000
3. DOL - MOB - Communication and electronic equipment repair - Maintenance Section IV - Building 8000
4. DOL - MOB - Radiator service and machine shop - Maintenance Section V - Building 8000
5. AOAP Lab - Building 8000*
6. 704th MNT Bn C Company - Battery service and repair shop - Maintenance Section III - Building 8000**

* Private contractor operated. (Trowell Inc.)

** Charlie Company of the 704th MNT Bn is a direct support element of DISCOM which operates under the guidance of DOL - MOB, Maintenance Section III.

Table 8

Quantities of Waste Generated at IMMS*

Materials	IMSS #	1	2	3	4	5	6
Spent 1,1,1 trichloroethane (TCA)		N/A	7700		N/A		N/A
Spent degreasing solvent**		12566	13351	1570	1570		
Antifreeze solution		5896	11440	N/A	3080		
Used motor oil		19000	42000	10		12580	
Contaminated sorbent		540	300				
Contaminated fuel		42700					
Oily rags		2100					
Transmission fluid		686					
Brake fluid		80					
Hydraulic fluid		4375					
Hazardous, faulty parts		685					
Contaminated fluid filters		3700					
TCA solvent tank bottom sludge			5280				
Spent Li-So_2 batteries				5			
Spent NICAD batteries				10			
Spent paint thinner					15		
Contaminated cutting oil					70		
Caustic wash (NaOH)					2500		
Chlorinated motor oil						1600	
Lead acid battery casings							300,000
Spent sulfuric acid							90,000***

* Quantities are reported in pounds per year.
** Low flash point type solvent (105°F) - Safety Kleen recycle.
***Drained sulfuric acid is neutralized with sodium bicarbonate and discharged to the post IWTP.

Table 9

Quantities of Hazardous/Nonhazardous Materials Used at IMSS

Materials	IMSS #	1	2	3	4	5	6
1,1,1 Trichloroethane		N/A	29722	N/A	N/A		
Degreasing solvent		14786	15709	1848	1848		
Motor oil		16200	70000	10			
Antifreeze solution		2992	15840	N/A	1540		
Sorbent		1200	400				
Diesel fuel		31500					
Mogas		25200					
Rags		2100					
Transmission fluid		686					
Brake fluid		210					
Hydraulic fluid		4375					
Fluid filters		3700					
Paint thinner					72		
Cutting oil					70		
Sodium Hydroxide					2288		
Sodium bicarbonate					75000		
Sulfuric acid							90000

Table 10

Aviation Maintenance Facilities (AMF)

1. 4th Aviation Regiment - Aviation Maintenance Facility - Butts Army Airfield - Building 9620
2. 2-158 Aviation Regiment - Aviation Maintenance Facility - Butts Army Airfield - Building 9620
3. 4th Aviation Brigade - F Company Aviation Maintenance Facility - Butts Army Airfield - Building 9604
4. 4-4 Task Force - Aviation Maintenance - Butts Army Airfield
5. 4th Aviation Brigade - E Company Aviation Maintenance - Building 9604
6. DOL - Aircraft Maintenance Bay - Butts Army Airfield - Building 9604

Table 11

Quantities of Wastes Generated at AMF*

Wastes	AMF #	1	2	3	4	5	6	Survey Total	IDMS Total
Spent degreasing solvent**		3142	3142	2356	425	2356	1570		12991
MEK degreaser		155		15	2			172	85
Paint stripper		77	8	8			39	132	
Paint thinner		77			2			79	135
Filters (paint booth)		24						24	
Empty containers		10		150	50	25		235	
Aircraft engine oil		1400	462	18	385	385	385	3035	1035
De-icer solution									
Nickel-cadmium batteries									20250
Potassium hydroxide				2				2	
Caustics		485		9		220		714	
Detergent floor wash		465		8		210		683	
Contaminated dirt									3500
Spent sorbent		100		100		100	300	600	
Contaminated JP - 4			1820	70		385		2275	1750
Oily rags		400		8		400	500	1308	
Solution sludge				8				8	
Contaminated water				400				400	
Hydraulic fluid			105				35	140	1700
Carbon Remover									171
Unused Paint									290
Grease									345
Alcohol									1031
Acetone									216
Cleaning Compound, NOS									275

* Quantities are reported in pounds per year.
** Low flash point type (105°F) - Safety Kleen recycle.

Table 12

Quantities of Hazardous/Nonhazardous Materials Used at AMF

Wastes	AMF #	1	2	3	4	5	6
Degreasing solvent		693		424	424	424	
MEK degreaser and cleaner				155		31	2
Paint stripper		77	8	8			
Paint thinner		92			?		
Filters (paint booth)		24					
Aircraft engine oil		1400	924	42	385	385	
De-icer solution			420				
Nickel-cadmium batteries							
Potassium hydroxide					42		
Caustics		485	352	18		220	
Detergent solution		465		8		210	
Spent sorbent		100		100		100	
Contaminated JP-4 fuel					3500		385
Dirty rags		400		8		400	
Hydraulic fluid			280				

Table 13

Paint Shops (PS)

1. DOL - Maintenance Operations Branch - Body and Paint Shop - Maintenance Section II - Building 8000
2. DPCA - Auto Skills Center - Vehicle Paint Booths - Building 2427

Table 14

Quantities of Wastes Generated at PS*

Wastes	PS #	1	2	Survey Total	IDMS Total
Hazardous empties		600		600	
Spoiled paint		600	50	650	19679
Paint thinner		4290	430	4720	7040
Paint stripper		90		90	
Caustics					
Detergent floor wash					
Contaminated dirt					
Spent sorbent		600		600	
Contaminated rags		150		150	
Tank sludge					
Contaminated water					
Spent paint filters		600	280	880	
Respiratory cartridges		240		240	
Coveralls		480		480	
Methylene chloride					65
Sealant					478
Bondo					284
Rust remover					140
Adhesive					210

*Quantities are reported in pounds per year.

Table 15

Quantities of Hazardous/Nonhazardous Materials Used at PS*

Materials	PS #	1	2
Paint thinner		17160	
Toluene		4290	
Paint stripper		90	
Caustics			
Detergent floor wash			
Spent sorbent			
Contaminated rags		75	
Paint filters		600	
Respirator cartridges		240	
Coveralls		480	

*Quantities are reported in pounds per year.

Table 16

Photography, Printing, Arts/Crafts Shops (PPAS)

1. DPTM - Training and Support Center - Photographic Section - Building 6010
2. DPTM - Training and Support Center - Graphics Section - Building 6103
3. DPTM - Training and Support Center - Devices Section - Building 6084
4. DPTM - Training and Support Center - Photographic section - Building 6138
5. DOIM - USAISC - Building 6120
6. DPCA - Photography Skill Center - Building 2200

Table 17

Quantities of Waste Generated at PPAS*

Wastes	PPRF #	1	2	3	4	5	6	Survey Total	IDMS Total
Bleach		1060			448		288	1796	102
Activator		720						720	
Developer		3632	192		576	408	1728	6128	4945
Cleaner		216						216	125
Fixer		2912	288		448		480	4128	
Toner			8				28	36	2946
Rinse			4					4	215
Stabilizer							288	288	
Lacquer thinner		215		15				230	
Enamel thinner		72						72	
Turpentine			14					14	
Stencil			200					200	
Silk screen			20					20	
Hexcell uralite		1000						1000	
Photo conditioner						96		96	
Waste inks					1			1	
Solvent rags									
Cleaning solvent						96		96	
Wetting solution						96		96	
Blankrola						739		739	863
Deglazing solvent					96			96	
Electrostatic ink					1500			1500	
Electrostatic solution					2002			2002	
Hypo							192	192	
Step bath							488	488	
Conversion solution									198
Adhesive									1071
Imager									88

*Quantities are in pounds per year.

Table 18

Quantities of Hazardous/Nonhazardous Materials Used at PPAS*

Wastes	PPRF #	1	2	3	4	5	6
Bleach		1060			448		288
Activator		720					
Developer		3632	192		576		1728
Cleaner		216					
Fixer		2912	288		448		480
Toner			8				28
Rinse			4				
Stabilizer							288
Lacquer thinner				350			
Enamel thinner							
Turpentine							
Stencil							
Silk screen							
Hexc[illegible] uralite							
Empty containers							
Photo conditioner						96	
Waste inks							
Solvent rags					100		
Cleaning solvent						96	
Wetting solution						96	
Blankrola						739	
Electrostatic solution							92
Waste ink mix					92		
Hype							192
Step bath							488

*Quantities are reported in pounds per year.

Table 19

Hospitals, Clinics, and Laboratories (HCL)

1. DHS - Evans Army Community Hospital - Building 7500
2. DENTAC - Dental Clinic Number 3 - Building 6225
3. Veterinary Hospital - Building 6001

Table 20

Quantities of Wastes Generated at HCL*

Wastes	HCL #	1	2	3	Survey Total	IDMS Total
Pathological		732		15600	16332	
Infectious		360000	149650		509650	
Pharmaceutical		90			90	90
Chemical						492
Radioactive						
Silver recovery		19			19	
Formaldehyde						430
Alcohol						915
Mercury						215
Benzene						280
Potassium phosphate						320
Disinfectant						185
Chloroform						75
Photo developer						460
Photo toner						216
Photo wash						290
Soda lime						215
Toluene						518
Xylene					308	480

*Quantities are reported in pounds per year.

Table 21

Quantities of Hazardous/Nonhazardous Materials Used at HCL*

Materials	HCL #	1	2	3
Xylene		293		
Mercury				
Photochemical				
Acids				
Bases				
Alcohols				
Formalin				
Formaldehyde				

*Quantities are reported in pounds per year.

Table 22

Heating and Cooling Plants (HCP)

1. DEH - Boiler Plant Section - Building 1860
2. DEH - Boiler Plant Section - Building 403
3. DEH - Boiler Plant Section - Building 9609
4. DEH - Boiler Plant Section - Building 6290
5. DEH - Boiler Plant Section - Building 6290
6. DPTMSEC-Museum Div.-FSH Museum; Bldg. 123

Table 23

Quantities of Waste Generated at HCP*

Materials	HCP #	1	2	3	4	5
Spent degreasing solvent			1400			
Contaminated fuel oil						
Cyclohexyl						
Caustic soda						
Boiler blowdown		1600	16000	80000	8000	160000
Toxic emissions						
Ash						
Miscellaneous						

*Quantities are reported in pounds per year.

Table 24

Quantities of Hazardous/Nonhazardous Materials Used at HCP*

Materials	HCP #	1	2	3	4	5
Degreasing solvent			1400			
Used oil		183890				
Fuel oil		289485				
Natural gas		336167				
Cyclohexyl			2	40		
Caustic soda		61	5	184	12	12
Tripolyphosp			8	454		52
Tannin			8	135		75
Sodium sulfite		373	4	95	3	50
Morpholine						211

*Quantities are reported in pounds per year.

Table 25

Waste Generation Summary

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	lb/yr/unit			Waste Stream Unit
			Survey	IDMS	Suggest	
Motor Pools and Vehicle Maintenance Facilities	1	191861	190103		190103	Spent petroleum naphtha
				1758	1758	Spent degreasing solvent, NOS
	2	1442		647	647	Carbon remover
			795		795	Carburetor cleaner
	3	247501	247501		247501	Spent antifreeze solution
	4	717424	635507	105000	635507	Used motor oil
				81917	81917	Chlorinated motor oil
	8	3744	3744		3744	Spent sulfuric acid
	10	32655	32655	20487	32655	Contaminated diesel, Mogas
	12	201850	201850	38301	201850	Spent lead-acid batteries
	13	305491	4903	1148	4903	Used brake fluid
			23041		23041	Used transmission fluid
			14342		14342	Used hydraulic fluid
			120680	95000	120680	Spent sorbent
			34825		34825	Contaminated rags
			6770	105000	105000	Contaminated soil
			1540		1540	Hazardous faulty parts
			685	1160	1160	Asbestos containing materials
Industrial Maintenance Small Arms Shops	1	29057	29057		29057	Spent degreasing solvent
	2	7700	7700		7700	Spent 1,1,1-trichloroethane
	3	20416	20146		20146	Spent antifreeze solution
	4	75190	73590		73590	Used motor oil
			1600		1600	Chlorinated motor oil
	7	15	15		15	Spent paint thinner
	8	92500	90000		90000	Spent sulfuric acid
			2500		2500	Spent sodium hydroxide
	10	42700	42700		42700	Contaminated fuels
	12	300015	300000		300000	Lead-acid battery casings
			5		5	Spent Li-So_2 batteries
			10		10	Spent NICAD batteries
	13	17816	686		686	Used transmission fluid
			80		80	Used brake fluid
			4375		4375	Used hydraulic fluid
			840		840	Contaminated sorbent
			685		685	Hazardous faulty parts

Table 25 (Cont'd)

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	lb/yr/unit Survey	lb/yr/unit IDMS	lb/yr/unit Suggest	Waste Stream Unit
			3700		3700	Contaminated fluid filters
			70		70	Contaminated cutting oil
			2100		2100	Oily rags
			5280		5280	TCA tank bottom sludge
	1	13379	12991		12991	Spent petroleum naphtha
			172	85	172	Spent MEK
		446		216	216	Spent acetone
	2			171	171	Carbon remover
				275	275	Cleaning compound, NOS
	4	3035	3035	1035	3035	Aircraft engine oil
	7	842	132		132	Spent paint stripper
			79	135	135	Spent paint thinner
			285		285	Spent paint filters
				290	290	Unused, spoiled paint
	3	716	714		714	Caustics
			2		2	Potassium hydroxide
	10	2275	2275	1750	2275	Contaminated JP-4
	12	20250		20250	20250	Spent NICAD batteries
	13	11866	140	1700	1700	Contaminated hydraulic fluid
			600		600	Spent sorbent
				345	345	Grease, NOS
			4375		4375	Contaminated hydraulic fluid
			30		30	Hazardous empties
			1308		1308	Contaminated rags
			8		8	Solvent tank sludge
				3500	3500	Contaminated soil, solids
Paint Shops	2	65		65	65	Spent methylene chloride
	4	1750	1750		1750	Used motor oil
	5	1031	1031		1031	Spent alcohol, NOS
	7	29521	4720	7040	7040	Spent paint thinner
			90		90	Spent paint stripper
			880		880	Spent paint filters
			240		240	Spent respirater cartridges
				478	478	Sealant
				284	284	Bondo
				140	140	Rust Remover
				210	210	Adhesive, NOS

Table 25 (Cont'd)

Waste Generating Process, Operation, or Condition	Waste Category	lb/yr	lb/yr/unit Survey	lb/yr/unit IDMS	lb/yr/unit Suggest	Waste Stream Unit
			480		480	Paint covered overalls
			650	19679	19679	Unused, spoiled paint
	13	4115	2600		2600	Spent oil, fuel filters
			840		840	Spent sorbent
			600		600	Hazardous empties
			75		75	Contaminated rags
Photography, Printing and Arts/Crafts Shops	1	96	96		96	Spent deglazing solvent
	2	1079	216	125	216	Spent film cleaner
			739	863	863	Spent blankrola solvent
	6	5621	288		288	Spent photo stabilizer
			1796	102	1796	Spent photo bleach
				215	215	Spent photo rinse
			36	2946	2946	Spent offset toner solvent
			92		92	Spent electrostatic solvent
			92		92	Spent electrostatic ink and toner
			192		192	Spent hypo. cleaning agent
			720		720	Spent photo activator
	7	316	230		230	Laquer thinner
			72		72	Enamel thinner
			14		14	Turpentine
	8	10663	6128	4945	4945	Spent photo developer
			4128		4128	Spent Photo fixer
			96		96	Ink roller conditioner
			488		488	Acetic acid photo bath
				198	198	Conversion solvent, NOS
				88	88	Imager
Hospitals, Clinics, and Laboratories	1	1278	308	480	480	Spent xylene
				280	280	Spent benzene
				518	518	Spent toluene
	2	505		430	430	Spent formaldehyde
				75	75	Spent chloroform
	5	915		915	915	Spent alcohol, NOS
	6	966		460	460	Spent photo developer
				216	216	Spent photo toner
				290	290	Spent photo wash
	9	185		185	185	Spent disinfectant, NOS
	11	90	90	90	90	Shelf-life pharmaceuticals
	13	511624		215	215	Contaminated mercury

Table 25 (Cont'd)

Waste Generating Process, Operation, or Condition	Waste Category	lb/yr	lb/yr/unit Survey	IDMS	Suggest	Waste Stream Unit
	6			320	320	Potassium phosphate
				215	215	Soda lime
			732		732	Pathological wastes
			509650		509650	Medical infections
				492	492	Miscellaneous chemicals
Heating and Cooling Plants	1	1400	1400		1400	Spent petroleum naptha
	8	265600	265600		265600	Caustic boiler blowdown
G E (formerly DEH)	7	8263		3702	3702	Unused, spoiled paint
				3451	3451	Sealant
				1110	1110	Polyurethane
	12	171		171	171	Furniture polish
Troop	9	18441		4762	4762	Shelf-life DS-2
				10717	10717	Shelf-life STB
				1854	1854	Calcium hydride
				1108	1108	Calcium hypochlorite
	12	13248		8461	8461	Spent mercury batteries
				1019	1019	Spent alkaline batteries
				3768	3768	Spent lithium batteries
	13	10559		1210	1210	Insecticides, NOS
				9349	9349	Magnesium carbon
Miscellaneous	2	125		100	100	Spent dichlorodifluoromethone
				25	25	Spent freon
	5	3720		3720	3720	Spent methonol
	8	750		750	750	Spent acetic acid
	13	1184		1184	1184	Detergent, NOS

Waste Categories: 1: Spent degreasing solvents (nonhalogenated); 2: Spent degreasing solvents (halogenated); 3: Spent antifreeze solution; 4: Used motor oil; 5: Used alcohols; 6: Spent photo and print chemicals; 7: Paint related materials; 8: Spent acids and bases; 9: Decontamination agents; 10: Contaminated fuels; 11: Pharmaceutical wastes; 12: Spent batteries; 13: Miscellaneous wastes

Table 26

Total Waste Generation Rates Sorted by Waste Categories*

Generator	Total	1	2	3	4	5	6	7	8	9	10	11	12	13
MPVM	1701968	191861	1442	247501	717424				3774		32655		201850	305491
IMSS	585409	29057	7700	20416	75190			15	92500		42700		300015	17816
AMF	52809	13379	446		3035			842	716		2275		20250	11866
PS	36482		65		1750	1031		29521						4115
PPAS	17775	96	1079				5621	316	10663					
HCL	515563	1278	505			915	966			185		90		511624
HCP	267000	1400							265600					
DEH	8434							8263					171	
Troop	42248									18441			13248	10559
Miscellaneous	5779		125			3720			750					1184
TOTAL	3233467	237071	11362	267917	797399	5646	6587	38957	373973	18626	77630	90	535534	862655

*Quantities are reported in pounds per year.

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 27 lists the operations, the corresponding materials used, and the wastes generated. Table 28 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*,[36] and other references.[37]

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.[38] 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.

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

[37] *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).

[38] 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.[39] 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.[40] 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.[41] Several standard methods are available for minimizing emissions from immersion cleaning, wipe cleaning, and spray cleaning operations.[42]

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

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

[41] 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.

[42] 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 29) 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 30). 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 31 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.[43] 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 32. 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 32 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.[44] 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.[45] 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[46] that could be produced by mixing used oils with radiator drainings

[43] 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).
[44] W.M. Toy, pp A-1 - A-23.
[45] W.M. Toy, p 20.
[46] 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.

(containing oxylates, phenols, ketones, and acids) and used solvents. Product segregation is initially cost-intensive, 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.[47]

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 emis-

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

sions 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.

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.[48] 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.[49] 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.[50]

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[51] 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).[52] Such test methods allow continuous monitoring of the solution to

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

[49] 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).

[50] 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.

[51] 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).

[52] 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.

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").

Antifreeze Solution - Process Change - Extend Life

A Military Specification, MIL-A-53009[53], developed by the U.S. Army Research and Development Center, Fort Belvoir, VA, allows the use of antifreeze (MIL-A-46153)[54] whose inhibitor system has reached a marginal condition.[55] 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).[56] 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 33 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.[57]

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 [SK]) 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

[53] Military Specification MIL-A-53009, *Additive, Antifreeze Extender, Liquid Cooling System* (Department of Defense [DOD], 6 August 1982).
[54] Military Specification MIL-A-46153, *Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package* (DOD, 31 July 1979).
[55] 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.
[56] R.H. Salvesan Associates, pp 35-36.
[57] 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).

disposed of. Contract recycling has been accepted as a good practice by the automobile industry.[58] Table 29 lists some of the equipment leasing and service companies.

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 29) 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 29.

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[59] 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,[60] 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.[61] More recent studies have placed the cost of such a qualification procedure at $75,000.[62]

[58] W.M. Toy, pp 29-30.
[59] 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.
[60] Mil-L-46152, *Lubricating Oil, Internal Combustion Engine, Administrative Service, Metric* (DOD, 1 August 1988).
[61] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, pp 16-19.
[62] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, p S-3.

Used Oil - Offsite Recycling - Sale to Recyclers

Sale of used lubricating oils may be the most economical answer for an installation. Although burning and closed-loop recycling agreements offer increased economic rewards, constraints may limit the options available to an installation and make selling used oil the only feasible alternative. The cost of selling or disposing of used oil includes sampling and testing the oil, storage before the sale, 55-gal drums for sale/disposal, inventorying expenses, advertising for bid solicitations, bid evaluation, bid letting, and accounting. Draft USEPA regulations, when finalized, could increase the workload of sales personnel slightly by requiring the selling installation (or DRMO/DRMS) to notify the USEPA of the intent to market used lubricating oil and obtain an identification number. Certified analyses on each batch of used oil will also be required, and if the oil is classified as a hazardous waste, it must be manifested and transported by a licensed hazardous waste hauler and may be distributed only to an industrial user.

Antifreeze Solutions - Onsite Recycling

In addition to reducing the quantity of waste produced, there is a major economic incentive for recycling and reusing antifreeze solutions. Because of the shortage of ethylene, the price of antifreeze has more than doubled in the past 2 years ($3 to $8/gal) and it is in short supply. A simple recycling method is available.[63] 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 29 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 30). 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.

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

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, 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.[64]

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.[65]

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.[66] 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.[67] Current Navy regulations limit the amount of used oil in fuel oil blends to 1 percent.[68] 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.[69]

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

[65] 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.

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

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

[68] 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).

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

Aqueous Wastes - Onsite Pretreatment - Filtration

Installing filters on aqueous waste streams to collect grit and heavy residue increases the life of the wash solution. In one case,[70] providing a pump-around loop through a 25-micron filter bag (on a slipstream from jet spray washer) extended the solution life by 2 weeks, thus minimizing the quantity requiring subsequent treatment or disposal.

Aqueous Wastes - Onsite Treatment - Evaporation

Aqueous wastes consist primarily of water with various amounts of contaminants. Evaporating the water minimizes the amount of waste requiring disposal. In an evaporation device, the water is heated away (using an electric or natural gas heating device) leaving behind a semisolid or solid residue requiring disposal. Oil, if present in the waste, could inhibit boiling. Solid residue accumulated on the inner surface of the evaporator could inhibit heat transfer and, therefore, it may have to be cleaned frequently. Table 34 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.[71] 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., SK, 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.[72] 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 29) for recovery of ethylene glycol that may be used as waste fuel.

Lead-Acid Battery Electrolyte - Treatment

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

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

NICAD Battery Electrolyte - Treatment

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

Table 27

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

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

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

Table 28

Waste Classification for MPVM and AMF*

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

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

Table 29

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

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

*Source: *Hazardous Waste Reduction Checklist - Automotive Repair Shops*, pp 17-20.
Note: Names of other companies specific to each area can be obtained from trade publications, associations, and local telephone directories.

Table 29 (Cont'd)

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

Table 29 (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		
Petroleum Recycling Corp. 1835 East 29th Street Signal Hill, CA 90806	(213) 595-4731 Processor			X		
Plastic Materials, Inc. 3033 West Mission Road Alhambra, CA 91083	(818) 289-7979 Hauler, seller, processor	X				
Rho-Chem Corporation 425 Iris Avenue Inglewood, CA 90301	(213) 776-6233 Hauler, processor	X				
Romic Chemical Corp. 2081 Bay Road East Palo Alto, CA 94303	(415) 324-1638 Hauler, processor	X				

Table 29 (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 30

Equipment Leasing Costs*

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

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

Table 31

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 85 gal 100 gal	\$3,400 \$3,800 \$4,500
Hot tank	60 gal	\$300

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

Table 32

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 33

Solvent Recovery Equipment

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

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

Table 34

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	$ 1995
Nordale Fluid Eliminator 990 Xylite Ave., N.E. Minneapolis, MN 55434 (603) 658-7111 (714) 885-0691	FE-150	150 gallons	$ 8000 - $13,000
Wastewater Treatment Systems 440 N. Central Ave. Campbell, CA 95008 (408) 374-3030	BM-50	50 gallons	$15,000 - $18,000

*Source: *Hazardous Waste Reduction Asessment 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 35. 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.[73] The typical coating time is 15 to 40 minutes. The phosphate immersion coating bath is maintained between 200 and 210 °F. The phosphate tank and heating elements are usually made of acid-resistant material. Some of the equipment used in the immersion coating process include: conveying equipment, if necessary; work-supporting equipment such as hooks, racks, baskets, and tumbling barrels; tanks associated with water and heat (steam or electricity); a drain to the sewer line; ventilation equipment; and drying equipment such as ovens, air heaters, fans, and compressors.[74] The

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[73] 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.

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

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.

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

Source Reduction - Solvent Cleaning

PC/MC/TCE - Product Substitution

If PC, MC, or TCE are still being used in vapor degreasing, 1,1,1-trichloroethane should be substituted. The hazards associated with it are much less than those with PC, MC, or TCE. It also has a higher threshold limit value (TLV, 350 ppm), in terms of worker safety, than PC (100 ppm) and TCE (100 ppm). Although MC has a higher TLV (500 ppm), it is a known carcinogen.[75]

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

Solvents are replaced in a vapor degreasing tank based on the operator's perception of its contamination or "dirtiness." A more scientific methodology must be used to determine a solvent's "solvation" power and cleaning efficiency. Chlorinated solvents have physicochemical and electrical properties that can be used to determine this capacity.[76]

A combination of tests including visible absorbence, viscosity, conductivity, and acid acceptance value (AAV), must be used to determine if a solvent is spent based on recommended scores listed in Tables 36, 37, and 38. If the solvent has a score of six or more, it is ready for reclamation disposal. Among all the tests, AAV is the most important because it determines the concentration of amine and alpha epoxide inhibitors left in the solvent. A standard titration procedure,[77] reacting the solution with excess hydrochloric acid which in turn is neutralized with sodium hydroxide, is used to measure the total AAV. Direct measurement instruments (UV/visible Spectrophotometer, Ostwald viscometer, and Conductivity meter) are available for the other tests. Eventually solvent test kits will be available for use at Army installations.[78] With continued use of the testing procedures, more accurate scores can be developed and substituted for those suggested in Tables 36, 37, and 38.

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

[76] B.A. Donahue, et al., *Used Solvent Testing and Reclamation, Volume II: Vapor Degreasing and Precision Cleaning Solvents*, Technical Report N-89/03/ADA204732 (USACERL, December 1988).

[77] ASTM Standard D 2942-86, "Standard Test Method for Total Acid Acceptance for Halogenated Organic Solvents (Nonreflux Methods)," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (1988).

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

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

A standard method[79] is available to qualitatively determine the amount of inhibitor present in 1,1,1-trichloroethane to prevent its degradation in the presence of aluminum or aluminum alloys. This test determines the stability of the solvent being used in a degreaser and also that of recycled material.

In this test, a cleaned/degreased aluminum coupon is immersed in inhibited 1,1,1-trichloroethane and scratched. Allowing sufficient time to elapse for a reaction to occur, the formation of dark resinous ("blood"-like) material, bubbling, and discoloration is noted. If the solvent is sufficiently inhibited, no reaction takes place. The reaction can be categorized into four groups: (1) no reaction; (2) bleeds but heals, no solvent discoloration; (3) bleeds but heals, solvent discoloration; and (4) bleeds with no healing. By continued use of this test method over a period of time, a site-specific semiqualitative procedure can be developed for determining when 1,1,1-trichloroethane is "spent" and should be recycled or disposed of.

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

Reducing air emissions is probably the most significant good operating practice in terms of reducing hazardous wastes released to the environment. Proper covers should be installed and used for both cold cleaning and vapor degreasing operations. The use of covers on vapor degreasing vats has been shown to result in a 24 to 50 percent reduction in solvent losses.[80] Boiling of solvent increases emissions by 81 percent as compared to covered-top vapor degreasers.[81] Standard guidelines[82] must be established to help minimize emissions from vapor degreasers that will reduce the hazards to workers, optimize system performance, and conserve material.

Other methods of reducing emissions from vapor degreasers include: increasing freeboard height (0.75 times or greater than the degreaser width); limiting hoist system speed to less than 11 ft/min; limiting the load's cross-sectional area to less than 0.5 times that of the degreaser width; installing a freeboard chiller with a minimum capacity of 100 Btu/hour/feet of perimeter coil; removing the load only when the liquid runoff has stopped; and protecting the degreaser from drafts, air currents, and excessively high velocity exhaust ducts.[83]

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

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

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[79] ASTM Standard D 2943-86, "Standard Method of Aluminum Scratch Test for 1,1,1-Trichloroethane," *Annual Book of American Society of Testing and Materials Standards*, Vol. 15.05 (1988).

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

[81] *Solvent Minimization and Substitution Guidelines.*

[82] ASTM Standard D 3640 80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (1988).

[83] ASTM Standard D 3640-80.

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

Sometimes stored new products may be cross-contaminated, making them unusable. This contamination is caused by using transfer equipment such as solvent pumps on drums containing several different products.

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

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

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

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

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

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

Aqueous cleaners that are possible substitutes for chlorinated solvents are commercially available.[84] The advantages of substituting aqueous cleaners for solvents include minimizing the exposure of workers to solvent vapors, and reduced liability and disposal costs. Since aqueous cleaners are usually biodegradable, the wastewaters produced can be discharged directly to a wastewater treatment plant for further treatment--no disposal of used solvents is required. Substituting aqueous cleaners for solvents will require additional cleaning steps and equipment to achieve the same cleaning performance. Some of the aqueous solvents, that have been determined to be possible substitutes for chlorinated solvents, are listed in Table 39.

One disadvantage of aqueous cleaners is that they are generally more corrosive. Tanks liners must be installed to prevent excessive corrosion. This may present a problem for open top vapor degreasers with baffles and heating coils. Noncorrosive cleaners typically do not possess the necessary cleaning power required. Aqueous cleaners also require agitation to work properly; installation of a circulating pump or ultrasonic agitator is often required. Furthermore, aqueous cleaners leave metals wet after cleaning. Parts must be blow dried to guard against rust. Particular problems have been noted in cleaning galvanized metal which corroded appreciably when aqueous cleaning solutions were used. Finally, oil removed from parts during cleaning will typically float on top of aqueous cleaning solutions and must be skimmed by an internally floating oil skimming pump or a small external pump and hydrocyclone which continuously cleans the aqueous cleaner and returns it to the tank.[85]

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

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

Using an ultrasonic cleaning process instead of vapor degreasing will eliminate the problems associated with wastes management. Ultrasonic cleaners use high frequency sound to discharge fine particles attached to surfaces. Further treatment of the aqueous waste stream may be required, depending on the concentration of toxic contaminants in solution. Additional information about ultrasonic equipment can be obtained from manufacturers (e.g., Crest Ultrasonics Corporation, (609) 883-4000).

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

Unnecessary changes of solvents from degreaser tanks must be avoided. A method of determining the need to change the solvent is to measure the vapor boiling temperature of the contaminated solvent. Solvent suppliers provide information about the boiling temperature range for all solvents. When a high temperature is reached, the cleaning efficiency of the solvent is minimum and a change is recommended. Other testing methodologies were mentioned above.

Controlling movement of parts in and out of the vapor degreaser (to less than 11 ft/min) can also be viewed as a process control technique that minimizes solvent dragout and emissions.[86] Speed control equipment (governors) must be used to allow for adequate draining time, and cooling and condesation of solvent in the chilling zone.

Vapor degreasers must not be used as drying chambers for parts that have been cleaned and rinsed with water. The wet parts introduce water into the solvent decreasing its useful life. The water may also react with 1,1,1-trichloroethane to form hydrochloric acid that corrodes equipment and contaminates the solvent. Use of water separators can extend the life of the solvent.

Recycling Onsite/Offsite - Solvent Cleaning

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

A closed-loop distillation system must be designed and used to recover 1,1,1-trichloroethane from vapor degreasers. Solution from the vapor degreasing tank is pumped into a distillation still and the pure 1,1,1-trichloroethane is pumped back into the tank after the recovery process. Adding inhibitors will be required. The still bottoms from the distillation process have to be disposed of as a hazardous waste. A list of manufacturers of distillation equipment is provided in Table 33. In addition to recycling of solvent, this process also segregates 1,1,1-trichloroethane from other wastes, thus preventing cross-contamination with other cleaning wastes.

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

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

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[86] ASTM Standard D 3640-80.

Treatment - Solvent Cleaning

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

Filtration devices, when used in a vapor degreasing operation, remove particles and thus extend the life of the solvent and reduce cleaning frequency. Equipment suppliers (e.g., Motor Guard Corporation, 415/569-9766) must be contacted to obtain additional information about filtration equipment.

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

Freeze crystallization is a treatment process that selectively crystallizes certain components from waste solvent. The crystals can then be filtered and disposed of separately. A flow rate of 0.25 gal/min is required[87] for continuous operation of freeze crystallization equipment (e.g., Heist Engineering Corporation, 415/283-8121). Dissimilar metals may thus be removed from waste solvent. This treatment process must be designed on a case-by-case basis.

1,1,1-Trichloroethane - Offsite Treatment

Methods that solvent recyclers use for recovery of solvents include: distillation, solvent extraction, and ultrafiltration. A list of solvent recyclers is provided in Table 29. Thermal destruction of contaminated solvent in a hazardous waste incinerator for energy recovery is also a common treatment technique.

Treatment - Alkaline Cleaning

Caustic Wastes - Onsite Treatment

Cleaning of metal substrate 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. Sludge collected on the bottom of the treatment tank must be tested for hazard characteristics and disposed of properly.

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

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

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,[88] 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.[89]

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

[89] C.H. 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).

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.[90]

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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[90] *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.[91] 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.[92] 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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[91] *Prolonging Machine Coolant Life.*

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

Table 35

Waste Classification for IMSS

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

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

Table 36

Test Criteria for Trichloroethylene

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

Table 37

Test Criteria for Perchloroethylene

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

Table 38

Test Criteria for 1,1,1-Trichloroethane

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

Table 39

Aqueous Solvents and Suppliers

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

7 WASTE MINIMIZATION FOR PAINT SHOPS

Paints are applied to metal or other surfaces (e.g., wood) for waterproofing, flameproofing, rustproofing, insulating, etc. There are three different categories of paints: architectural, original equipment manufacture (OEM), and special purpose. Architectural paints are used on buildings. OEM paints are used in industries that manufacture automobiles, appliances, and furniture.[93] 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.[94]

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.[95] 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, large quantities of solvent wastes are generated during equipment cleaning. Table 40 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

[93] ICF Associates, Inc.
[94] P.L. Layman, "Paints and Coatings: the Global Challenge," *Chemical and Engineering News* (September 30, 1985), pp 27-68.
[95] 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 is easier to train people to use it. The operators' attitudes improve. The operation is less labor intensive. Maintenance is easier and the overall operating costs are lower. Powder costs are minimally affected by petroleum prices and the operation is more flexible to changing coating requirements.

However, powder application equipment is more expensive to install than solvent-based or high solids coating equipment. Another disadvantage is that powder coating must be done at elevated temperatures. It is not usable on heat sensitive substrates such as plastics, wood, and assemblies containing nonmetal parts. Formulations with lower cure temperatures (275 °F) are being developed.[96]

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.[97]

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.[98] 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.[99]

One company that unsuccessfully tried to convert to water-based painting reported that the increased drying time led to production scheduling problems. The new system took several hours for drying, compared to the 30 minutes required for the solvent based process. It required an increased amount of surface cleaning before the water-based coating could be applied. The time and cost

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[96] ICF Associates, Inc.
[97] ICF Associates, Inc.
[98] ICF Associates, Inc.
[99] 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.[100]

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

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

Radiation-curable coatings do not contain solvents and therefore could be good substitutes. A liquid prepolymer is allowed to react with a thinner under ultraviolet light to form a coating. These coatings have been found to be effective on a number of surfaces.[102]

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.[103] 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.[104]

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[100] ICF Associates, Inc.

[101] 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).

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

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

[104] 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.[105]

Solvent Wastes - Better Operating Practices - Maintain Equipment Properly

Proper equipment maintenance is critical to reducing the number of reject products and improving productivity.[106] 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.[107]

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.[108]

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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[105]ICF Associates, Inc.
[106]ICF Associates, Inc.
[107]ICF Associates, Inc.
[108]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 non-hazardous 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.[109] 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.[110] 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

[109] L.J. Durney.
[110] J. Kohl, P. Moses, and B. Triplett.

of a Navy study[111] 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.[112]

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 33 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.[113] 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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[111] Acurex Corporation, *Navy Paint Booth Conversion Feasibility Study*, CR 89.004 (Prepared for the Naval Civil Engineering Laboratory [NCEL], Port Hueneme, CA, 1989).

[112] 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.

[113] 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.[114]

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 40

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

[114] SCS Engineers, Inc.

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

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

A printing process usually follows image processing, including typesetting and the photographic processing step discussed above. However, an intermediate step to prepare plates to carry the image to paper is necessary. A roller transfers ink onto a plate or a cylinder. The image on the plate or cylinder is transferred to a rubber blanket which in turn transfers it to paper. There are four different types of image carriers: manual - in screen printing; mechanical - for relief printing; electrostatic - in offset duplicating; and photomechanical - most common method of platemaking.[115] 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.[116]

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.[117]

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 41 and 42.

Most of the waste minimization options discussed in this chapter have been extracted from *Waste Audit Study - Commercial Printing Industry*.[118]

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[115] Jacobs Engineering Group, Inc., *Waste Audit Study - Commercial Printing Industry* (California Department of Health Services, Sacramento, CA, May 1988).
[116] Jacobs Engineering Group, Inc.
[117] Jacobs Engineering Group, Inc.
[118] 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.[119] 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

[119] 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.[120] 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 - Extended 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:[121]

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.[122] 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.

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

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.

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 Chemicals 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.[123] 3M has also developed a platemaking system that eliminates the need for photoprocessing, and has been found to be economical for large plating operations.[124]

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.[125] 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.[126] Water-based inks are not available for lithographic printing operations.

[123] M.E. Campbell and W.M. Glenn.
[124] M.E. Campbell and W.M. Glenn.
[125] Jacobs Engineering Group, Inc.
[126] 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:[127]

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:[128]

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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[127] Jacobs Engineering Group, Inc.
[128] 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:[129] reducing the amount of hazardous silver compounds in wastewaters, extending the useful life of fixing baths, and redeeming the precious metal value of silver.

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

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

A detailed discussion of methods and procedures for silver recovery including: general procedures for hypo collection and recovery, procedures for removing silver from recovery units, recommended recovery procedures for use with automatic film processors, and procedures for using the metallic

[129] Jacobs Engineering Group, Inc.

replacement recovery cartridges are outlined in the Defense Logistics Agency's *Defense Utilization and Disposal Manual.*[130]

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.[131] 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.[132]

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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[130] *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.

[131] *Defense Utilization and Disposal Manual.*

[132] 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 41

Typical PPAS Operations With Materials Used and Wastes Generated*

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

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

Table 42

Waste Classification for PPAS

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

9 WASTE MINIMIZATION FOR HOSPITALS, CLINICS, AND LABORATORIES

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

For this discussion, some of the definitions for hospital wastes are extracted from Army Regulation (AR) 40-5.[133] Detailed definitions and classifications of infectious wastes can be obtained from USEPA's *Guide to Infectious Waste Management*.[134]

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.[135]

Radioactive wastes are usually generated by the radiology ward, nuclear medicine, clinical pathology, and laboratories that use radionuclides. Some of the radionuclides administered to patients during treatment include: $^{99\text{-M}}$Technetium, ^{51}Chromium, ^{32}Phosphorus, and ^{131}Iodine.[136] Most of the radioactive wastes that require special handling and disposal are generated by the use of radionuclides such as ^{14}Carbon, ^{4}Hydrogen, and ^{131}Iodine, in clinical laboratories.

A number of different types of hazardous wastes are generated in HCL, although in small quantities. Table 43 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.

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[133] Army Regulation (AR) 40-5, *Preventive Medicine* (HQDA, 30 August 1986).
[134] *Guide to Infectious Waste Management*, EPA/530-SW-86-014 (USEPA, Washington, D.C., 1986).
[135] 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.
[136] D. Kraybill, T. Mullen, and B.A. Donahue.

Photographic films and chemicals are used in radiology. Other toxics and corrosives are used throughout the hospitals.

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*,[137] and *Waste Audit Study - General Medical and Surgical Hospitals*.[138] 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).[139] 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.[140] 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.

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

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

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

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

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

Source Reduction - Infectious and Pathological Wastes

IW/PW - Better Operating Practices - Segregation/Labeling

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

IW/PW - Better Operating Practices - Collection/Transportation

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[141] has revealed that it is Extraction Procedure (EP) toxic for heavy metals.

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

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

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*.[142]

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[143] have to be complied with and the wastes must be turned in to the installation's hazardous wastes storage building.

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[142] *Infectious Hazardous Waste Handling and Disposal*, Technical Guide Number 147 (USAEHA, 1986).
[143] 40 CFR 262.34, *Onsite Accumulation Requirements*.

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

HW (solvents) - Product Substitution

Nonhalogenated solvents must be substituted for halogenated solvents (e.g., TCE, 1,1,1-trichloroethane, MC, etc.). Simple alcohols and ketones are good substitutes for petroleum 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.[145] Disposal actions must be coordinated with the installation's environmental office. Sewer disposal is an environmentally unsound practice and must be avoided.

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

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

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.

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.[146]

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).[147] 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.[148] However, the actual cleaning frequency must be determined based on the use and amount of spillage in the hood.

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[146] Ecology and Environment, Inc.
[147] Ecology and Environment, Inc.
[148] Ecology and Environment, Inc.

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.

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.[149]

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 33 lists manufacturers of industrial distillation equipment. For laboratories, stills made of glassware (process-spinning band distillation[150]) 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.

[149] Ecology and Environment, Inc.

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

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 29 lists some of them.

HW (mercury) - Offsite Recycling

If more than 10 lb of liquid mercury is accumulated, it can be sold to a commercial reprocessor.[151] 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.[152] 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.[153]

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[151] National Research Council, pp 44-55.
[152] National Research Council, Chapter 4.
[153] National Research Council, Chapter 9, pp 111-125.

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.

Table 43

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

Table 43 (Cont'd)

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

10 WASTE MINIMIZATION FOR OTHER SOURCE TYPES

Heating and Cooling Plants

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

A number of efficiency related boiler maintenance procedures can be used to minimize environmental pollution, while correcting malfunctions in boiler operation and preventing performance degradation. Component malfunction or performance degradation can cause increases in: stack gas temperature; excess air requirements; carbon monoxide, smoke, or unburned carbon in ash; convection or radiation losses from the boiler exterior, ductwork, and piping; blowdown above that required to maintain permissible water concentrations; and auxiliary power consumption by fans, pumps, or pulverizers. In addition to the normal maintenance recommended by manufacturers, efficiency-related maintenance procedures must be performed to extend equipment life and for personnel safety. These procedures include:[154] 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 44). Used oil that meets the specifications can be burned in any burner

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

(space heater, nonindustrial boiler, industrial boiler, utility boilers, and industrial furnaces),[155] whereas other waste oils can only be burned in high-efficiency industrial boilers, industrial process furnaces, or boilers that have demonstrated compliance with performance standards set for hazardous waste incinerators. Nonspecification used oils can be blended with virgin oil to meet specifications and burned in an industrial or nonindustrial boiler.

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

Laundry and Drycleaning Facilities

Laundry and drycleaning facilities on a Army installation are the responsibility of the DOL. Caustic soda and other corrosive chemicals are used in the laundry. Perchloroethylene (PERC) is the most common drycleaning solvent used. The two other solvents used are Valclene™ (fluorocarbon 113 or tetrachloroethylene), and petroleum solvent (Stoddard). Use of solvents and corrosive chemicals in these processes results in the generation of contaminated wastewater and dry wastes (Table 45). Table 46 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 45, 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 47 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

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

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

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

Pesticide Users

Army installations have a number of pesticide users including the entomology shop (pest control services), the garden shop (lawn, garden, and tree services), and the golf courses. Table 48 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.[156] Treatment methods include destruction with chlorine or lime, incineration, and carbon adsorption.[157] 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 49. OB/OD is the simplest and has been the primary method of demilitarization used at Army installations.[158] 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 50 lists the elements found in soils, including some that are regulated under RCRA and HSWA. Soils at all the active and inactive sites must be analyzed to determine the chemical content and proper disposal.

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[156] Ventura County Environmental Health, *Hazardous Waste Reduction Guidelines for Environmental Health Programs* (California Department of Health Services, Sacramento, CA, 1987).
[157] *Standard Handbook of Hazardous Waste Treatment and Disposal,* H.M. Freeman, Ed. (McGraw Hill, New York, NY, 1989).
[158] D.W. Layton, et al., *Demilitarization of Conventional Ordnance: Priorities of Data-Base Assessments of Environmental Contaminants,* UCRL-15902 (U.S. Army Medical Research and Development Command [USAMRDC], Fort Detrick, MD, 1986).

Some of the materials in the demilitarization inventories at installations may have a recovery value in excess of the cost of the original item because of the increase in material and manufacturing costs.[159] Recovery and reuse of such materials before burning will reduce raw material costs and production requirements, and, thereby, minimize wastes generated. A number of processes (e.g., resolvation of ground propellants, selective solvent extraction, disposal of scrap propellant, solution-pelletization, etc.) are available for recovery and reuse of propellants or their ingredients. Processing propellants by such reclamation techniques[160] 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[161] 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.[162] Many of the Army's USTs are more than 30 years old, greater than 10,000 gal, may contain hazardous substances, are made of steel, and have a high potential for leakage. A leak potential index (LPI)

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

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

[161] 40 CFR Parts 280-281, *Underground Storage Tanks: Technical Requirements and State Program Approval; Final Rule*, pp 37081 - 37247.

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

associated with the data base has been devised to indicate the likelihood of individual tank leakage.[163] The LPI is a tool that enables tank managers to group tanks based on the likelihood of leaks. This information indicates which tanks should be monitored more closely, which should be tested, and which should be considered for replacement.

The HAZMIN technique of inventory control is very effective in detecting tank leaks. This method requires regular measurement of the level of substances in the tanks. Records must also be maintained concerning addition and withdrawl of products. Comparison of inflow, outflow, and the inventory indicates product loss. Other leak detection methods can be grouped into volumetric methods, nonvolumetric methods, and leak effects monitoring.[164] 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 44

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

[163] 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.

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

* 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."

Table 45

Amounts of Typical Hazardous Wastes Generated from Drycleaning Operations*

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

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

Table 46

Drycleaning and Laundry Operations and Wastes Classification*

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

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

Table 47

Wastes Classification: Woodworking and Preserving Operations*

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

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

Table 48

Waste Classification: Pesticides*

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

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

Table 48 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Pesticides Containing Carbamates:				
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
Phenylmercurie 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 Nitrador	Waste substituted nitrophenol pesticide, liquid, NOS	Flammable liquid	UN2780
	Selinon Sinox Trifocide Trifrina			
Dinoseb	DNBP Basanite	Waste substituted nitrophenol pesticide, solid, NOS	Poison B	UN2779
	Caldon Chemox general	Waste substituted nitrophenol pesticide, liquid, NOS	Poison B	UN7890
	Chemox PE Dinitro	Waste substituted nitrophenol pesticide, liquid, NOS	Flammable liquid	UN2780
	Dinitro general Dynamite Elgetol 318 Gebutox			

Table 48 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Dinoseb (Cont'd)	Hel-Fire			
	Nitropone C			
	Premerge 3			
	Sinox general			
	Subitex			
	Vertac general weed killer			
	Vertac selective weed killer			
Organophosphate pesticides:				
Dimetboate	AC-12880	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			
	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			

Table 48 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
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, liquid, NOS	Flammable liquid	UN2784
	Bladan			
	Corothion			
	E-605			
	ENT 15108			
	Ethyl parathion			
	Etilon			
	Folidol E-605			
	Fosterno 50			
	Niran			
	Orthophos			
	Panthion			
	Paramar			
	Paraphos			
	Parathene			
	Parawet			
	Phoskil			
	Rhodiatox			
	Soprathion			
	Stathion			
	Thiophos			
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	Amerol	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			
	Simazol			
	Weedazol			
	Weedazol TL			

Table 48 (Cont'd)

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

Table 48 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
2.4,5-T (Cont'd)	Super D Weedone			
	Tormona			
	Transamine			
	U 46			
	Veon 245			
	Weedar			
	Weedone			
Silvex	2.4,5-TP	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			
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 48 (Cont'd)

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

Table 48 (Cont'd)

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

Table 48 (Cont'd)

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

Table 49

Ingredients Contained in Propellants, Explosives, and Pyrotechnics

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

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

Table 50

Common Elements Found in PEP and OB/OD Soil Residue

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

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

11 WASTE MINIMIZATION FOR MISCELLANEOUS WASTES

Polychlorinated Biphenyls

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

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

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

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

PCBs in Transformers

In the United States, there are 150,000 askarel (nonflammable electrical fluid) transformers, each of which contains thousands of pounds of PCBs with a wide range of concentrations.[165] 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.

[165] 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 51 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 52 lists the names and addresses of companies that provide retrofilling services.

USACERL's PCB Transformer System

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

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

Onsite Mobile Treatment Units

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

Lithium Batteries

Lithium batteries are discarded from troop equipment that uses batteries as a reserve power source. Six types of primary lithium batteries are commonly used: Li-CuO, Li-nnO2, Li-(CFx)n, Lithium Sulfur dioxide (Li-SO2), Li-SO2Cl2, and Lithium thionyl chloride (Li-SOCl2).

The U.S. Navy has proposed the development of a center of excellence to develop a fully permitted state-of-the-art, portable disposal technology for world-wide utilization.[166] A study conducted

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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).

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

by USAEHA to evaluate the disposal of lithium batteries under RCRA regulations,[167] noted that fully charged and duty-cycle discharge batteries were hazardous because of reactivity and/or ignitability characteristics and must be discharged through the DRMO. Fully discharged batteries are not hazardous and could be disposed of in a permitted landfill. Assurances must be sought that the batteries have reached their fully discharged state. Manual discharging methods such as soaking in an aqueous solution are not practical and alternative approaches must be explored.

A recent review presents general information regarding lithium batteries.[168] It includes information about battery technology, safety aspects, purchasing, packaging, transport, storage, and disposal.

Ordnance

A number of hazardous ordnance materials are used on Army installations. Ingredients contained in some of them were listed in Table 49. Further details are available in Technical Manual (TM) 9-1300-214.[169] Army directives prohibit burial of ordnance materials or dumping them in waste places, pits, wells, marshes, shallow streams, rivers, inland waterways, or at sea. All existing locations of buried explosives must be identified and marked accordingly. The only means of disposal available is destruction by burning and detonation (discussed in Chapter 10). Proper operating procedures for disposal of discarded ordnance materials should be developed and updated frequently to comply with Federal, State, and local regulations.

Contaminated Soil

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

A number of nonthermal and thermal treatment techniques are available for decontamination of soil.[170] 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.

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

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

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

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

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.[171] 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:[172] returning drums to suppliers, contracting with a drum conditioner, contracting with a scrap dealer, and, lastly, disposal in an approved landfill.

Returning Drums to Suppliers

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

Contracting With a Reconditioner

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

Contracting With a Scrap Dealer or Disposal in a Landfill

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

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[171] Ventura County Environmental Health, p 3-2.

[172] *Managing Empty Containers*, Fact Sheet (Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Table 51

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 52

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 Draft Technical Report[173] for a detailed discussion of the process of economic analysis and use of the model.) A part of the model related to nonspecific or "general" waste types is used to determine the life cycle costs and comparison of alternatives for waste streams in this report. Many other publications on economic analysis are available.

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

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

Used Oil

A large quantity of used oil, primarily engine lubricating oil, is generated on Army installations. Fort Carson generates 114,000 gal/yr of used oil; 5700 gal/yr of it is chlorinated waste oil. 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

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

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

A comparison of the life cycle (10-yr) costs for the two techniques was p[illegible]d for fleets ranging from 50 to 5000 vehicles.

Investment costs for the purchase of a FLOC evacuation unit and engine adapter kits are assumed to all occur in the first year. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for both options. The model's default values retained for this analysis include: site preparation and installation - 15 percent of total equipment costs; logistics and procurement - 7 percent of installed equipment costs; contingencies - 10 percent of installed equipment costs; labor rate (manager) - $16.00 per hour; labor rate (laborer) - $11.00 per hour; 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 Operational and Maintenance (O & M) costs. Other assumptions made in the analysis 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 procurement cost of a small FLOC evacuation unit and engine adapter kits is approximately $2260. An additional $2265 is required to implement this system for costs of site preparation and personnel training. The cost of larger evacuation units increases with size.
- The system is used 260 working days per year.
- The utility cost for each FLOC unit is $75/yr/unit.
- Costs do not escalate.
- Repair and maintenance is $50/yr/unit.
- One FLOC unit can handle approximately 35 to 40 vehicles per day. If more than 10,000 oil changes are conducted annually, two or more units will be required.

Table 53 lists the saving to investment ratios (SIRs) and discounted payback periods (DPPs) for implementing a FLOC system to service 100, 250, 500, 1000, and 5000 vehicles twice per year. In almost every case, the SIR is 0.39 (1 = economical) and therefore provides no DPP within the expected economic life of the equipment. Table 54 lists the computer SIRs and DPPs when the average number of oil changes per vehicle increases from two up to six times per year for 1000 vehicles. Only when the number of oil changes per vehicle each year is six or greater, which is not likely to occur, does the FLOC system become cost effective to implement.

Other options analyzed for management of used oil include: (1) minimal processing, blending, and burning (status quo); (2) minimal processing, offsite disposal; (3) comprehensive processing, blending, and burning; (4) comprehensive processing, sale to an offsite recycler; and (5) minimal processing, sale to an offsite recycler. Proper segregation of used oil from other wastes generated on Fort Carson is a prerequisite for all management options analyzed. It is particularly important for option 5. The water content in the used oil cannot exceed 5 percent for a recycler to purchase it. Five percent of all the oil generated is assumed to contain halogenated contaminants at concentrations greater than 1000 ppm and has to be disposed of as a hazardous waste.

Investment costs for a vacuum dehydrator and degasifier[174] used in comprehensive processing are assumed to be all incurred in the first year. A 10-year economic life and midyear discounting at a rate of 10 percent are assumed for the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/hr,
- Labor rate (laborer) - $11.00/hr,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Transportation of hazardous waste - $0.04/lb, and,
- Annual logistics and procurement - 1.6 percent of other O&M costs.

The major assumptions made in the analysis were:

- Nonsegregated oil may be considered hazardous depending on the concentration of halogens and heavy metals.

[174] Baron and Associates, Inc., Cookville, TN; (615) 528-8476.

- Hazardous oil, when burned in a boiler without permits, is subject to fines. Operating without permits or in violation of permits will cause the facility to be shut down by the regulating agency.

- Disposal cost for hazardous halogenated oil is $4.50/gal.

- Disposal cost for nonhazardous nonhalogenated oil is $0.75/gal.

- Disposal cost for oily sludge generated from comprehensive and minimal processing activities is $3.25/gal.
- Transportation cost for onsite transfer and consolidation of hazardous and nonhazardous used oil and oily sludge generated from processing activities is $0.10/gal.

- Sampling and testing costs for the oil before its transfer to the boiler facility and before burning, offsite disposal, or offsite sale are $0.036/gal and $0.006/gal, respectively.

- Fifty-five gallon disposal drums required for containerization of oily processing sludge are $20.00 each.

- Liability cost for onsite transportation and transfer of nonhazardous used oil, hazardous waste oil, and processing sludge is $0.002/gal. Liability costs associated with all offsite transportation is $0.008/gal.

- Labor costs are assumed to accrue at the following rates: onsite transfer of waste oil and processing sludge to DRMO for disposal - 0.01 hr/gal; onsite transfer of nonhazardous oil to the boiler facility - 0.0008 hr/gal; minimal processing at the boiler facility - 0.0016 hr/gal; and drumming of processing sludge and upkeep of minimal processing equipment - 0.0002 hr/gal.

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

- Maintenance and repair costs for minimal processing equipment and comprehensive processing equipment are $0.001/gal and $0.006/gal, respectively. Maintenance costs associated with boiler equipment for blending and burning options are $0.11/gal with minimal processing and $0.03/gal with comprehensive processing.

- Utility costs for minimal and comprehensive processing equipment are based on default values provided in the economic analysis model. For minimal processing of used oil, a cost of $0.005/gal is assumed; for comprehensive processing, it is $0.013/gal. An additional cost of $0.005/gal of used oil is assumed for wastewater treatment associated with comprehensive processing.

- Sale to an offsite recycler is applicable only to nonhazardous oil and is contingent upon proper segregation and prevention of excessive water contamination. Used oil can be sold to such a recycler for $0.05/gal after comprehensive processing, and for $0.015 with only minimal processing.

- Escalation rates used for some of the costs are as follows: transportation - 4 percent; liability -

4 percent; disposal - 8 percent; sampling and testing - 4 percent; other materials and supplies - 4 percent; maintenance and repair - 4 percent; and utility - 4 percent.

Figure 5 compares the NPVs of the life cycle (10-yr) costs for the five used oil management options. Oil mixed with solvents may be a hazardous waste and must be tested to prove otherwise. Burning hazardous waste in the Fort Carson boilers is prohibited. Option 2 (offsite disposal) is the most expensive option at any generation rate. The current practice (option 1) of minimal processing, blending, and burning in a boiler is the next most expensive option. Comprehensive processing requires investment in a vacuum dehydrator. Because of the reduced maintenance and repair associated with boiler and labor costs, option 3 is less expensive than option 1. The sale options (4 and 5) cost about the same. Used oil sale prices of \$0.05/gal and \$0.015/gal are used in options 4 and 5, respectively. Five percent of the oil still must be disposed of as a hazardous waste.

At the current generation rate (114,000 gal/yr), the NPV O&M cost for the status quo option is \$553,344 (\$55,334/yr). By investing \$17,855 in a vacuum dehydrator for comprehensive processing, blending, and then burning (option 3), an annual savings of \$8520 could be realized over the present operating costs. The SIR and DPP computed for this change are approximately 4.77 and 3.91 years, respectively. The sale of used oil, following comprehensive processing to lower its water content (option 4), could produce an annual savings over the status quo of \$14,541. The SIR and DPP computed for this comparison are approximately 8.14 and 2.36, respectively.

Sale of used oil following minimal processing or sale of used oil following comprehensive processing, are the lowest cost management options for Fort Carson. However, it is very difficult to find a recycler for used oil unless its water content is below 5 percent. Purchase of a vacuum dehydrator and implementation of option 3 is recommended. The proper storage and careful segregation of used oil from hazardous waste streams (i.e., solvents, hydraulic fluid, contaminated fuels, etc.) and other contaminants (i.e., rain water, dry sweep, etc.) must be strictly enforced at all the vehicle maintenance facilities.

Antifreeze Solution

MPVMs are the primary generators of waste antifreeze solution during regular maintenance of vehicles and major radiator repairs. Since the antifreeze solution is not considered a hazardous waste, it is diluted with water and drained into a sewer in most Army installations. Recycling of the waste solution is possible as discussed in Chapter 5. It was considered as a minimization alternative and the results of the economic analysis is presented below.

Investment costs for the antifreeze recycling machine are assumed to be all incurred in the first year. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - \$16.00/hr,

* Adjustments for leave - 18 percent of total man hours,
* Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
* Number of work days in a year - 260,
* Average maintenance - 5.75 percent of equipment costs,
* Transportation of hazardous waste - $0.04/lb, and,
* Annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the assumptions made in the economic analysis are:

* Disposal cost of antifreeze is $6.50/gal.
* Labor hours for manager (bids, etc.) - 1 hr/1000 gal; and laborers (drumming and transport) - 1 hr/100 gal.
* Cost of "Glyclean" recycling system is $2,368. Two "Glyclean" systems are required when waste generation rates exceed 10,000 gal/yr.
* The cost of a 55-gal drum of "Glyclean" additives is $26.65/gal. About 0.03 gal of additive is needed per 1 gal of antifreeze recycled.
* It takes about 0.5 hr to recycle 100 gal of used antifreeze.
* The purchase price of new antifreeze is $8.45 per gallon (on GSA schedule)
* Recycled antifreeze is equivalent to a 50 percent mixture of antifreeze and water.
* Utility costs associated with "Glyclean" machine operation is $0.02/gal of waste.
* A 50 percent dilution with water is used for the first year of purchase; no dilution is required in subsequent years.
* Repair and maintenance cost is $0.006/gal.
* The liability cost for both disposal and reuse is $0.01/gal.
* The industrial waste treatment cost after discharge is $3.10/1000 gal of wastewater.
* Escalation is 8 percent for disposal and 4 percent for others.

- Onsite transport cost from point of waste generation to recycling facility and back or to DRMO for disposal is $2.00/100 gal.

Figure 6 shows the comparison among the total life cycle (10-yr) costs for the following management options: (1) offsite disposal; (2) onsite recycling and reuse with one "Glyclean" recycling systems; (3) discharge to the IWTP (status quo); and (4) onsite recovery and reuse with two "Glyclean" systems. Recycling antifreeze solution onsite results in a considerable savings over both disposal and discharge options at any generation rate.

Fort Carson generates 30,445 gal/yr of spent antifreeze solution. The NPV of the current management practice amounts to $979,514 per 10 years (or $97,951/yr). Purchasing two recycling systems would require an NPV investment of $166,481. The resultant NPV savings would be $742,930 (or $74,293/yr). The SIR and DPP computed for this conversion are estimated at 4.46 and 2.57 years, respectively. The purchase of two "Glyclean" reconditioning systems and the implementation of an onsite recycling program for spent antifreeze is recommended.

Cleaning Solvent Waste

Cleaning solvents such as petroleum distillates (PD680-II), petroleum naptha, varsol, etc., are used in parts cleaning operations as discussed in Chapter 5. At Fort Carson, the most widely used practice is that of contract recycling. Safety Kleen (SK) is the contractor that leases parts cleaning equipment and replaces the solvent periodically. The estimated waste generation rate is 30,610 lb/yr (5940 gal/yr).

Management options chosen for economic analysis in this section are: (1) onsite distillation and reuse through the purchase of a 55-gal batch still; (2) contract recycling with low flash point solvent and leased parts-washing equipment (LE 105); (3) contract recycling with low flash point solvent and government owned parts-washing equipment (OE 105); and (4) contract recycling with high flash point solvent and leased equipment (LE 140). Investment costs required for distillation equipment and a startup volume of fresh solvent in option 1 are assumed to be incurred in the first year. A 10-yr economic life and a midyear discounting at a rate of 10 percent are assumed for all the options. The model's default values retained for this analysis include:

- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/hr,
- Labor rate (laborer) - $11.00/hr,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,

- Transportation of hazardous waste - $0.04/lb, and

- Annual logistics and procurement - 1.6 percent of other O&M costs.

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

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

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

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

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

- Volume of the still bottoms is assumed to be 10 percent of the total waste stream.

- Fresh solvent make-up is expected to be 30 percent of the waste volume to be purchased every year.

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

- Laboratory analytical costs are assumed to be a minimum of $50.00/yr.

- Transporting and warehousing costs are based on the volume of wastes generated; about $2.00/100 gal.

- The cost of electricity is $0.05 per kWh.

- The cost of disposal of still bottoms (assumed hazardous) is $4.00/gal.

- Cost of new solvents (SK - flash point 105 °F, boiling point 310-400 °F) is $1.60/gal, and PD 680-II (NSN 6850-00-285-8011) is $2.24/gal.

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

- Labor cost for loading and unloading the still will be less than 2.0/hr. According to manufacturers, the loading and unloading of a 55-gal still varies from 1/4 to 1/2 hr/batch.

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

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

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

- A one-time installation charge associated with 30-gal capacity washers is $30.00 per wasner and is considered an investment cost.

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

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

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

Figure 7 shows the comparison of the NPV total life cycle (10-yr) costs for the different management options over a waste generation range between 5000 and 40,000 gal/yr.

SK is a private vendor of cleaning and degreasing solvent recycling services (on GSA schedule through June 1991) that currently maintains a contract with Fort Carson (option 2). With few exceptions, most of the vehicle maintenance facilities on Fort Carson have been equipped with parts-washing equipment leased from SK. The cleaning equipment varies in style and capacity from 5-gallon, multi-level units up to 40-gallon stationary tanks that require special installation. Each unit is serviced monthly by SK and replenished with clean, recycled solvent. The solvent supplied by the vendor is roughly equivalent to PD680-I in flash point and chemical composition. SK assumes the responsibility for spent solvent containerization, transport to the recycling facility, and disposal of solvent tank bottom: The spent solvent and tank bottoms are manifested as hazardous waste based on the flashpoint ot the fresh solvent (105 °F). Although a nonhazardous solvent with a higher flashpoint (140 °F) is available from the vendor, it has not been requested by Fort Carson because of its prohibitive cost. The annual operating costs of the current contract with SK are estimated at $71,000. Switching to a higher flashpoint solvent (option 4) would require an addition $29,000/yr at the current contract volume. Option 4 is the most expensive management alternative examined in this analysis.

Onsite distillation (option 1) with a 55-gal still is the most economical option. An investment of $60,162 results in NPV savings of $330,971 (or $33,097/yr) when compared to the status quo (option 2). The SIR and DPP are 5.50 and 2.73, respectively. Although onsite distillation is an economical option, switching to it would cause a number of logistics and other problems in procurement of new solvent, transport of solvent, full-time operation of a still, etc.

Contract offsite recycling (with leased equipment) is an effective waste minimization option. Its continuation with a higher flash point solvent (option 4) is therefore recommended.

Lead-Acid Batteries/Battery Acid

An estimated 6300 nonserviceable lead-acid vehicle batteries were generated on Fort Carson in FY 1988-1989. The acid from all nonserviceable batteries is drained and neutralized with sodium bicarbonate. At the time of this investigation, only one of the installation's three lead-acid battery shops was functioning as a neutralization point (DOL - Bldg 8000). Neutralization at the other two shops had been halted due to problems with inadequate ventilation and space (Bldg 8030) and with the neutralization sump drainage connect at Bldg 8142. The acid from batteries brought to Bldg 8142 is still drained, but into 55-gal plastic drums for transport to Bldg 8000 for neutralization. All empty battery casings are inverted, deliberately punctured, and strapped to wooden pallets for shipment to a contractor of the Department of Energy (DoE) in Idaho Falls, ID, for lead recovery.

An economic analysis was performed to compare the costs and benefits of four different management options for nonserviceable lead-acid batteries. Options formulated for comparison are: (1) draining batteries for casing transfer to DoE and disposal of acid as hazardous waste; (2) no draining by recycling the batteries with their acid through a local contractor (assuming no cracked batteries are generated); (3) recycling noncracked batteries with their acid through a local contractor and then draining and neutralizing the acid from cracked batteries (assuming 10 percent of the nonserviceable batteries are cracked); and (4) draining and neutralizing acid from all nonserviceable batteries and transfer of the dry casings to DoE (status quo).

Investment costs for neutralization in options 3 and 4 are assumed to be incurred in the first year. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/hr,
- Labor rate (laborer) - $11.00/hr,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Transportation of hazardous waste - $0.04/lb,
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other assumptions used in the calculations are:

- Weight of a typical battery without electrolyte is 50 lb.
- Volume of electrolyte per battery is 1.5 gal. (@ 9.99 lb/gal).
- Weight of electrolyte per battery is 15 lb (density - 10 lb/gal).
- Sale price of casings through DRMO is $0.0214/lb as scrap.
- The cost of disposal of drummed electrolyte is $6.00/gal.
- Cost escalation factors: disposal, 8 percent; liability, 4 percent; raw materials, 4 percent; other materials/supplies, 4 percent; sampling/testing, 4 percent; maintenance and repair, 4 percent; and IWTP costs, 4 percent.
- Transportation and storage cost is $0.07/battery and $0.04/gal of electrolyte.
- Transportation cost of sump sludge to DRMO is $0.02/gal of treated electrolyte.
- Liability costs for disposal, $0.013; transport, $0.002/lb of casings, and draining, $0.001; or precipitation, $0.001/lb of electrolyte.
- Cost of sodium bicarbonate is $0.13/gal of electrolyte neutralized;
- The quantity of neutralized sludge produced is 0.05 lb/lb of electrolyte.
- Neutralized sludge disposal cost (including labor) is $0.05/lb.
- Wastewater treatment cost is $3.10/1000 gal.
- Labor hours in bringing batteries to DRMO is 1 hr/150 units.
- Labor hours for bringing drummed electrolyte to DRMO is 0.5 hr/55 gal drum.
- The purchase price of a 55-gal plastic disposal drum is $20.00.
- Battery salvage value is $0.0214/lb.
- The labor hours for draining and drumming of electrolyte is 0.04 hr/gal.
- The labor hours for monthly neutralization sump maintenance (cleaning, drum, and transport to DRMO) is assumed to be 2 hr.
- Costs associated with neutralization sump and pH meter upkeep are $10.00/1000 gal of electrolyte treated ($0.01/gal).
- Labor hours required for neutralization is 0.02 hr/gal of electrolyte.

- Labor hours for manager (for bid preparation, etc.) is 1 hr/500 batteries.

- Batteries are sold to a recycler (American Battery Company, Colorado Springs, CO) at $2.25/65 lb.

- No site preparation costs.

- Sampling and testing costs are $0.05/gal.

Figure 8 shows a comparison of the total life cycle (10-yr) costs of options 1 through 4. Option 1 is always more expensive than options 2, 3, and 4 over the range of 1000 to 200,000 gal/yr. Wet recycling (option 2) results in net earnings rather than costs and is therefore the best option. Assuming that 10 percent of the batteries are cracked, disposal of spent electrolyte from them and the wet recycle of uncracked batteries (option 3) is less expensive than draining and neutralization (option 4). The actual number of cracked batteries may be a lot smaller than the assumed 10 percent and will lower the slope of the line corresponding to option 3 in Figure 7.

Fort Carson generates 9500 gal/yr of spent electrolyte. At this rate, switching to wet recycling will result in NPV savings of $87,615 (or $8615 per year) and additional revenue of $26,740 in 10 years (or $2674 per year). Assuming that 10 percent of the batteries get cracked, wet recycling of uncracked batteries and disposal of acid would result in a net savings of $52,813 (or $5281 per year). Disposal of all the acid as a hazardous waste can be done at an annual operating costs of $64,691.

The onsite neutralization of battery acid with sodium bicarbonate on Fort Carson constitutes elementary treatment and is permissible under State and Federal regulations provided the discharged effluent is not laden with lead or other EP Toxic heavy metals. The only effluent parameter regularly tested has been pH. In June 1990, grab samples were collected from the neutralization sump in Bldg 8000 for heavy metal analysis. Should the sump samples test positive for EP Toxicity, a strong possibility exists that discharged effluent could also be toxic. In terms of regulatory compliance and future liability associated with environmental contamination, the continued practice of draining and neutralizing the acid from all the nonserviceable lead-acid batteries generated on Fort Carson is not sound. Private battery recyclers, as well as the contractor currently employed through the DoE, are willing to accept nonleaking batteries with their acid. From legal, waste minimization, and economic perspectives, wet recycling through a local contractor is the best management option for nonserviceable lead-acid vehicle batteries generated on Fort Carson, and is strongly recommended.

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

A 250-gal capacity, vapor spray degreaser that uses 1,1,1-trichloroethane is regularly used at Bldg 8000 (DOL - Maintenance Operations Branch - Consolidated Maintenance Building) for the rapid degreasing of large vehicle assemblies and related components. The degreaser is set into the floor of the maintenance bay and is as old as the building (1973). Because of its age, the degreaser is exempt from current air pollution emission standards enforced by the State for this type of equipment. Because of its older design, with hinged, gull-winged door covers and low freeboard height, and from impatient operating practices involving rapid equipment drag out, a large quantity of solvent is lost to drippage outside the confines of the tank and to evaporation during its operation. Hazardous waste streams generated from its operation include spent 1,1,1-trichloroethane and degreaser tank bottoms; which contain solvent residues, grease and dirt, and trash (torn gaskets and other small items loosened from parts during cleaning). Fifty-five gallons of fresh solvent is added to the tank's sump weekly to replenish loses to evaporation and carry-off. The degreaser is shut down approximately four times each year for cleaning and maintenance. During each cleaning, the sump is completely drained and refilled with 250 gallons of fresh solvent. Approximately 5280 pounds of degreaser tank bottoms and fallen debris are removed from the degreaser annually. An economic analysis was performed to determine the practicality of retrofitting the existing degreaser with new equipment to improve its operating efficiency and to achieve a reduction in generated wastes. Technologies considered in this analysis include: online and batch-type solvent distillation equipment; a motorized, biparting, horizontal power cover; and increasing the freeboard height. The substitution of different cleaning agents for 1,1,1-trichloroethane or replacing the process altogether with high pressure jet washers were not considered practical options given the variability in size and desired cleaning precision of equipment used in the degreaser, the frequency of its use, and the increased drying times associated with aqueous or caustic based cleaners.

Investment costs for the equipment modifications are assumed to be all incurred in the first year. A 10-yr economic life and midyear discounting at a rate of 10 percent are assumed for the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/hr,
- Labor rate (laborer) - $11.00/hr,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Transportation of hazardous waste - $0.04/lb,
- Annual logistics and procurement - 1.6 percent of other O&M costs.

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

- An escalation rate of 4 percent was applied to the recurring costs of raw replacement materials, replacement materials, liability, utilities, other materials and supplies, maintenance and repair, and sampling and testing.
- An escalation rate of 8 percent was assumed for offsite disposal costs.

- Liability costs were assumed as follows: onsite distillation and reuse - $0.03/gal, vapor degreaser operation - $0.01/gal, and offsite disposal - $0.08/gal.

- During the batch recycling process, it was assumed that 20 percent of the waste stream was lost with each distillation cycle. Ten percent of the waste was assumed to have evaporated and 10 percent was lost to still bottom residue.

- With the closed-loop (continuous) recycling process (in-line, continuous flow distillation unit) 10 percent of the waste stream was assumed lost to still bottoms, with no evaporative loss.

- Evaporative loss from operating the vapor degreaser as it is presently equipped was assumed to be 55 gal/week. Thirty seven percent less evaporative loss was estimated to result from the implementation of a motorized power cover and a 15 in. increase in freeboard height.

- During 1 year, 660 gal of degreaser tank sludge were generated and required disposal as a hazardous waste.

- Repair and maintenance costs for major equipment were based on use rates and 5.75 percent of the original purchase prices. If equipment was used less than 2080 hr/yr, costs were adjusted.

- Fifty-gal drums needed for disposal of vapor degreaser tank bottoms, distillation residue, and spent solvent were estimated to cost $20.00 per drum.

- Disposal costs for solvent tank bottoms, and distillation residue are $3.00/gal.

- The purchase cost for fresh solvent is $6.75/gal.

- Transportation costs for solvent still residue, and tank sludge from point of generation to DRMO for disposal are $2.00/gal.

- Costs of cooling water and electricity were assumed to be $0.70/1000 gal and $0.05 per kWh, respectively. Annual utility costs for vapor degreaser operation (which requires steam, cooling water, and electricity) were approximately $2288/yr. Utility costs for batch and online distillation units are $0.10/gal of recycled 1,1,1-trichloroethane.

- Sampling and testing costs are $50/yr.

- Labor costs associated with the vapor degreaser cleaning, maintenance, and solvent replenishment (status quo) were estimated from a requirement of 109 hr/yr. This estimate was held constant for options using batch distillation units. A 37 percent reduction in replenishment time and a 50 percent reduction in cleaning and replacement time were predicted with the implementation of an on-line distillation unit and a motorized power cover with increased freeboard height.

- Labor hours associated with the transport of spent solvent tank bottoms and distillation residue were held constant for all options at 1 hr/100 gal.

- Labor hours associated with the operation of batch distillation units (loading and unloading) were based on manufacturer estimates of 3/4 hr/batch for a 15-gal still and 1-1/2-hr/batch for a 55-gal still. Similar labor costs were not associated with the in-line unit.

- Managerial labor costs were assumed to accrue in a supervisory capacity at a rate of 1 hr for every 24 laborer hours.

- Major equipment costs used in this analysis were as follows: 15-gal batch still - $10,128, 55-gal batch still - $24,609, 40 gal/hr in-line distillation unit (Detrex Model FC-15-SW) - $15,500 (including installation), and motorized bi-parting power cover (from Detrex) with a 15 in. increase in freeboard height - $20,000 (including installation).

- Startup expenses for all options included initial purchase of 80 percent of the 1,1,1-trichloroethane normally used.

With the above assumptions, life cycle (10-yr) costs were calculated for: (1) offsite disposal and purchase of fresh solvent (status quo), (2) onsite distillation with a 15-gal still, (3) onsite distillation with a 55-gal still, and (4) onsite, in-line distillation with a 40 gal/hr distillation unit with the addition of 15 in. to the freeboard height and a motorized, bi-parting power cover.

Table 56 shows the detailed comparison of all the options at the current waste generation and material usage rates. The NPV O&M costs for the current practice is $295,122 ($29,512 per year). Investing $44,767 in the equipment modifications will result in an annual savings of $13,956. The SIR and DPP are 3.12 and 4.22, respectively. Therefore, such an investment is recommended for Fort Carson. The investment will lead to both waste minimization and economic payoff (i.e., payback in 4.22 years).

Paint Thinner Waste

Paint thinner waste is generated from the cleaning of painting equipment as discussed in Chapter 7. Onsite distillation (with a 5-gal batch still) and contract recycling were the two options examined and compared with the current practice of purchasing fresh thinner and offsite disposal (1004 gal/yr).

Investment costs for onsite distillation are assumed to be all incurred in the first year. A 10-yr economic life and mid-year discounting at a rate of 10 percent were assumed for all the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,

- Logistics and procurement - 7 percent of installed equipment costs,

- Contingencies - 10 percent of installed equipment costs,

- Labor rate (manager) - $16.00/hr,

- Labor rate (laborer) - $11.00/hr,

- Adjustments for leave - 18 percent of total man hours,

- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,

- Number of work days in a year - 260,

- Average maintenance - 5.75 percent of equipment costs,

- Transportation of hazardous waste - $0.04/lb,

- Annual logistics and procurement - 1.6 percent of other O&M costs.

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

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

- An escalation rate of 8 percent was assumed for offsite disposal costs, and 6 percent for cor..ract recycling 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 is assumed to evaporate 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 is an annual cost that is 5.75 percent of the original cost of the equipment and is based on a continual use of 2080 hr/yr. If the equipment is not used for the total time, the costs are adjusted accordingly.

- Laboratory analytical costs are estimated to be a certain percentage of labor costs. However, the minimum laboratory cost per sample may be substantially higher than the computed value for wastes generated in small volumes. A minimum of $50.00 is assumed.

- Transportation and warehousing costs depend on the volume of waste handled and the distance between points of waste generation and distillation based on cost of $0.50/mi.

- Costs of cooling water and electricity are assumed to be $0.70/1000 gal and $0.05/kWh, respectively.

- Disposal cost of thinner waste is $3.00/gal (1989 price - DRMO).

- 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 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. Therefore, vacuum attachments are not required.

- GSA price for 5-gal size paint thinner is $3.65/gal. If available in a 55-gal drum, the price could be even lower. For purpose of this analysis a price $3.65/gal is assumed.

- Labor costs for loading and unloading of the still, especially for batch 5-gal or 15-gal sizes, will be less than 2 hr (default value in the model). The labor requirement for operating 5-gal and 15-gal stills are 1/2 and 3/4 hr/batch, respectively.

- 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. Currently, it is estimated that the cost of power per gallon of solvent distilled is $0.10.

- Equipment manufacturers such as Finish Engineering, Recyclene, and Progressive Recovery, Inc., were contacted for the price of distillation equipment. The price of one manufacturer was competitive with the price of similar equipment of another manufacturer (Table 55). Since Finish Engineering currently has a GSA contract, the corresponding GSA prices (5-gal, $2770; 15-gal, $10,128) for stills with no vacuum attachment were used.

- Eighty percent of the cost of initial purchase of raw materials is included with the initial cost of equipment. The remaining 20 percent was included as an annual operations and maintenance cost.

- Cost of leasing equipment and supply/recycle of thinner obtained from SK is $75 per batch. The volume of each batch is 7.5 gal. Liability costs associated with the contract, transportation, and ultimate disposal in this arrangement is assumed to be $0.01/gal.

With the above assumptions, life cycle costs were calculated for: (1) offsite disposal and purchase of fresh thinner (status quo or current practice), (2) contract closed-loop recycling or disposal, (3) onsite distillation with a 5-gal still, and (4) onsite distillation with a 15-gal still. Net present values of total 10-yr costs were calculated for the above options for a number of annual generation rates ranging from 100 to 2000 gal/yr. Figure 9 shows the comparison between the NPVs for all the options.

There are no investment costs associated with options 1 and 2. A 5-gal still (option 3) is cost effective beyond 150 gal/yr when compared to offsite disposal. It is more cost effective than contract recycling (option 2) from volumes as low as 50 gal/yr. Option 2 is, therefore, the most expensive option for generation rates beyond 50 gal/yr.

Fort Carson generates about 1004 gallons per year of paint thinner waste which is disposed of through DRMO. The NPV operating costs for the current practice are $114,933 ($11,493/yr). Investing $18,568 for a 15-gal still will result in an annual savings of $7260. The SIR and DPP are 3.91 and 3.53, respectively. The purchase of a 15-gal still is therefore recommended. In addition to minimizing wastes, a payback can be expected in less than 4 years.

Table 53

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 54

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

Table 55

Purchase Cost (1989) of Distillation Stills

Manufacturer	Model	Capacity (gal)	Price ($) no vacuum attachment	Price ($) vacuum attachment
Finish Engineering	LS-Jr	5	$ 2770	$ 4338
	LS-15IID	15	$ 10,128	$ 13,361
	LS-55IID	55	$ 20,123	$ 24,609
Recyclene	R-2	5	$ 2995	
	RS-20	20-25	$ 11,900	
Progressive Recovery, Inc.	SC-25	15	$ 7290	$ 12,865
	SC-50	35	$ 11,300	$ 16,895

Table 56

Comparison of Minimization Options for 1,1,1-Trichloroethane Wastes

Option Name	Inv. Costs. ($)	O&M Costs	Total	SIR	DPP
Offsite disposal (current practice)	0	295,122 (29,512)	295,122	-	-
15-gal Batch Still	$16,453	220,631 (22,063)	237,084	4.53	3.51
55-gal Batch Still	$32,613	218,170 (21,817)	250,783	2.36	5.99
40 gal/h In-line Still with power cover and 15 in. freeboard increase	$44,767	155,565 (15,557)	200,332	3.12	4.22

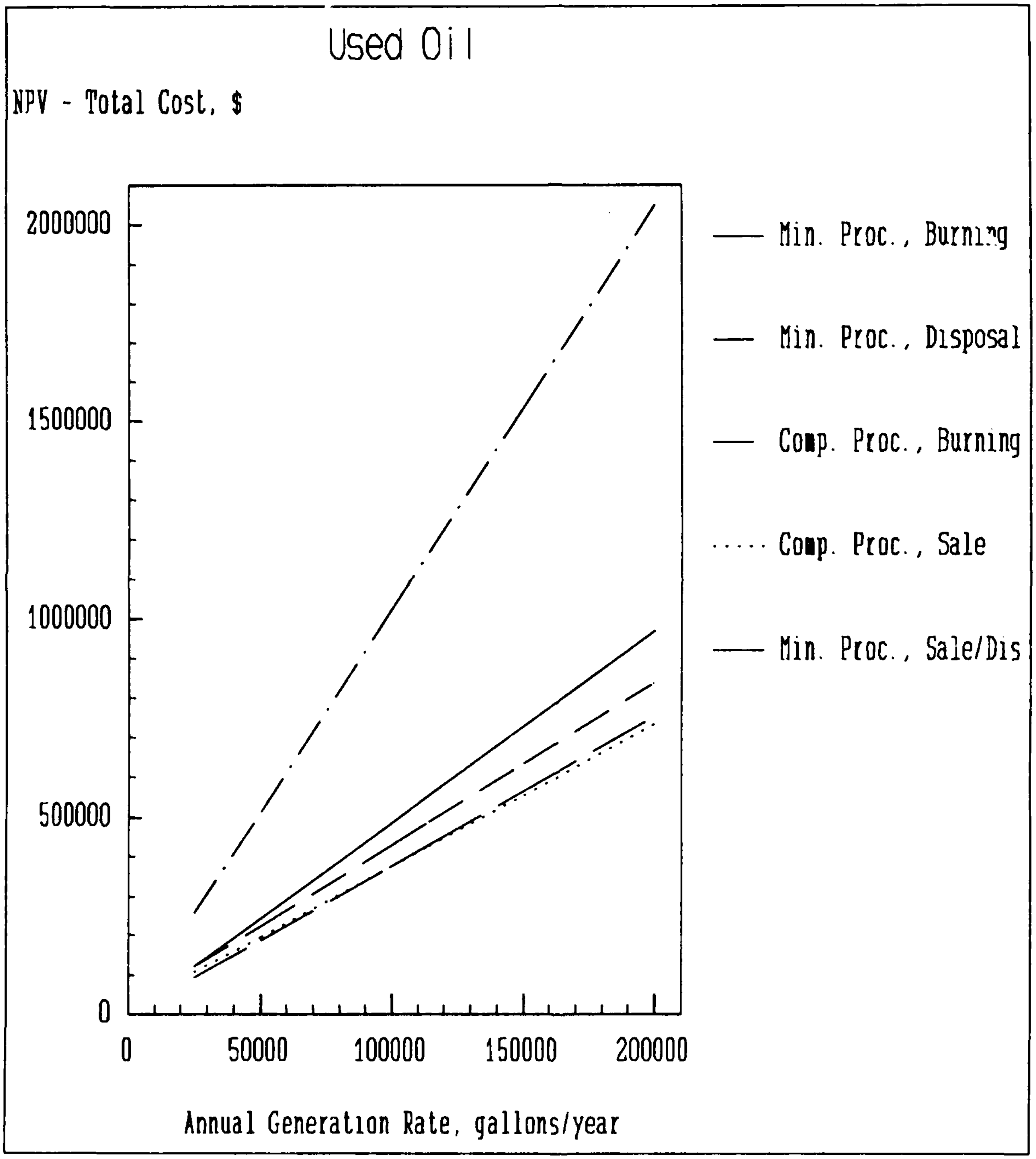

Figure 5. **Comparison of the NPVs of the total 10-yr costs of implementing options for the minimization of used oil.** Minimal processing and then burning defines the status quo.

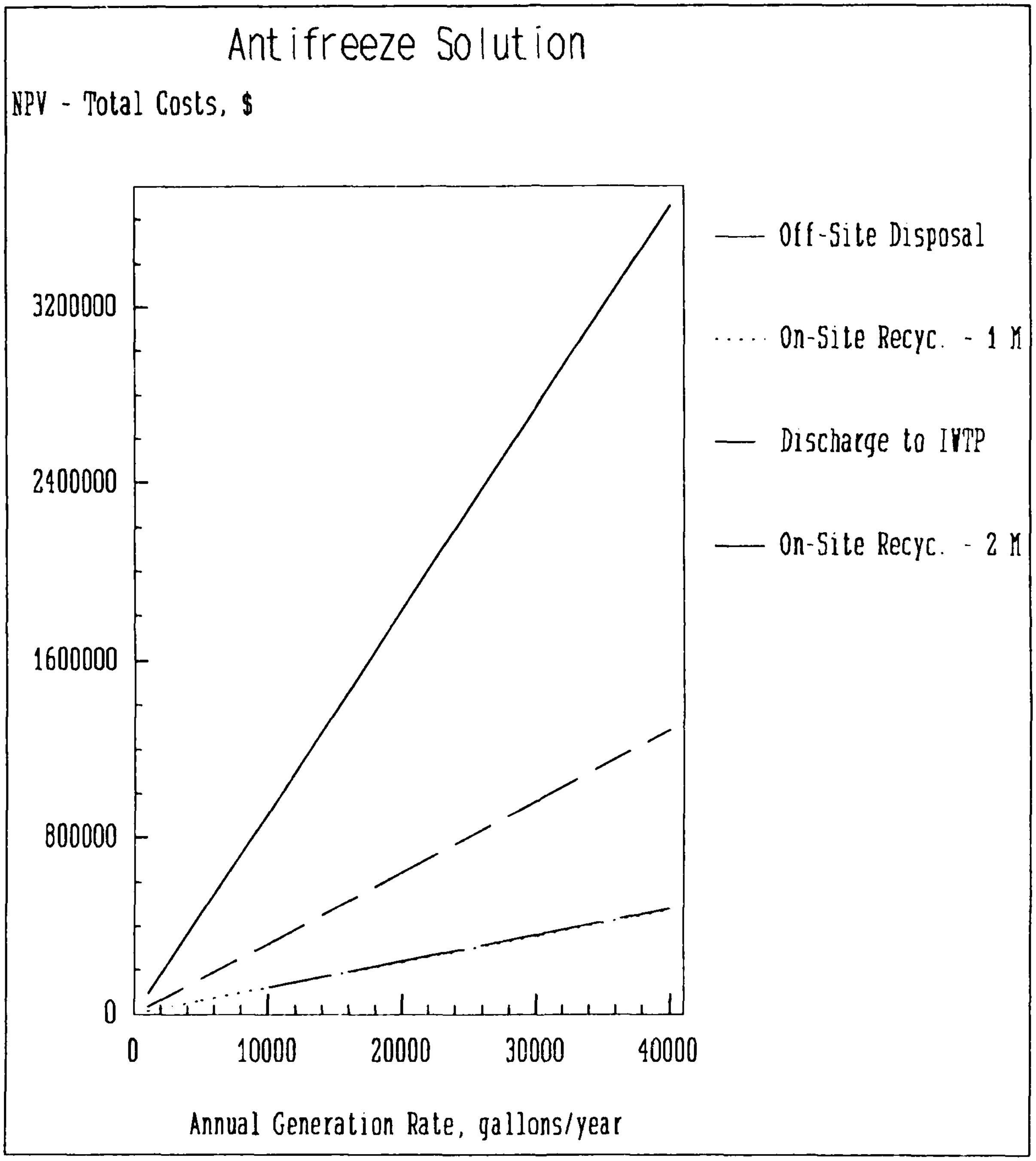

Figure 6. **Comparison of the NPVs of the total 10-yr costs for implementing options for the minimization of spent antifreeze.** Discharge to the IWTP defines the status quo.

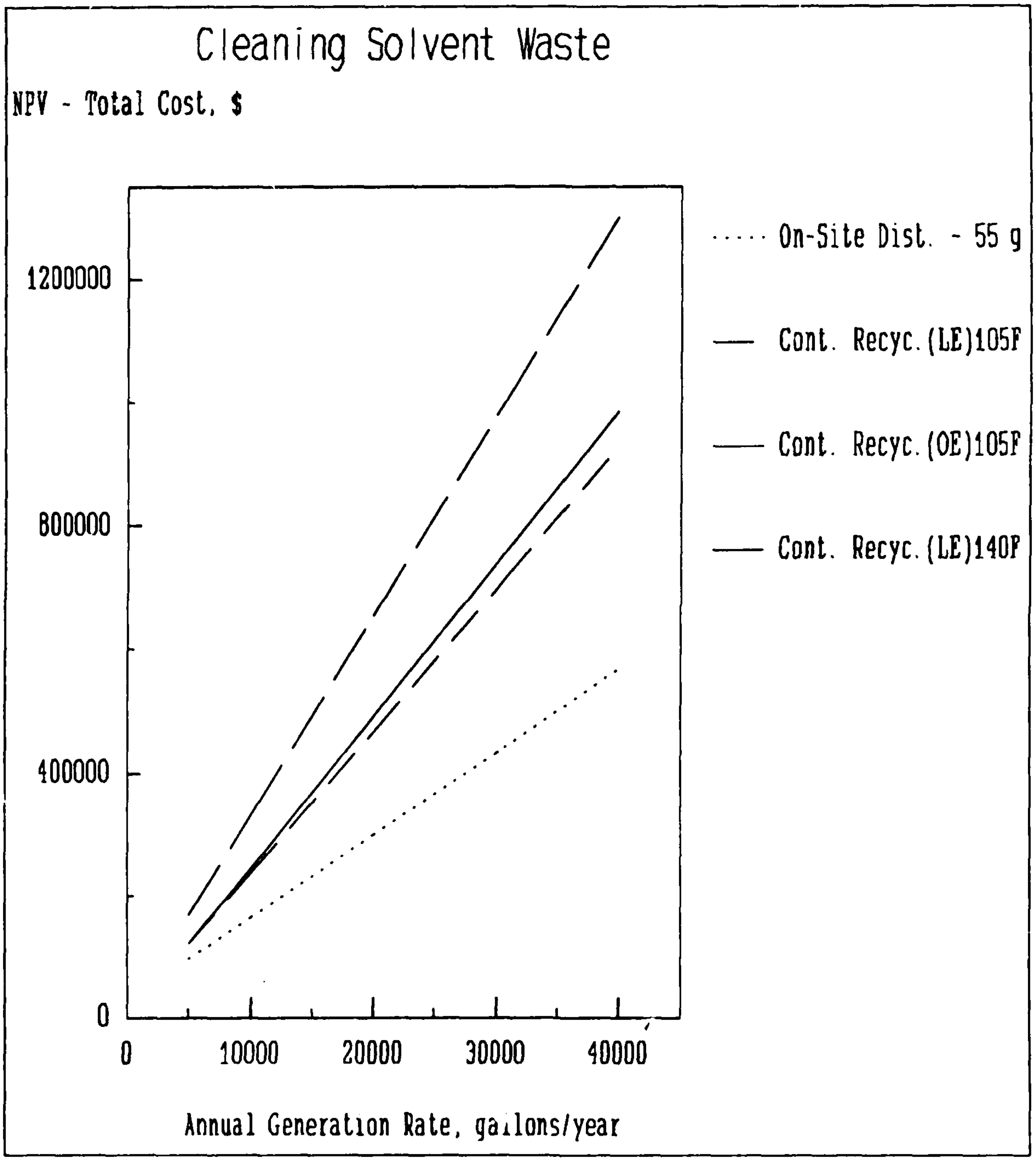

Figure 7. **Comparison of the NPVs of the total 10-yr costs for implementing options for the minimization of cleaning solvent waste.** Contract recycle (LE 105 F) defines the status quo.

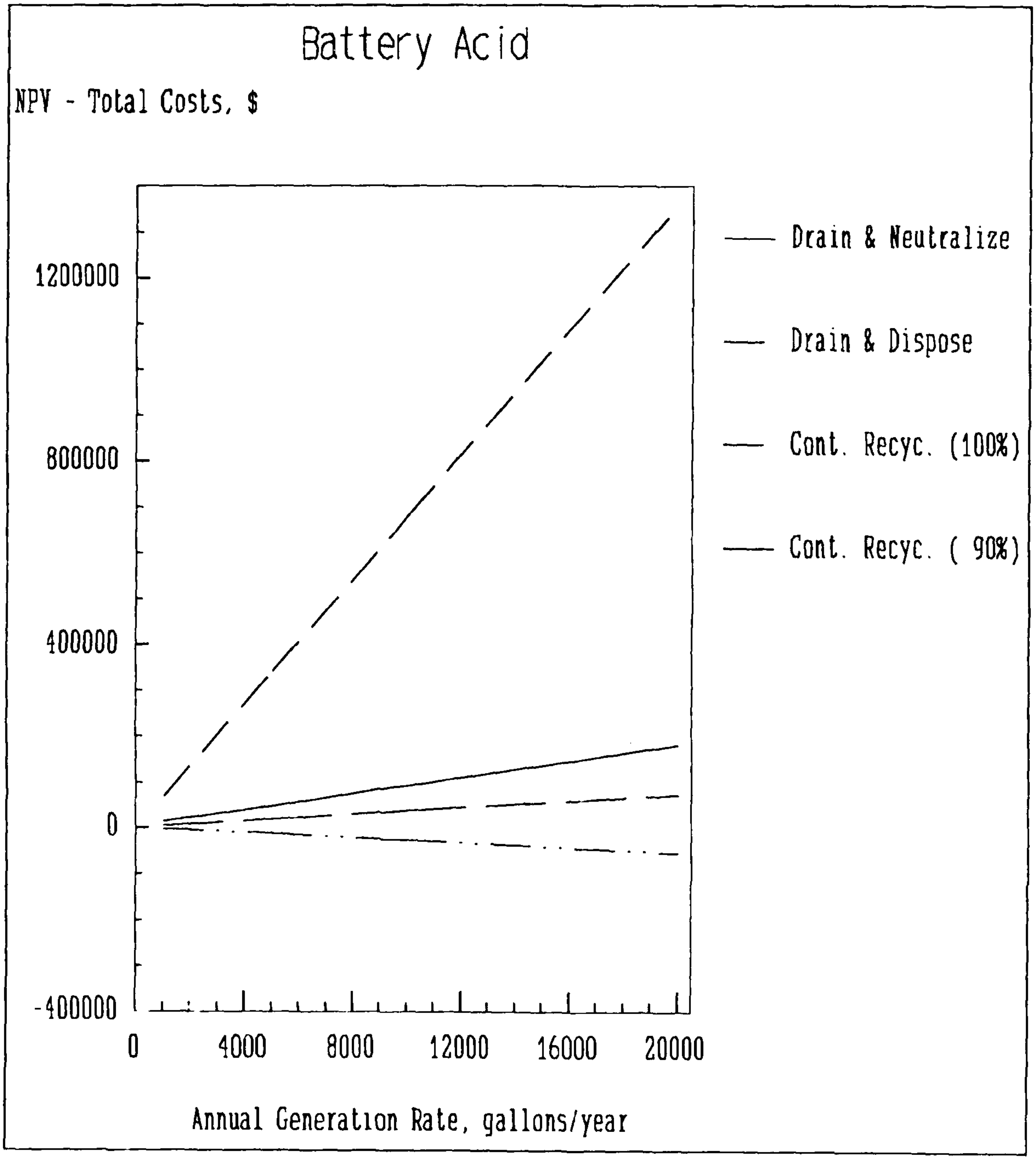

Figure 8. **Comparison of the NPVs of the total 10-yr costs for implementing options for the minimization of spent battery acid.** Draining and neutralization define the status quo.

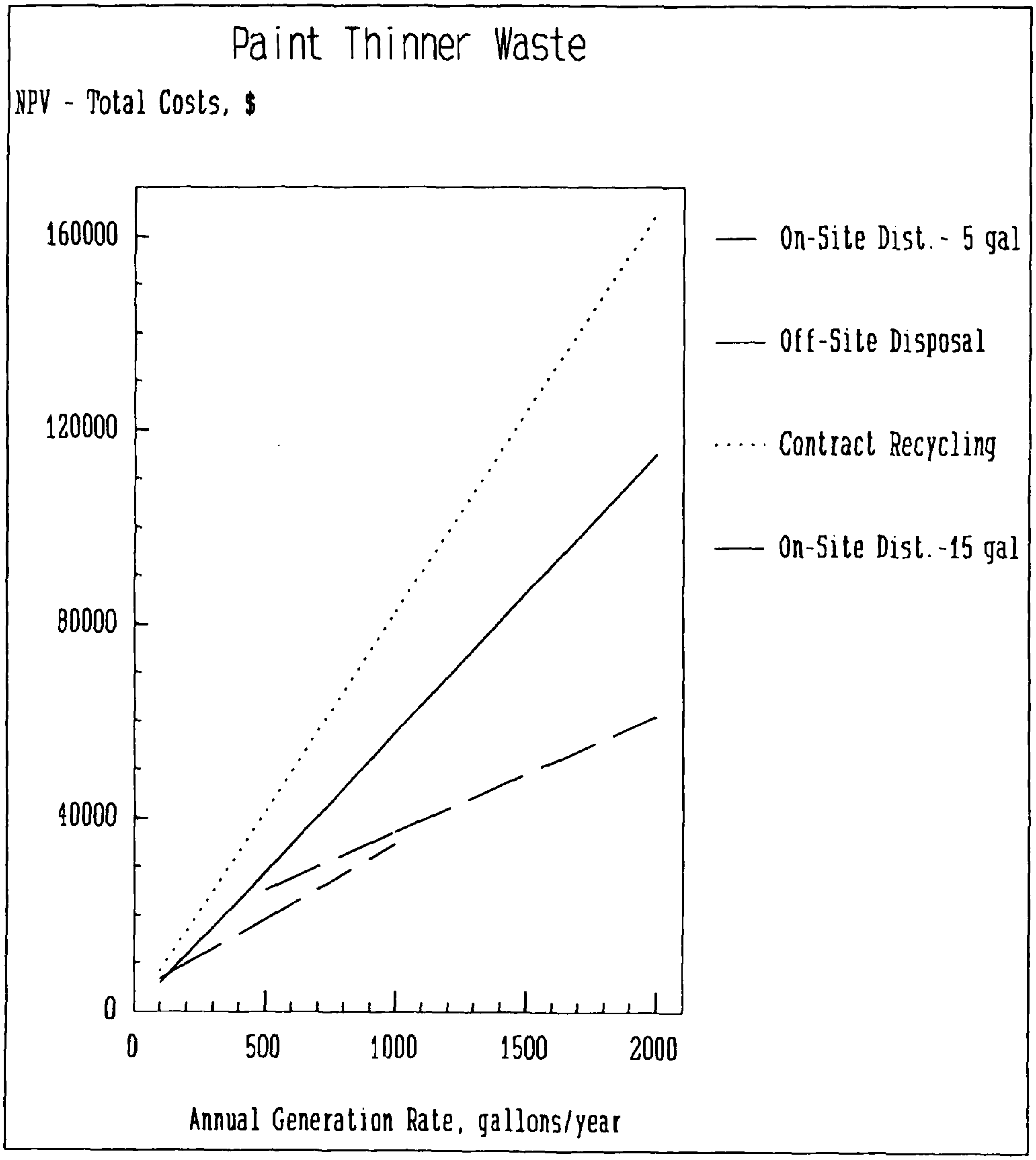

Figure 9. **Comparison of the NPVs of the total 10-yr costs for implementing options for the minimization of paint thinner waste.** Offsite disposal defines the status quo.

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.

Fort Carson is a troop installation with few tenants. It is regulated by the USEPA and the State of Colorado as a generator of hazardous waste and owner of treatment, storage, and disposal facilities.

A good HW management program has been established. A HW inventory was developed according to AR 420-47, however it is not comprehensive and should be updated.

The HW management plan is not up-to-date.

Used oil is the largest quantity waste generated at the rate of 797,399 lb/yr. Used solvents and other HW are occasionally mixed with used oil at many of the individual activities, creating large quantities of "hazardous" waste oil. Mixing of water from floor washing with oil in underground storage tanks results in a liquid with very little recycle value. Following minimal processing (oil/water separation), the used oil is currently blended with natural gas and burned in one of the boilers in Bldg 1860.

Spent lead-acid battery acid is generated at the rate of 93,744 lb/yr and neutralized with sodium bicarbonate in Bldg 8000. The neutralized acid is released into the sanitary sewer system; drained batteries are strapped to wooden pallets and turned in to DRMO for recycling. The acid is likely to be EP toxic for lead. Therefore, the practice of neutralization and draining into the sewer may be illegal.

A closed-loop (Safety Kleen [SK]) contract has been established for recycling parts cleaning solvent used (235,309 lb/yr) by all the vehicle maintenance facilites. However, a hazardous (ignitable) solvent (flash point 105 °F) is being used. It should be replaced with a nonhazardous solvent (flash point $\geq$ 140 °F).

Some of the other wastes generated are: battery casings (535,534 lb/yr), other corrosives (280,229 lb/yr), spent antifreeze solution (267,917 lb/yr), contaminated fuels (77,630 lb/yr), paint related material (38,957 lb/yr), decontaminating agents (18,626 lb/yr), spent halogenated solvents (11,362 lb/yr), photographic/printing chemicals (6587 lb/yr), used alcohols (5646 lb/yr), other nonhalogenated solvents (1762 lb/yr), pharmaceutical wastes (90 lb/yr), and miscellaneous wastes (862,655/yr).

An estimated total of 1646 tons/yr of wastes are generated. This estimate does not include PCB transformers. Half of it consists of lead-acid battery casings, medical infectious wastes, and boiler blowdown. Only 448 tons/yr of "potentially" hazardous wastes are generated.

The wastes selected for technical economic analysis are used oils, spent antifreeze solution, spent cleaning solvent, battery acid, 1,1,1-trichloroethane and its sludge, and paint thinner. The options examined include current practices (offsite disposal, burning, etc.), onsite recycling (distillation, filtration, etc.), contract recycling, segregation/processing, and process equipment modification. Most of the other wastes (e.g., contaminated fuels) can be minimized by implementing simple source reduction techniques ("better operating practices").

Recommendations

A training program was established in 1988 by the EENR office to train personnel from each of the individual units. It concentrates on POL management and should be updated to include proper HW management (including packaging, labeling, storing, transport, etc.) and minimization.

The training program for handling hazardous material and management of hazardous wastes must be improved to ensure compliance with 40 CFR 264.16 and enhance minimization.

The waste analysis plan to characterize and define all (air, water, liquid, and solid) wastes from all the generators should be revised to include frequency of analysis, etc., to ensure compliance with Federal and State of Colorado laws.

The EENR Office personnel must conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes. A comprehensive survey of waste generation and management helps in the development of inventories of quantities of hazardous materials used and wastes generated. These inventories must be updated periodically to reflect changes and disbanding of certain activities.

A HM and HW tracking (manifest) system should be implemented. 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.

All generators must develop an inventory system and maintain proper records of materials procured and wastes generated from each of the activities. These records must be inspected regularly by the supervisors and EENR office personnel.

The hazardous waste management plan must be updated.

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.

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:[175] (1) segregation (e.g., eliminate mixing of hazardous and nonhazardous wastes to improve their recyclability); (2) improved material handling and inventory practices (e.g., avoid accumulation of expired shelf-life materials, avoid spills, etc.); (3) preventive maintenance (e.g., prevent leaks and spills); (4) production scheduling (e.g., minimize quantities of unused raw materials and batch-generated wastes); and (5) minor operational changes. Implementation of "better operating practices" usually requires only minimal employee training and changes to standing operating procedures/practices (SOPs).

The feasible options, discussed in Chapter 12, for minimization of used oil, antifreeze solution, cleaning solvent waste, batteries/battery acid, spent 1,1,1-trichloroethane and its sludge, and paint thinner waste must be funded and implemented. The practice of burning used oil must be modified to include a preprocessing step using a vacuum dehydrator and degasifier (investment cost - $17,855). Implementation of proper segregation practices, and periodic testing with test kits and by laboratory analyses must be implemented. An annual savings of $8520 can be expected.

Contract recycling of cleaning solvent through SK must be continued. However, a modification of the contract to require supply of a higher flash point solvent is recommended. The additional annual cost is estimated to be $28,664.

A large quantity of antifreeze solution is drained into the sanitary sewer system at Fort Carson. Spent antifreeze can be recycled as discussed in Chapter 5. An investment of $166,481 is required to

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

purchase two Glyclean recycling machines. With an annual savings of $74,293 when compared to wastewater treatment and discharge losses, a payback period of 2.57 years is expected.

Wet recycling of lead-acid batteries is recommended in place of the current practice of draining and neutralizing spent electrolyte. A savings of $8762/yr and an additional revenue of $2674 can be expected when sold to a battery recycler.

For paint thinner waste, it is recommended that a small, 15-gal batch still be purchased at a total investment cost of $15,783. The annual operating cost is $2116 and payback can be expected in 5.41 years.

Equipment modifications to include an on-line distillation unit, motorized power cover, and increase in freeboard height, are required to reduce the wastes and emissions generated from the vapor degreaser located in Bldg 8000. A total investment cost of $44,767 and an annual operating cost $15,557 is anticipated. These modifications will result in an annual savings of $12,437, with payback in 4.22 years.

Generation of all other wastes can be reduced by more than 30 percent by managerial changes, training, and implementation of "better operating practices" and other appropriate minimization techniques as discussed in Chapters 5 through 11.

The Fort Carson Hazardous Waste Management Board, chaired by the Installation Commander, must adopt the HAZMIN plan and establish policies and procedures required for its implementation. The expected implementation date is 31 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 of the techniques must be monitored and the achievements in waste minimization (e.g., percent minimized) documented. Waste minimization of 37 percent and "hazardous" waste minimization of 54 percent (see Appendix A, and Table A3) are to be expected upon proper implementation.

A waste minimization program never ends. Preventing waste generation and thereby reducing the pollution of air, land, and water, must be a continuous quest. The goal of such a program must be to reduce wastes to the maximum extent possible. All waste generating processes must be continuously assessed and reassessed to account for changes in economic status (e.g., increase in disposal costs), changes in design of production processes, maintenance procedures, and/or technical/technological breakthroughs.

METRIC CONVERSION TABLE

1 Btu	=	0.293 W
1 gal	=	3.785 L
1 in.	=	25.4 mm
1 mi	=	1.6 km
1 lb	=	0.37 kg
1 psi	=	6.89 kPa
1 ton	=	0.9 MT
°C	=	5 (°F - 32)/9

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APPENDIX A:

FORT CARSON - HAZMIN PLAN

1. BACKGROUND

The Hazardous and Solid Wastes Amendments (HSWA)[1] to the Resource Conservation and Recovery Act (RCRA),[2] passed in 1984, require the generators of hazardous wastes to certify that they have a waste minimization program. Every waste shipment manifest is accompanied with the following declaration, in compliance with Section 3002 (b) of HSWA:

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

Therefore, all facilities that meet the RCRA definitions of Generator (more than 1000 kg or 2205 lb/month) and Small Quantity Generator (100 to 1000 kg or 220 to 2205 lb/month) of HW have to implement waste minimization programs.

HSWA [Section 3002(a)] also requires the generators of hazardous wastes to submit a biennial report, including documentation on efforts to reduce the volume and toxicity of wastes generated. Facilities that treat, store, or dispose of hazardous wastes are required [HSWA, Section 3005(h)] to submit annual reports accompanied with similar declarations on waste minimization.

In the broadest sense, HAZMIN may be defined as the process of reducing the net outflow of hazardous waste effluents from a given source (or generating process). Minimization would include any source reductions in the generation of hazardous wastes as well as any recycling activities that would result in either a reduction in the total volume or quantity of hazardous wastes, or a reduction in the toxicity of hazardous wastes produced or both as long as it is consistent with the national goal of minimizing present and future threats to the environment.[3] HAZMIN, therefore, can be achieved by:

> Source Reduction - which refers to reduction or elimination of waste generation at the source, usually within a process. It also implies any action taken to reduce the amount of waste leaving a process;
>
> Recycling Onsite/Offsite - which is the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in a process. Recycling also implies the reclamation of useful constituent fractions from within a waste or removal of contaminants allowing it to be reused; and/or

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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.
[3] *Minimization of Hazardous Waste. Executive Summary and Fact Sheet*, EPA/530/SW-86/033A (EPA, Office of Solid Waste, Washington, D.C., 1986).

Treatment - eliminating hazardous characteristics of a waste making it nonhazardous to human health and environment.

For any particular waste, the minimization options must be evaluated in the hierarchy of source reduction first, followed by recycling (including, recovery and reuse), and, finally, treatment. There may always remain some small amount of residue (e.g., ash) which will require "ultimate" disposal (e.g., landfill burial). Although attempts have been made to clearly define the three HAZMIN categories, there may be overlap for certain specific techniques. Maximum waste reduction is usually achieved by using the best combination of suitable techniques from all three categories.

Recognizing the liabilities of improper disposal and the advantages of waste minimization, the Joint Logistics Commanders set a DOD-wide goal of 50 percent reduction in hazardous waste generation by 1992, based on the baseline generation in 1985. The Department of Army has adopted this DOD goal and established a policy[4] applicable to all Active Army, Reserve, and National Guard installations.

2. PURPOSE

The purpose of the Fort Carson Installation Hazardous Waste Minimization (HAZMIN) plan is to provide a specific plan of action to reduce the quantities and toxicities of hazardous wastes (HW) generated within the installation boundaries.

3. SCOPE

The scope of the plan extends to all the HW regulated under the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Wastes Amendments (HSWA), and the State of Colorado Hazardous Waste Regulations.

4. GOALS

4.1 Department of Army (DA) HAZMIN Goals

Process, Operation, or Condition	Percent HW Reduction Desired by 1992
Cleaning/degreasing	40
Transportation vehicle maintenance	0
Fueling operations	30
Battery shop operations	50
Painting	50

[4] Office of the Assistant Chief of Engineers, "Hazardous Waste Minimization (HAZMIN) Policy," Department of the Army, 1989, 15 pages.

Sand blasting	60
Metalworking	15
Graphic Arts	40
Electrical maintenance	60
Waste treatment sludge	60

4.2 Fort Carson HAZMIN Goals

Same as DA goals.

4.3 HAZMIN Reduction Estimation

Percent HW reduction for any calender year (CY) =

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

5. PROGRAM MANAGEMENT

5.1 Fort Carson 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 Assistant Division Commander (Support) and consists of the following members:

Assistant Division Commander (Support) (ADC/S)
Garrison Commander (GS)
Director of Engineering and Housing (DEH)
Director, Environment, Energy, and Natural Resources (EENR)
Director of Logistics (DOL)
Director of Personnel and Community Activities (DPCA)
Director of Reserve Component Support (DRCS)
Director of Plans, Training, and Mobilization (DPTM)
Assistant Chief of Staff (ACofS, G1/AG)
Assistant Chief of Staff (ACofS, G2)
Assistant Chief of Staff (ACofS, G3)
Assistant Chief of Staff (ACofS, G4)
Assistant Chief of Staff (ACofS, G5)
Deputy Chief of Staff (DC/S)
Inspector General (IG)
Director, Defense Reutilization and Marketing Office (DRMO)
Installation Safety and Occupational Health Manager
Public Affairs Officer (PAO)
Staff Judge Advocate (SJA)

Director of Resource Management (DRM)
Director of Health Services (DHS)
Director of Dental Services (DDS)
Commander, 1st Brigade
Commander, 2nd Brigade
Commander, 3rd Brigade
Commander, Division Artillery
Commander, Division Support Command
Commander, 43rd Support Group
Commander, 4th Battalion, 61st Air Defense Artillery
Commander, 4th Engineering Battalion
Commander, 124th Signal Battalion
Commander, 104th Military Intelligence Battalion
Commander, 4th Aviation Brigade (Combat)
Commander, Headquarters Command

5.2 The activities at Fort Carson that are generators of hazardous waste, used oil, and miscellaneous toxic wastes; and references to the appropriate chapter (in the assessment technical report) are:

	Chapter Number
Motor Pools/Vehicle Maintenance Facilities	4, 5
Aviation Maintenance Facilities	4, 5
Industrial Maintenance, Small Arms Shops, etc.	4, 6
Paint Shops	4, 7
Photography, and Printing Operations	4, 8
Hospitals, Clinics, and Laboratories	4, 9
Other Generators	4, 10

6. TRAINING

6.1 Personnel Training

A training program will be developed, by the Director, EENR for personnel involved in handling of hazardous materials and management of hazardous wastes to ensure compliance with 40 CFR 264.16.

6.2 Training Content, Schedules, and Techniques

Personnel from HW generating activities must be given supervised on-the-job training as well as formal courses. The formal courses must be designed similar to the program offered by the U.S. Army Environmental Hygiene Agency, or the U.S. Army Logistics Management Center. Refresher courses must be taught by the Environmental Personnel from the DEH Environment, Energy, and Natural Resources division.

The objective of a formal (or refresher) course must be to provide each student with the abilities to:[5]

1. Recognize, identify, and classify hazardous materials.

2. Take actions necessary to prevent hazardous chemical incidents, protect personnel health, and prevent damage to the environment.

3. Properly package, label, store, handle, and transport hazardous materials and hazardous waste.

4. Take immediate action in response to hazardous materials spills or other emergencies.

5. Implement appropriate HAZMIN techniques.

6. Properly manage the resources under his/her control to prevent violation of applicable laws, regulations, and policies.

6.3 Implementation of Training Program

The Chief of the Training Division (DPTM) will direct a training program designed by the Director, EENR. All new and/or reassigned personnel will not work in positions dealing with hazardous materials/wastes unless they have completed the appropriate program within 6 months of the date of employment or reassignment. All supervisors will, annually, review the training status of their personnel.

6.4 Records

a. The Personnel Directorate (Fort Carson and tenant activities) will maintain records pertaining to job experience and the training completion requirements. The records must include description of the type/nature of initial and continuing training each person receives.

b. Fort Carson will maintain records of all current personnel until deactivation of a particular unit/organization 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 Command Initiatives: For the HAZMIN program to be successful, the Commander and the chain of command for all the troops and tenants must make a commitment to all the goals (section 2) and establish specific goals at the generator (or activity) level.

The Installation Commander will develop an environmental policy statement emphasizing pollution minimization and assign direct responsibility to all personnel as protectors of the

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

environment in their day-to-day work. All personnel will be notified (through the *Mountaineer* and inter-office memorandums) regarding the command commitment and goals.

Personnel incentives (such as awards, commendation, etc.) must be provided to encourage new HAZMIN ideas and to reward implementation of successful HAZMIN projects.

7.1.2 The installation must solicit cooperation with the host community (Colorado Springs) 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 Carson (including all the tenants). Tracking HM from the supply warehouse to generators and HW from the generators to final storage before disposal, will provide a mass balance and improve minimization opportunities.

7.1.5 HAZMIN programs will be incorporated into the agenda of the Environmental (and Hazardous Waste) Management Board Meetings. Proper coverage must be provided in the installation newspaper (*Mountaineer*) to ensure wide acceptance among personnel.

7.1.6 Director, EENR, and the Installation Safety and Occupational Health Manager will combine resources to develop a training program for personnel in hazardous materials/waste handling and emergency response (according to Section 6) which is required by law.

7.1.7 Director, EENR, will develop a waste analysis program to characterize and define all (air, water, liquid, and solid) waste streams from all the generators to ensure compliance with Federal and State laws.

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

7.1.9 The EENR Hazardous Waste Program Manager will conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes.

7.2 Generator Actions

7.2.1 All generators must program for disposal of hazardous wastes following the decentralization of funding beginning in Fiscal 1990.

7.2.2 All generators will appoint environmental (hazardous waste) coordinators who would be responsible for minimizing generation (of air emissions, water pollution and solid wastes), proper interim storage, and turn-in of hazardous wastes.

7.2.3 The environmental (or hazardous waste) manager should interface with the EENR Hazardous Waste Program Manager in all matters pertaining to waste management and minimization.

Individuals appointed to this duty will devote more time than is customary for a typical "extra duty."

7.2.4 All environmental managers will maintain proper records (logbooks) of materials procured and wastes generated from each activity and report on a monthly basis to the EENR.

7.2.5 All generators must, with the help of EENR, completely characterize (in terms of composition, periodicity of generation, why and how generated, etc.) all the waste streams, document and provide relevant data when requested by the EENR.

7.2.6 All generators will include HAZMIN requirements ("Better Operating Practices" as outlined in Chapters 5 through 11) and specified by the EENR in their standing operating procedures (SOPs).

7.3 Current HAZMIN Projects

7.3.1 Cleaning Solvent - Recycle Onsite/Offsite - Contract Recycling

A used solvent recycling program has been designed to collect and recycle used cleaning solvent (Petroleum Naphtha) used in motor pools, vehicle/aviation maintenance facilities, and other parts cleaning activities. Source reduction (e.g., better operating practices, testing, etc.) must be implemented by all generators to reduce the quantities used. Use of a substitute (e.g., Citrikleen) must also be explored.

From the economics of solvent use (at a total rate of 30,160 gal/yr) it is determined that onsite distillation (using a 55-gal batch still) is more economical than the current closed-loop (Safety Kleen [SK])[6] contract recycling for minimizing cleaning solvent wastes.

Estimated Cost: Investment - $60,162; Annual O&M - $38,105

Estimated Annual Savings: $33,100

Estimated Payback Period: 2.73 years

However, some of the practical aspects of disbanding current operations, purchase of new equipment, logistics of setting-up, operating a recycling center, and transporting spent solvent to the central location and recycled solvent back to the users, etc., makes the change to on-site distillation undesirable. The current practice of SK contract recycling should be continued and extended to include other generators who have government-owned solvent cleaning tanks.

The existing SK contract should be modified to substitute the solvent (flash point 105 °F) being delivered with a nonignitable solvent (flash point > 140 °F). The solvent waste in such a case is a nonhazardous waste and is exempt from reporting requirements.

Estimated Cost: Annual O&M - $99,866

Estimated "Additional" Annual Cost: $28,664

Estimated Waste Reduction (Recycling Alone): 0 percent

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

Estimated Waste Reduction (Source Reduction and Recycling): 40 percent

Estimated "Hazardous" Waste Reduction: 100 percent

7.3.2 Used Oil - Treatment - Burning

Used oil is currently accumulated by all the generators and a contractor transports it to a tank farm located near the main boiler house. About 114,000 gal/yr of used oil is generated. Five percent of it is contaminated with halogenated solvents and has to be treated as a hazardous waste.

Comprehensive processing followed by continued burning of used oil at one of the boilers is recommended. 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)[7] 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 flash point, and the total halogens, sulfur, 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. An air pollution permit has to be obtained.

Estimated Cost: Investment - $17,855; Annual O&M - $46,815

Estimated Annual Savings: $8,520

Estimated Payback Period: 3.91 years

Estimated Waste Reduction (Treatment Alone): 0 percent

Estimated Waste Reduction (Source Reduction and Treatment): 30 percent

Estimated "Hazardous" Waste Reduction: 0 percent

7.4 Future HAZMIN Projects

7.4.1 Spent Lead-Acid Batteries/Battery Acid - Source Reduction - No Draining/Sale

The current practice at Fort Carson is to drain the lead-acid batteries and neutralize the spent acid. About 9500 gal/yr of acid is generated.

Lead-acid batteries (sealed and unsealed) must be accumulated at the generators (e.g., motor pools) on pallets. These batteries, when bound securely to the pallets, can be recycled through a recycler. If the batteries are being recycled, they are exempt from RCRA reporting requirements and, therefore, do not require reporting and manifesting paperwork necessary for other hazardous wastes.

[7]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.

Estimated Price: Annual O&M - $2674 (revenue)

Estimated Annual Savings: $8762

Estimated Waste Reduction (Source Reduction/Recycling): 100 percent

Estimated "Hazardous" Waste Reduction: 100 percent

7.4.2 Used Antifreeze Solution - Onsite Recycling

Used antifreeze solution is generated at the rate of 30,445 gal/yr by the vehicle maintenance facilities at Fort Carson. It is drained into the industrial sewer. Although antifreeze is not a hazardous waste, it is difficult to treat and can cause an upset at the sewage treatment plant. In addition, the price of new antifreeze has more than doubled in the past two years ($4.00 to $8.45/gal). A technology (Glyclean filtration system - unit price: $2,400) exists for recycling the 50 percent antifreeze solution.

Use of the Glyclean system is recommended.

Estimated Cost: Investment - $166,481; Annual O&M - $9795

Estimated Annual Savings: $74,293

Estimated Payback Period: 2.57 years

Estimated Waste Reduction (Recycling Alone): 100 percent

Estimated Waste Reduction (Source Reduction and Recycling): 100 percent

Estimated "Hazardous" Waste Reduction: 0 percent

7.4.3 Paint Thinner/Residue - Recycle Onsite/Offsite - Distillation

The Paint Shop belonging to the DOL Operations Maintenance Branch (Bldg 8000) will purchase a 15-gal distillation still for recycling paint thinner wastes. Thinner wastes generated elsewhere on Fort Carson will be brought to the DOL shop and distilled. The still bottoms have to be disposed of as hazardous waste. Permit requirements, if any, will be reviewed by the environmental office before the installation and operation of the still.

Estimated Price: Investment - $15,783; Annual O&M - $2116

Estimated Annual Savings: $3630

Estimated Payback Period: 5.41 years

Estimated Waste Reduction (Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated "Hazardous" Waste Reduction: 90 percent

7.4.4 1,1,1-Trichloroethane/Degreaser Tank Bottoms - Source Reduction and Recycle Onsite/Offsite - Equipment Modifications and Continuous Recycling

The Maintenance Operations Branch of the DOL owns an old (i.e., 1975) vapor-spray-vapor degreaser (VS 800-S-H, manufactured by DETREX Chemical Industries, Inc.) which is located in Maintenance Section III of the DOL Consolidated Maintenance Building (Bldg 8000). It is a large machine (≈ 500 cu ft) used to clean oversize (e.g., engine blocks, canon barrels, etc.) and small parts.

The vapor degreasing operations use nearly 3860 gal/yr of 1,1,1-trichloroethane. Approximately, 2860 gal/yr of it is lost because of its volatility and poor operating practices of the personnel. The total hazardous waste generated includes spent solvent (250 gal/3 months), and tank bottoms (5280 lb/yr). An investment in a biparting motorized cover, a 40 gal/hr inline distillation unit, and an increase in freeboard height to 15 in. is recommended. Better operating practices and process controls (as discussed in Chapter 5) must also be implemented.

Estimated Cost: Investment - $44,767; Annual O&M - $15,557

Estimated Annual Savings: $12,437

Estimated Payback Period: 4.22 years

Estimated Waste Reduction (Source Reduction and Recycling): 54 percent

Estimated Emissions Reduction (Source Reduction): 37 percent

Estimated "Hazardous" Waste Reduction: 54 percent

7.4.5 Other Wastes - Source Reduction

Implement "better operating practices" and other appropriate minimization techniques according to references in Section 5.2.

Estimated Waste Reduction: 30 percent

Estimated "Hazardous" Waste Reduction: 20 percent

7.5 Overall Estimate of Expected Waste Reduction

Expected Waste Reduction: 37 percent

Expected "Hazardous" Waste Reduction: 54 percent

8. REFERENCES

8.1 Fort Carson installation waste generation data is given in Tables A1 and A2.

8.2 The calculations for the "overall" estimated waste reduction (in Section 7.5) are presented in Table A3.

8.3 This plan is in Appendix A of the *Hazardous Waste Minimization Assessment: Fort Carson, Colorado Springs, Colorado.*

9. IMPLEMENTATION

Estimated Implementation Date: September 31, 1990.

10. RESPONSIBILITIES

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

Job Title	Name	HAZMIN Activity
Director, Environmental, Energy and Natural Resources Office	T. Warren	Overview of the entire program; chair the committee; and others as noted in section 10.3.
Deputy Director, EENR, Environmental Program	M. Barber	Vicechair of the committee. Help the Director, EENR and coordinate implementation with the hazardous waste program manager and other committee members.
Hazardous Waste Program Manager, EENR	T. Tjerandsen	Establish a hazardous materials/ waste training program; establish waste inventory and inspection program; establish a HW/HM tracking program; coordinate with Safety Officer, Fire Director, DRMO and all the environmental coordinators.
Installation Safety and Occupational Health Manager	R. Whitmore	Establish a chemical inventory program; flag and control purchase of hazardous materials; coordinate with the environmental engineer regarding maintaining and updating inventory.
Director, Defense Reutilization and Marketing Office	W. Tilley	Establish proper waste turn-in procedures; waste contract management; explore offsite reclamation and waste exchange options.

Project Manager, GE Operations	J. McDavid	Inventory control of materials and wastes; vehicle/equipment maintenance, painting and laboratory wastes minimization; pesticides management; PCB transformer inventory management.
Chief, DEH Fire Department	V. Witham	Coordinate with safety office; inventory flammable/toxic materials; SARA Title III compliance.
Chief, DOL Transportation Management Branch	E. Mestas	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DOL Maintenance Operations Branch	D. Ganshow	Inventory control of materials and wastes; painting, machining, and weapons cleaning wastes minimization.
Chief, DOL Aircraft Maintenance Branch	E. Mestas	Inventory control of materials and wastes; aviation maintenance wastes minimization.
Chief, DOL Supply Activity	M. Olliver	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical usage inventory and demand history by each generator.
Manager, GE Supplies Division	R. Rosemark	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical usage inventory and demand history by each generator.
Chief, MEDDAC Logistics Materiel Branch	CPT K. LaFrance	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical usage inventory and demand history by each laboratory and generator.
Chief, DPCA Education Center	W. Ensminger	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DPTM Training and Audiovisual Support Center	N. Amodeo	Inventory control of materials and wastes; photographic and printing wastes minimization.

Chief, Preventive Medicine Evans Army Community Hospital	CPT E. Selzer	Establish inventory of hazardous materials/wastes; establish waste generators monitoring program; coordinate minimization and proper disposal practices (infectious, hazardous, and radioactive wastes) with environmental office.
XO, 1st Brigade	LTC C.G. Bailey	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 2nd Brigade	LTC D.M. Harris	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 3rd Brigade	LTC L.L. Harrold	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 4th Aviation Brigade	LTC F.A. Treyz	Inventory control of materials and wastes; aviation and vehicle maintenance wastes minimization.
XO, Division Artillery	LTC W.J. Carden	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, Division Support Command	LTC J.H. Lantz	Inventory control of materials and wastes; vehicle maintenance, and industrial maintenance wastes minimization.
XO, 43rd Support Group	LTC C.R. Coffer, Jr.	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 4th Battalion, 61st Air Defense Artillery	LTC O.A. Nagel	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 4th Engineering Battalion	LTC P.K. Bailey	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 124th Signal Bn.	LTC W.E. Francis, Jr.	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 104th MI Battalion	MAJ K.A. Dickinson	Inventory control of materials and wastes; vehicle maintenance wastes minimization.

XO, Headquarters Command	MAJ M.L. Magrini	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, Naval Reserve Center	LCDR T.E. McKee	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 3rd Battalion 87th Infantry (USAR)	LTC F.H. Mann	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Environmental (or Hazardous Waste) Managers		As discussed in Section 10.4.

10.2 **Responsibilities of all HAZMIN Committee Members (except Director, EENR)**

10.2.1 Identify and prioritize activities required to achieve the goals outlined in this plan.

10.2.2 Provide information on HAZMIN techniques to the actual generators of hazardous waste.

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 Director, EENR regularly.

10.2.5 Assist the Director, EENR, in preparing an Annual HAZMIN status report.

10.3 **Responsibilities of the Director, Environment, Energy and Natural Resources Office**

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

10.3.2 Revise and update this plan annually.

10.3.3 Prepare a HAZMIN status report when requested by HQFORSCOM or HQDA.

10.3.4 Program funds necessary to accomplish HAZMIN goals.

10.3.5 Chair the HAZMIN Committee.

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

10.4 **Responsibilities of Environmental (or Hazardous Waste) Managers**

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

10.4.2 Obtain training (organized by EENR) on all the applicable environmental laws and train all subordinate personnel.

10.4.3 Implement "better operating practices" through: inventory control (maintaining logbooks for materials procured and pollution generated); segregation of wastes; spill and leak prevention; and scheduling frequent preventive maintenance of equipment.

10.4.4 Examine and implement the use of substitute nonhazardous or less hazardous materials in place of hazardous materials.

10.4.5 Examine and implement "process changes" such as: process modifications; equipment modifications; and changes in operation settings, to reduce the quantities of pollution generated.

10.4.6 Examine and implement technologies for recycling, reuse, or treatment of wastes. Information about technologies and equipment suppliers can be obtained from environmental personnel at EENR.

Table A1

Summary of Fort Carson Waste Generation

Waste Generating Operation Process, or Condition	Waste Category*	lb/yr	lb/yr/unit Survey	IDMS	Suggest	Waste Stream Unit
Motor Pools and Vehicle Maintenance Facilities	1	191861	190103		190103	Spent Petroleum Naphtha
				1758	1758	Spent Degreasing Solvent, NOS
	2	1442		647	647	Carbon Remover
			795		795	Carburetor Cleaner
	3	247501	247501		247501	Spent Antifreeze Solution
	4	717424	635507	105000	635507	Used Motor Oil
				81917	81917	Chlorinated Motor Oil
	8	3744	3744		3744	Spent Sulfuric Acid
	10	32655	32655	20487	32655	Contaminated Diesel, Mogas
	12	201850	201850	38301	201850	Spent Lead Acid Batteries
	13	305491	4903	1148	4903	Used Brake, Fluid
			23041		23041	Used Transmission Fluid
			14342		14342	Used Hydraulic Fluid
			120680	95000	120680	Spent Sorbent
			34825		34825	Contaminated Rags
			6770	105000	105000	Contaminated Soil
			1540		1540	Hazardous Faulty Parts
			685	1160	1160	Asbestos Containing Materials
Industrial Maintenance Small Arms Shops	1	29057	29057		29057	Spent Degreasing Solvent
	2	7700	7700		7700	Spent 1,1,1 Trichloroethane
	3	20416	20146		20146	Spent Antifreeze Solution
	4	75190	73590		73590	Used Motor Oil
			1600		1600	Chlorinated Motor Oil
	7	15	15		15	Spent Paint Thinner

*1: spent degreasing solvents (nonhalogenated), 2: spent degreasing solvents (halogenated), 3: spent antifreeze solution, 4: used motor oil, 5: used alcohols, 6: spent photo and print chemicals, 7: paint related materials, 8: spent acids and bases, 9: decontamination agents, 10: contaminated fuels, 11: pharmaceutical wastes, 12: spent batteries, and 13: miscellaneous wastes.

Table A1 (Cont'd)

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	lb/yr/unit Survey	lb/yr/unit IDMS	Suggest	Waste Stream Unit
	8	92500	90000		90000	Spent Sulfuric Acid
			2500		2500	Spent Sodium Hydroxide
	10	42700	42700		42700	Contaminated Fuels
	12	300015	300000		300000	Lead-acid Battery Casings
			5		5	Spent Li-So_2 Batteries
			10		10	Spent NICAD Batteries
	13	17816	686		686	Used Transmission Fluid
			80		80	Used Brake Fluid
			4375		4375	Used Hydraulic Fluid
			840		840	Contaminated Sorbent
			685		685	Hazardous Faulty Parts
			3700		3700	Contaminated Fluid Filters
			70		70	Contaminated Cutting Oil
			2100		2100	Oily Rags
			5280		5280	TCA Tank Bottom Sludge
Aviation Maintenance Facility	1	13379	12991		12991	Spent Petroleum Naphtha
			172	85	172	Spent MEK
				216	216	Spent Acetone
	2	446		171	171	Carbon Remover
				275	275	Cleaning Compound, NOS
	4	3035	3035	1035	3035	Aircraft Engine Oil
	7	842	132		132	Spent Paint Stripper
			79	135	135	Spent Paint Thinner
			285		285	Spent Paint Filters
				290	290	Unused, Spoiled Paint
	3	716	714		714	Caustics
			2		2	Potassium Hydroxide
	10	2275	2275	1750	2275	Contaminated JP-4
	12	20250		20250	20250	Spent NICAD Batteries

Table A1 (Cont'd)

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	Survey	lb/yr/unit IDMS	Suggest	Waste Stream Unit
	13	11866	140	1700	1700	Contaminated Hydraulic Fluid
			600		600	Spent Sorbent
				345	345	Grease, NOS
			4375		4375	Contaminated Hydraulic Fluid
			30		30	Hazardous Empties
			1308		1308	Contaminated Rags
			8		8	Solvent Tank Sludge
				3500	3500	Contaminated Soil, Solids
Paint Shops	2	65		65	65	Spent Methylene Chloride
	4	1750	1750		1750	Used Motor Oil
	5	1031	1031		1031	Spent Alcohol, NOS
	7	29521	4720	7040	7040	Spent Paint Thinner
			90		90	Spent Paint Stripper
			880		880	Spent Paint Filters
			240		240	Spent Respirater Cartridges
				478	478	Sealant
				284	284	Bondo
				140	140	Rust Remover
				210	210	Adhesive, NOS
			480		480	Paint Covered Overalls
			650	19679	19679	Unused, Spoiled Paint
	13	4115	2600		2600	Spent Oil, Fuel Filters
			840		840	Spent Sorbent
			600		600	Hazardous Empties
			75		75	Contaminated Rags
Photography, Printing, and Arts/Crafts Shops	1	96	96		96	Spent Deglazing Solvent
	2	1079	216	125	216	Spent Film Cleaner
			739	863	863	Spent Blankrola Solvent

Table A1 (Cont'd)

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	lb/yr/unit Survey	lb/yr/unit IDMS	lb/yr/unit Suggest	Waste Stream Unit
	3	5621	288		288	Spent Photo Stabilizer
			1796	102	1796	Spent Photo Bleach
				215	215	Spent Photo Rinse
			36	2946	2946	Spent Offset Toner Solvent
			92		92	Spent Electrostatic Solvent
			92		92	Spent Electrostatic Ink and Toner
			192		192	Spent Hypo. Cleaning Agent
			720		720	Spent Photo Activator
	7	316	230		230	Laquer Thinner
			72		72	Enamel Thinner
			14		14	Turpentine
	8	10663	6128	4945	4945	Spent Photo Developer
			4128		4128	Spent Photo Fixer
			96		96	Ink Roller Conditioner
			488		488	Acetic Acid Photo Bath
				198	198	Conversion Solvent, NOS
				88	88	Imager
Hospitals, Clinics, and Laboratories	1	1278	308	480	480	Spent Xylene
				280	280	Spent Benzene
				518	518	Spent Toluene
	2	505		430	430	Spent Formaldehyde
				75	75	Spent Chloroform
	5	915		915	915	Spent Alcohol, NOS
	6	960		460	460	Spent Photo Developer
				216	216	Spent Photo Toner
				290	290	Spent Photo Wash
	9	185		185	185	Spent Disinfectant, NOS

Table A1 (Cont'd)

Waste Generating Operation, Process, or Condition	Waste Category	lb/yr	Survey	lb/yr/unit IDMS	Suggest	Waste Stream Unit
	11	90	90	90	90	Shelf-Life Pharmaceuticals
	13	511624		215	215	Contaminated Mercury
				320	320	Potassium Phosphate
				215	215	Soda Lime
			732		732	Pathological Wastes
			509650		509650	Medical Infections
				492	492	Miscellaneous Chemicals
Heating and Cooling Plants	1	1400	1400		1400	Spent Petroleum Naptha
	8	265600	265600		265600	Caustic Boiler Blowdown
G E (formerly DEH)	7	8263		3702	3702	Unused, Spoiled Paint
				3451	3451	Sealant
				1110	1110	Polyurethane
	12	171		171	171	Furniture Polish
Troop	9	18441		4762	4762	Shelf-Life DS-2
				10717	10717	Shelf-Life STB
				1854	1854	Calcium Hydride
				1108	1108	Calcium Hypochlorite
	12	13248		8461	8461	Spent Mercury Batteries
				1019	1019	Spent Alkaline Batteries
				3768	3768	Spent Lithium Batteries
	13	10559		1210	1210	Insecticides, NOS
				9349	9349	Magnesium Carbon
Miscellaneous	2	125		100	100	Spent Dichlorodifluoromethone
				25	25	Spent Freon
	5	3720		3720	3720	Spent Methonol
	8	750		750	750	Spent Acetic Acid
	13	1184		1184	1184	Detergent, NOS

Table A2

Total Waste Generation Rates by Waste Categories*

Generator	Total	1	2	3	4	5	6	7	8	9	10	11	12	13
MPVM	1701968	191861	1442	247501	717424				3774		32655		201850	305491
IMSS	585409	29057	7700	20416	75190			15	92500		42700		300015	17816
AMF	52809	13379	446		3035			842	716		2275		20250	11866
PS	36482		65		1750	1031		29521						4115
PPAS	17775	96	1079				5621	316	10663					
HCL	515563	1278	505			915	966			185		90		511624
HCP	267000	1400							265600					
GE (DEH)	8434							8263					171	
Troop	42248									18441			13248	10559
Miscellaneous	5779		125			3720			750					1184
TOTAL	3233467	237071	11362	267917	797399	5646	6587	38957	373973	18626	77630	90	535534	862655

*Quantities are reported in pounds per year.

Table A3

Calculation of the Overall Waste Reduction Factors

Waste	Quantity lb/yr (gal/yr)	Estimated Reduction	Estimated "HW" Reduction
Cleaning Solvent	235,309 (30,610)	0.00	1.00
Used Oil	797,399 (114,000)	0.30	0.10
Battery Acid	93,744 (9500)	1.00	1.00
Antifreeze	267,917 (30,445)	1.00	0.00
Paint Thinner	7040 (1000)	0.80	0.90
TCA	7700 (1000)	0.80	0.90
Degreaser Tank Bottoms	5280	0.00	0.00
Other Wastes	530,034*	0.30	0.20
	Weighted Average	0.37	0.54**

* Does not include: boiler blowdown - 265,600 lb/yr; infectious wastes - 509,650 lb/yr; lead-acid batteries/casings - 501,850.
**Since (nonchlorinated) used oil and antifreeze are not "hazardous wastes" they have been excluded from this calculation.

APPENDIX B:

HAZMIN PROTOCOL AND SURVEY FORMS

HAZMIN Protocol

Goals

1. Define current status of waste generation and management practices.
2. Identify and evaluate new waste minimization alternatives.
3. Identify support for existing alternatives/activities.
4. Identify areas/activities requiring further research and development.

Approach

I. Review information available at the installation.

II. Talk to several groups of individuals.

III. Develop a list of waste streams and rank them.

IV. Develop information on each waste stream.

V. Identify minimization options for each waste stream.

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

VII. Conduct detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

HAZMIN Protocol

I. Review information available at the installation.

The information reviewed by the survey team includes:

1. Installation policies/programs on waste minimization, if any.
2. Hazardous waste manifests, annual (and biennial) reports, and other RCRA information since 1985.
3. State and local regulations that are more stringent than federal regulations.
4. Environmental audit/review reports.
5. Emission inventories.
6. Permit and/or permit applications, and any regulatory violations.
7. Contracts with waste management firms.
8. Waste assays and/or tests.
9. Materials purchase orders, purchase records.
10. Maps, organizational charts, list of activities associated with different buildings.
11. Production/maintenance schedules.
12. Operator data logs, batch sheets.
13. Operation manuals, process descriptions, standard operating procedures (SOPs).
14. Process flow diagrams (PFDs) and facilities layout.
15. Heat and material balances for production processes and pollution control systems.
16. Safety procedures for handling hazardous materials.

Products:

1. List of information sources.
2. Waste stream list.
3. Survey agenda or checklist detailing what is to be accomplished.
4. List of questions that need to be resolved.
5. List of information that needs to be gathered.

HAZMIN Protocol

II. Talk to several groups of individuals.

Identify appropriate individuals to interview among:

1. Environmental personnel
   - who compile USEPA/State reports
   - who compile DRMO reports
2. Waste generators
   - supervisors
   - shop foremen and production employees
3. Hazardous waste managers
   - operators of 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

III. Develop a list of waste streams and rank them.

Develop a waste generation inventory based on reports, permits, and observation. Inventory must be representative of "normal" operations.

Ranking criteria:

1. Composition
2. Quantity (volume or mass generated per year and unit of production)
3. Degree of hazard (toxicity, flammability, corrosivity, etc.)
4. Method and cost of disposal
5. Potential for minimization and recycling
6. Compliance status (in or out)
7. Potential liability (past spills or accidents; proximity to water)
8. Degree of acceptability of changes at the installation
9. Installation personnel preference for options

Products:

1. Waste description with rationale for selection
2. Description of facilities, processes, and waste streams

IV. Develop information on each waste stream.

The following information must be developed on each waste stream based on observation and available reports:

1. Waste characterization
   - chemical/physical analysis
   - reason for hazardous nature

2. Waste source

3. Baseline generation

4. Present method of TSD and associated costs

5. Past/present minimization efforts and associated costs

Some points to be reviewed in the above determination are:

- actual point of generation
- details about subsequent handling/mixing
- "hazardous" versus nonhazardous
- physical and chemical characteristics
- quantities by waste treatability category
- potential variations in the rate of production, maintenance, etc.
- potential for contamination or upset
- true costs for management, onsite and offsite including tax, fringe, and overhead for labor; cost of space; vehicle insurance, maintenance, fuel, etc.

V. 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

VII. Detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

The following aspects must be considered in the final detailed analysis:

1. Technical soundness and commercial availability

2. Evaluation of detailed life cycle costs of all the options for each waste stream

3. Detailed comparison of costs of the current practices with alternative options to obtain savings to investment ratios and discounted payback periods

4. Implementation period

HAZMIN Survey Forms

Installation____________________Date__________POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Motor Pools & Vehicle Maintenance Facilities

Generator (Unit Name)________________Building_______DODAAC_______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
Carburetor cleaner		Carburetor cleaner	
Waste oil		Engine oil	
Antifreeze solution		Antifreeze	
Lead-acid batteries		Lead-acid batteries	
Battery acid		Battery acid	
Aqueous detergent or caustic wastes (engine/radiator washing)		Caustic/detergent	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (mogas/diesel)		Fuel: diesel mogas	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Other fluids (transmission, brake, etc.)		Other fluids (transmission, brake, etc.)	
Mixed wastes			
Hazardous faulty parts (e.g., brake pads)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC________________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Aviation Maintenance Facilities

Generator (Unit Name)________________Building_______DODAAC______UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
MEK degreaser & cleaner		Methyl ethyl ketone	
Calibrating fluid (specify)		Calibrating fluid (specify)	
Paint stripper (specify)		Paint stripper (specify)	
Paint thinner (specify)		Paint thinner (specify)	
Filters (paint booth)		Filters (paint booth)	
Used paint cans			
Waste engine oil		Engine oil	
Deicer solution		Deicer	
Nickel-cadmium batteries		Nickel-cadmium batteries	
NICAD battery electrolyte		Battery electrolyte (pottasium hydroxide)	
Aqueous detergent or caustic wastes (engine washing)		Caustic/detergent (engine washing)	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (Avgas)		Fuel (Avgas)	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone________

WASTE STREAM/MATERIALS USAGE: Industrial Maintenance, Small Arms Shops, etc.

Generator (Unit Name)________________Building_______DODAAC______UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Degreasing solvent (trichloroethylene)		Trichloroethylene	
Degreasing solvent (1,1,1-trichloroethane)		1,1,1-trichloroethane	
Degreasing solvent (others)		Degreasing solvent (others, specify)	
Paint thinners (specify)		Paint thinners (specify)	
Surface cleaners (specify)		Surface cleaners (specify)	
Paint wastes			
Waste oil		Lubricating oil	
Hydraulic/cutting fluids		Hydraulic & cutting fluids	
Corrosive chemicals (caustic soda)		Caustic soda	
Corrosive chemicals (phosphoric acid)		Phosphoric acid	
Corrosive chemicals (chromic acid)		Chromic acid	
Corrosive chemicals (phosphate solution)		Phosphate	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Tank bottoms (specify)			
Paint/sand blasting wastes			
Steam cleaning compound (alkali wastes)		Alkali	
Radioactive wastes		Radioactive sources	
Batteries (lead-acid, NICAD)		Batteries: Lead-acid Nickel-cadmium	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________ **Date**__________ **POC**______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Paint Shops

Generator (Unit Name)________________ **Building**_______ **DODAAC**______ **UIC**______

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Old/used paint cans			
Old/used paint			
Paint thinners (specify)		Paint thinners (specify)	
Paint strippers (specify)		Paint strippers (specify)	
Caustic wastes		Caustic soda	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Filters from paint booths		Filters (paint booths)	
Sludges from water-wall booths			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________**Date**__________**POC**______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Hospitals, Clinics, and Laboratories

Generator (Unit Name)________________**Building**_______**DODAAC**________**UIC**___

Waste Stream	**Generation Rate** (indicate units: gal/yr lb/yr, pints/mo, etc.)	**Material Input**	**Usage Rate** (indicate units: gal/yr lb/yr, pints/mo, etc.)
Pathological wastes (specify)			
Medical infectious wastes (specify)			
Pharmaceutical wastes (specify)			
Chemical wastes (specify)		Laboratory chemicals (xylene) Laboratory chemicals (mercury) Laboratory chemicals (others, specify)	
Radioactive wastes (specify)			
Photographic wastes (specify)		Photographic chemicals (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________**Date**__________**POC**____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Photography, Printing, Arts/Crafts Shops, etc.

Generator (Unit Name)________________**Building**_______**DODAAC**______**UIC**____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Solvents (specify)		Solvents (specify)	
Inks (specify)		Inks (specify)	
Photographic chemical wastes (specify)		Photographic chemicals (specify)	
Printing chemical wastes (specify)		Printing chemicals (specify)	
Bath dumps			
Paint wastes			
Paint/sand blasting wastes			
Other dry wastes			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Heating and Cooling Plants

Generator (Unit Name)________________Building_______DODAAC_______UIC___

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
		Waste oil	
Contaminated fuel oil		Fuel oil	
		Natural gas	
Combustible chemicals (cyclohexylamine)		Combustible chemicals (cyclohexylamine)	
Combustible chemicals (other, specify)		Combustible chemicals (others, specify)	
Corrosive chemicals (caustic soda/potash)		Corrosive chemicals (caustic soda/potash)	
Corrosive chemicals (other, specify)		Corrosive chemicals (other, specify)	
Boiler blowdown			
Toxic emissions			
Ash			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation__________________ _**Date**__________**POC**______________________
Phone__________

WASTE STREAM/MATERIALS USAGE: Laundry and Drycleaning Facilities

Generator (Unit Name)__________________**Building**________**DODAAC**________**UIC**____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Corrosive chemicals (caustic soda)		Corrosive chemicals (caustic soda)	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Drycleaning compound (perchloroethylene)		Perchloroethylene	
Drycleaning compound (others, specify)		Drycleaning compound (others, specify)	
Equipment filters		Filters	
Contaminated water			
Other dry wastes (specify)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Miscellaneous Generators

Generator (Unit Name)________________Building_______DODAAC_______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Wet chemical wastes (specify)		Wet Chemicals (specify)	
Dry chemical wastes (specify)		Dry Chemicals (specify)	
Off-shelf life chemicals			
Used chemicals (pesticides, etc.)			
Batteries (specify)		Batteries (specify)	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Contaminated soil			
Demilitarized ammunition			
Decontaminating agents (STB, DS2, etc.)			
Hazardous empty containers (drums etc.)			
Contaminated equipment (PCB transformers etc.)			
Contaminated water		Water	
Sludge from water treatment		Water treated	
Leachate into groundwater			
Infectious wastes			
Ordnance			
Fire-fighting foam		Fire fighting foam	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC__________________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Motor Pools & Vehicle Maintenance Facilities

Generator (Unit Name)________________Building_______DODAAC__________UIC_______

Waste Stream	Generation Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
MEK degreaser & cleaner		Methyl ethyl ketone	
Calibrating fluid (specify)		Calibrating fluid (specify)	
Paint stripper (specify)		Paint stripper (specify)	
Paint thinner (specify)		Paint thinner (specify)	
Filters (paint booth)		Filters (paint booth)	
Used paint cans			
Waste engine oil		Engine oil	
Deicer solution		Deicer	
Nickel-cadmium batteries		Nickel-cadmium batteries	
NICAD battery electrolyte		Battery electrolyte (pottasium hydroxide)	
Aqueous detergent or caustic wastes (engine washing)		Caustic/detergent (engine washing)	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (Avgas)		Fuel (Avgas)	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________ **Date**__________ **POC**_________________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Industrial Maintenance, Small Arms Shops, etc.

Generator (Unit Name)______________ **Building**______ **DODAAC**__________ **UIC**_________

Waste Stream	Generation Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)
Pathological wastes (specify)			
Medical infectious wastes (specify)			
Pharmaceutical wastes (specify)			
Chemical wastes (specify)		Laboratory chemicals (xylene) Laboratory chemicals (mercury) Laboratory chemicals (others, specify)	
Radioactive wastes (specify)			
Photographic wastes (specify)		Photographic chemicals (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________**Date**__________**POC**__________________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Photography, Printing, Arts/Crafts Shops, etc.

Generator (Unit Name)____________**Building**______**DODAAC**_________**UIC**___________

Waste Stream	Generation Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/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: gallons/yr pounds/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gallons/yr pounds/yr, pints/mo, etc.)
Wet chemical wastes (specify)		Wet Chemicals (specify)	
Dry chemical wastes (specify)		Dry Chemicals (specify)	
Off-shelf life chemicals			
Used chemicals (pesticides, etc.)			
Batteries (specify)		Batteries (specify)	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Contaminated soil			
Demilitarized ammunition			
Decontaminating agents (STB, DS2, etc.)			
Hazardous empty containers (drums etc.)			
Contaminated equipment (PCB transformers etc.)			
Contaminated water		Water	
Sludge from water treatment		Water treated	
Leachate into groundwater			
Infectious wastes			
Ordnance			
Fire-fighting foam		Fire fighting foam	
Miscellaneous (specify)		Miscellaneous (specify)	

LIST OF ABBREVIATIONS AND ACRONYMS

AAFES	Army Air Force Exchange Service
AFPMB	Armed Forces Pest Management Board
AHS	Academy of Health Sciences
AMF	Aviation Maintenance Facility
AOAP	Army Oil Analysis Program
APCD	Air Pollution Control Division
APEN	Air Pollution Emissions Notice
AQCR	Air Quality Control Region
AR	Army Regulation
ARCOM	U.S. Army Reserve Command
BMO	Battalion Maintenance Officer
BOD	Biochemical Oxygen Demand
Btu	British thermal unit
CARC	Chemical Agent Resistant Coating
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CE	Corps of Engineers
CEWI	Combat Electronic Warfare Intelligence
CFR	Code of Federal Regulations
COD	chemical oxygen demand
DA	Department of the Army
DEH	Directorate of Engineering and Housing
DENTAC	U.S. Army Dental Activity
DESR	Defense Environmental Status Report
DLA	Defense Logistics Agency

DOD	Department of Defense
DOL	Directorate of Logistics
DOT	Department of Transportation
DPCA	Directorate of Personnel and Community Affairs
DPTM	Directorate of Plans, Training, and Mobilization
DRMO	Defense Reutilization and Marketing Office
DRMS	Defense Reutilization and Marketing Service
EA	Environmental Assessment
EENR	Energy, Environment, and Natural Resources Division
EOD	Explosive Ordnance Disposal
EOR	Environmental Operations Review
FLOCS	Fast Lubricating Oil Change System
FORSCOM	U.S. Army Forces Command
FR	Federal Register
FY	Fiscal Year
GE	General Electric
HAZMIN	Hazardous Waste Minimization
HCL	Hospitals, Clinics, and Laboratories
HMTC	Hazardous Materials Technical Center
HSC	Health Services Command
HSWA	Hazardous and Solid Waste Amendments
HW	Hazardous Waste
HWMB	Hazardous Waste Management Board
IDMS	Integrated Database Management System
IMSS	Industrial Maintenance, Small Arms Shops
INSCOM	U.S. Army Intelligence and Security Command
ISC	U.S. Army Information Systems Command

ISCP	Installation Spill Contingency Plan
IWTP	Industrial Wastewater Treatment Plant
JAG	Judge Advocate General
JLC	Joint Logistics Commanders
LAO	Logistics Assistance Office
MACOM	Major Command
MAIT	Maintenance Assistance and Indstruction Team
MEDDAC	Medical Department Activity
MGD	Million Gallons Per Day
MI	Military Intelligence
MPVM	Motor Pools and Vehicle Maintenance
MSB	Main Support Battalion
MSDS	Material Safety Data Sheet
NAAQS	National Ambient Air Quality Standard
NIPDWR	National Interim Primary Drinking Water Regulations
NIPER	National Institute for Petroleum and Energy Research
NPDES	National Pollutant Discharge Elimination System
NSDWR	National Secondary Drinking Water Regulations
NSN	National Stock Number
OB/OD	Open Burning/Open Detonation
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PCMS	Pinon Canyon Maneuver Site
PL	Public Law
PMB	Plastic Media Blasting
POL	Petroleum, Oils, and Lubricants
PPAS	Photography, Printing, and Arts/Crafts Shops

PS	Paint Shops
RCRA	Resource Conservation and Recovery Act
SIP	State Implementation Plan
SOP	Standing Operating Procedure
SPCCP	Spill Prevention Control and Countermeasures Plan
SQG	Small Quantity Generator
SS	Suspended Solids
TASC	Training and Audiovisual Support Activity
TMP	Transportation Motor Pool
TOPO	Defense Maping Agency, Hydrographic/Topographic Center
TSDF	Treatment, Storage, or Disposal Facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
USACERL	U.S. Army Construction Engineering Research Laboratory
USACIC	U.S. Army Criminal Investigation Command
USAEHA	U.S. Army Environmental Hygiene Agency
USEPA	U.S. Environmental Protection Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USE	Used Solvent Elimination
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
WWII	World War II
WWTP	Wastewater Treatment Plant
XO	Executive Officer

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