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Guides to Pollution Prevention

The Pesticide Formulating Industry

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February 1990

GUIDES TO POLLUTION PREVENTION
The Pesticide Formulating Industry

RISK REDUCTION ENGINEERING LABORATORY
AND
CENTER FOR ENVIRONMENTAL RESEARCH INFORMATION
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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NOTICE

This report has been subjected to the U. S. Environmental Protection Agency's peer and administrative review and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This document is intended as advisory guidance only to pesticide formulators in developing approaches for pollution prevention. Compliance with environmental and occupational safety and health laws is the responsibility of each individual business and is not the focus of this document.

Worksheets are provided for conducting waste minimization assessments of pesticide formulating facilities. Users are encouraged to duplicate portions of this publication as needed to implement a waste minimization program.

FOREWORD

Pesticide formulating facilities generate wastes during such operations as decontamination of mixing and storage of equipment, housekeeping, and laboratory testing for quality assurance. The wastes generated are: containers with leftover raw materials; pesticide dust and scrubber water from air pollution control equipment; volatile organic compounds; off-specification products and laboratory analysis wastes; spills; waste sands or clays; waste rinse water and solvent; laundry waste water; and stormwater runoff contaminated with pesticides.

Reducing the generation of these wastes at the source, or recycling the wastes on or off site, will benefit pesticide manufacturers by reducing raw materials needs, reducing disposal costs, and lowering the liabilities associated with hazardous waste disposal. This guide provides an overview of the pesticide formulating processes and operations that generate waste and presents options for minimizing waste generation through source reduction and recycling.

ACKNOWLEDGMENTS

This guide is based in part on waste minimization assessments conducted by Environmental Science and Engineering (ESE) for the California Departemnt of Health Services (DHS). Contributors to these assessments include: David Leu, Benjamin Fries, Kim Wilhelm, and Jan Radimsky of the Alternative Technology Section of DHS. Much of the information in this guide that provides a national perspective on the issues of waste genteration and minimization for pesticide formulators was provided originally to the U. S. Environmental Protection Agency by Versar, Inc. and Jacobs Engineering Group, Inc. in *Waste Minimization-Issues and Options, Volume II*, report no. PB87-114369(1986). Jacobs Engineering Group, Inc. edited and developed this version of the waste minimization assessment guide, under subcontract to Radian Corporation (USEPA contract 68-02-4286). Lisa M. Brown of the U. S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, was the project officer responsible for the preparation and review of this document. David A. Lewis of the Agricultural Chemical Group, FMC Corporation also served as a reviewer.

CONTENTS

SECTION 1
INTRODUCTION

This guide is designed to provide pesticide formulators with waste minimization options appropriate for this industry. It also provides worksheets designed to be used for a waste minimization assessment of a pesticide formulating facility, to be used in developing an understanding of the facility's waste generating processes and to suggest ways to reduce the waste.

The guide should be used by pesticide formulating companies, particularly their plant operators and environmental engineers. Others who may find this document useful are regulatory agency representatives and consultants.

The worksheets and the list of waste minimization options for pesticide formulating were developed through assessments of three pesticide formulating firms commissioned by the California Department of Health Services (Calif. DHS, 1987). The three firms' facility operations, manufacturing processes, and waste generation and management practices were surveyed, and their existing and potential waste minimization options were characterized. Economic analyses were performed on selected options.

Waste minimization is a policy specifically mandated by the U.S. Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (RCRA). As the federal agency responsible for writing regulations under RCRA, the U.S. Environmental Protection Agency (EPA) has an interest in ensuring that new methods and approaches are developed for minimizing hazardous waste and that such information is made available to the industries concerned. This guide is one of the approaches EPA is using to provide industry-specific information about hazardous waste minimization. The options and procedures outlined can also be used in efforts to minimize other wastes generated in a facility.

EPA has also developed a general manual for waste minimization in industry. The *Waste Minimization Opportunity Assessment Manual* (USEPA 1988) tells how to conduct a waste minimization assessment and develop options for reducing hazardous waste generation at a facility. It explains the management strategies needed to incorporate waste minimization into company policies and structure, how to establish a company-wide waste minimization program, conduct assessments, implement options, and make the program an on-going one. The elements of waste minimization assessment are explained in the Overview, next section.

In the following chapters of this manual you will find:

- A profile of the pesticide formulating industry and the processes used by the industry (Section Two);
- Waste minimization options for pesticide formulating firms (Section Three);
- Waste minimization assessment guidelines and worksheets (Section Four)
- An Appendix, containing:
  - Case studies of waste generation and waste minimization practices of pesticide formulating firms;
  - Where to get help: Additional sources of information.

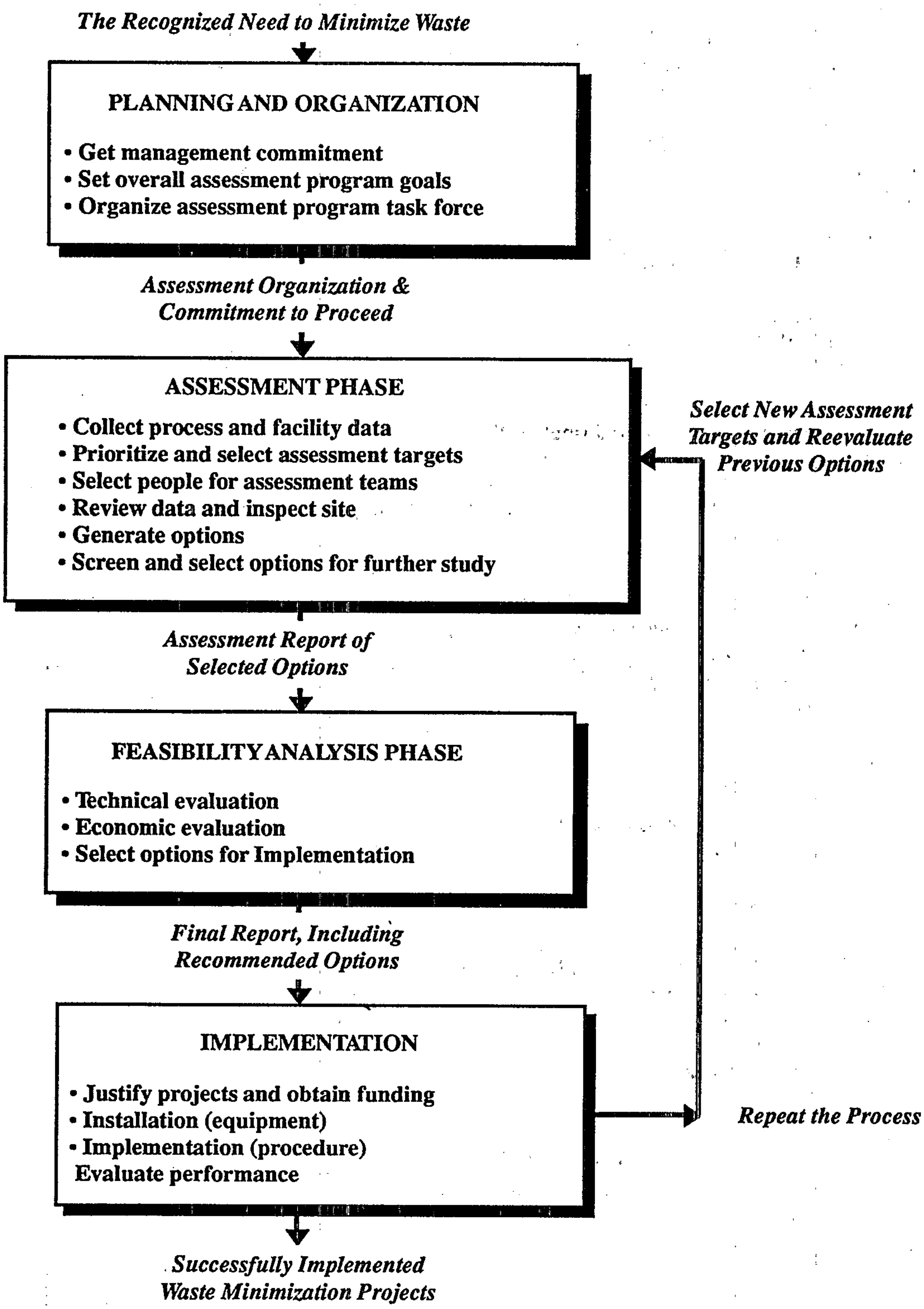
Overview of Waste Minimization Assessment

In the working definition used by EPA, waste minimization consists of *source reduction* and *recycling*. Of the two approaches, source reduction is usually considered preferable to recycling from an environmental perspective. *Treatment* of hazardous waste is considered an approach to waste minimization by some states but not by others, and thus is not addressed in this guide.

A Waste Minimization Opportunity Assessment (WMOA), sometimes called a waste minimization audit, is a systematic procedure for identifying ways to reduce or eliminate waste. The steps involved in conducting a waste minimization assessment are outlined in Figure 1 and presented in more detail in the paragraphs below. Briefly, the assessment consists of a careful review of a plant's operations and waste streams and the selection of specific areas to assess. After a particular waste stream or area is established as the WMOA focus, a number of options with the potential to minimize waste are developed and screened. The technical and economic feasibility of the selected options are then evaluated. Finally, the most promising options are selected for implementation.

To determine whether a WMOA would be useful in your circumstances, you should first read this section

Figure 1. The Waste Minimization Assessment Procedure



describing the aims and essentials of the WMOA process. For more detailed information on conducting a WMOA, consult the *Waste Minimization Opportunity Assessment Manual.*

The four phases of a waste minimization opportunity assessment are:

- Planning and organization
- Assessment phase
- Feasibility analysis phase
- Implementation

PLANNING AND ORGANIZATION

Essential elements of planning and organization for a waste minimization program are: getting management commitment for the program; setting waste minimization goals; and organizing an assessment program task force.

Assessment Phase

The assessment phase involves a number of steps:

- Collect process and facility data
- Prioritize and select assessment targets
- Select assessment team
- Review data and inspect site
- Generate options
- Screen and select options for feasibility study

Collect process and facility data. The waste streams at a facility should be identified and characterized. Information about waste streams may be available on hazardous waste manifests, National Pollutant Discharge Elimination System (NPDES) reports, routine sampling programs and other sources.

Developing a basic understanding of the processes that generate waste at a facility is essential to the WMOA process. Flow diagrams should be prepared to identify the quantity, types and rates of waste generating processes. Also, preparing material balances for various processes can be useful in tracking various process components and identifying losses or emissions that may have been unaccounted for previously.

Prioritize and select assessment targets. Ideally, all waste streams in a facility should be evaluated for potential waste minimization opportunities. With limited resources, however, a plant manager may need to concentrate waste minimization efforts in a specific area. Such considerations as quantity of waste, hazardous properties of the waste, regulations, safety of employees, economics, and other characteristics need to be evaluated in selecting a target stream.

Select assessment team. The team should include people with direct responsibility and knowledge of the particular waste stream or area of the plant. Operators of equipment and the person who sweeps the floor should be included, for example.

Review data and inspect site. The assessment team evaluates process data in advance of the inspection. The inspection should follow the target process from the point where raw materials enter the facility to the points where products and wastes leave. The team should identify the suspected sources of waste. This may include the production process; maintenance operations; and storage areas for raw materials, finished product, and work in progress. The inspection may result in the formation of preliminary conclusions about waste minimization opportunities. Full confirmation of these conclusions may require additional data collection, analysis, and/or site visits.

Generate options. The objective of this step is to generate a comprehensive set of waste minimization options for further consideration. Since technical and economic concerns will be considered in the later feasibility step, no options are ruled out at this time. Information from the site inspection, as well as trade associations, government agencies, technical and trade reports, equipment vendors, consultants, and plant engineers and operators may serve as sources of ideas for waste minimization options.

Both source reduction and recycling options should be considered. Source reduction may be accomplished through:

- Good operating practices
- Technology changes
- Input material changes
- Product changes

Recycling includes:

- Use and reuse of waste
- Reclamation

Screen and select options for further study. This screening process is intended to select the most promising options for full technical and economic feasibility study. Through either an informal review or a quantitative decision-making process, options that appear marginal, impractical or inferior are eliminated from consideration.

FEASIBILITY ANALYSIS

An option must be shown to be technically and economically feasible in order to merit serious consideration for adoption at a facility. A technical evaluation determines whether a proposed option will work in a specific application. Both process and equipment changes need to be assessed for their overall effects on waste quantity and product quality.

An economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. As in any project, the cost elements of a waste minimization project can be broken down into capital costs and economic costs. Savings and changes in revenue also need to be considered.

IMPLEMENTATION

An option that passes both technical and economic feasibility reviews should then be implemented at a facility. It is then up to the WMOA team, with management support, to continue the process of tracking wastes and identifying opportunities for waste minimization, throughout a facility and by way of periodic reassessments. Either such ongoing reassessments or an initial investigation of waste minimization opportunities can be conducted using this manual.

References

California DHS. 1987. *Waste Audit Study: Pesticide Formulating Industry.* Report prepared by Environmental Science and Engineering, Inc., Sacramento, Calif. for the Alternative Technology Section, Toxic Substances Control Division, California Dept. of Health Services. November 1987.

USEPA. 1988. *Waste Minimization Opportunity Assessment Manual.* Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio., EPA/625/7-88/003.

SECTION 2
PESTICIDE FORMULATING INDUSTRY PROFILE

Industry Description

As defined by Standard Industrial Classification (SIC) 2879, the pesticide formulating industry includes companies which formulate and prepare agricultural pest control chemicals or pesticides. This includes insecticides, herbicides, and fungicides. These products are formulated from pesticide concentrates manufactured elsewhere and are distributed to farmers in ready-to-use form.

The industry is comprised of roughly 330 establishments nationwide. Approximately 59% of the establishments are located in 10 states, although no one state accounts for a major share of the industry. Most of the establishments are located near the agricultural areas which make use of the products.

Products and Their Uses

The agricultural chemicals industry (SIC 2879) produces pesticides and other agricultural chemicals not elsewhere classified, such as soil conditioners. In the U.S., over 600 different pesticides are produced (Kryeger 1983). Most pesticides can be classified as either insecticides, herbicides, or fungicides, although many other minor classifications exist. Table 1 lists the production of the major classes of pesticides. Each division is subdivided to chemical type.

The product formulations that were included in the waste minimization assessments of this Guide were agricultural, industrial, and household pesticide formulations. These include insecticides, herbicides, and rodenticides. Excluded from the study were preservatives, disinfectants, and cleaning agents.

There are three types of pesticide formulations; solvent-based, water-based, and solid-based.' In solvent-based formulations, the solvent serves as the carrier solution for the pesticide ingredient. A solvent-water emulsion may also be used as the carrier. Typical solvents are light aromatics such as xylene, chlorinated organics such as 1,1,1-trichloroethane, and mineral spirits. As with solvent-based formulations, water serves as the carrier solution for the active pesticide ingredient in the water-based formulations. Other water-based formulations are in the form of suspensions or emulsions. The solvent- and water-based formulations are applied directly in liquid form or propelled as an aerosol.

There are many types of dry-based pesticide formulations prepared by blending solid active ingredients with inert solids such as clay and sand. Some dry formulations are prepared by absorbing liquid active ingredients with solid carrier materials. Some common dry-based formulations are dusts, wettable powders, granules, treated seed, and bait pellets and cubes.

TABLE 1. 1982 PESTICIDE PRODUCTION IN THE U.S.

Product	Quantity Produced (tons per year)
Insecticidal formulations	
Inorganic compounds	54,300
Organic compounds	206,750
Chlorinated hydrocarbons	18,900
Carbamates	78,400
Organophosphates	73,150
Biological (botanical, bacterial)	11,250
Other organics	25,050
Herbicide formulations	
Inorganic compounds[a]	N/A
Organic compounds	541,750
Phenoxy	101,400
Metal organic	9,450
Triazine	97,250
Urea, amide, benzoic, other organics	333,150
Fungicide formulations	
Inorganic compounds[a]	N/A
Organic compounds	56,250
Other pesticidal formulations	
Fumigants	17,450
Defoliants and desiccants	3,500
All other[a]	N/A

[a]Data not available.

Source: 1982 Census of Manufacturers (USDC 1985).

Roughly 75% of all insecticides and herbicides, and 66% of all pesticides, are used on agricultural cropland. The remainder are used in private homes and gardens and on commercial and industrial property (Dillon 1981). The majority of pesticides are used on only a few major crops. Currently, cotton, corn, and apples receive 67% of all insecticides used in agriculture. Corn and soybeans receive 60% of the herbicides used, and 84% of the fungicides are applied to fruits and vegetables. Only 48% of the total U.S. cropland is treated with pesticides (Dahlston 1983).

Raw Materials

Pesticide formulation converts highly concentrated pesticide active ingredients into convenient-to-use products at application concentrations packaged for the end-user. As listed below, input raw materials include the pesticide concentrates from pesticide manufacturing plants as well as diluents and other chemical additives used in the formulating process:

Active Agents

Organic/inorganic pesticides: insecticides, herbicides, fungicides, other

Formulations and preparation materials

Dry formulations:
- organic flours, sulfur, silicon oxide, lime, gypsum, talc, pyrophyllite, bentonites, kaolins, attapulgite, volcanic ash

Liquid formulations:
- Solvents: xylenes, kerosenes, methyl isobutyl ketone, amyl acetate, chlorinated solvents
- Propellants: Carbon dioxide, nitrogen
- Others: wetting and dispersing agents, masking agents, deodorants, emulsifiers

Process Description

There are two major steps in the production of pesticides for agricultural use. The first step is the manufacturing of the pesticide concentrate from basic chemical feedstocks including petrochemicals, inorganic acids, gases such as chlorine, and other chemicals. This produces the pesticide, but not in a form which is ready for use. The second major step, which is the focus of this report, is the formulation and preparation of the pesticide for final use. Block flow diagrams of the steps involved in formulating liquid-based and dry-based pesticide products are presented in Figures 2 and 3 respectively.

The processes used to formulate pesticides generally consist of blending operations where the active ingredients are mixed with the inert ingredients previously mentioned. Also, particle size reduction operations such as milling and coating operations for granule and treated seed production are used. Generally, chemical reactions do not occur.

Conventional blending equipment is used for pesticide formulation. This equipment includes tanks equipped with mixers for liquid formulations and blending mills for solid formulations. Ancillary equipment includes storage tanks, rotary kilns for curing solid formulations, pumps, hoppers, and conveyors. Mixing tank capacities generally vary from less than 100 gallons to several thousand gallons for liquid formulations. Solids blending mill capacities are usually on the order of several hundred pounds to three tons.

Packaging of the pesticides formulations most commonly occurs at the same plant where the formulating is performed. This avoids the cost of transporting the high volume, dilute formulations. Packaging generally involves pouring liquid formulations into 55-gallon drums or glass bottles for distribution. For solid formulations, the material is usually gravity fed from hoppers into drums or paper bags for distribution.

Waste Description

In order to present a meaningful discussion of source reduction techniques that are applicable to the pesticide formulating industry, the sources of waste generation in this industrial segment must first be described. Pesticide formulating generally involves the blending of concentrated active pesticide ingredients with inert diluents, and the actual formulation process typically does not generate wastes. However, related non-formulating activities do generate hazardous wastes. These include decontamination of mixing and storage equipment, housekeeping operations, and laboratory testing for quality assurance. The wastes and their process origins are listed in Table 2.

Decontamination of liquid pesticide mixing and storage equipment generates pesticide-contaminated wastewater or solvent, depending upon whether the equipment is used to formulate water or solvent-based pesticides. Decontamination of the blending equipment is performed for the same reasons as for the liquid pesticide formulating equipment. The decontamination is commonly performed using high pressure water hoses equipped with spray nozzles, portable steam generators, or by running a batch of solvent through the formulating equipment. Floor washing is typically performed using water hoses equipped with spray nozzles. It may also involve the use of mops and squeegees.

Reuseable active ingredient containers, such as 55-gallon drums, are often decontaminated by triple rinsing. They then can be sold or given to commercial recycling firms. The decontamination is usually performed using a high pressure water hose equipped with a spray nozzle or a portable steam jenny.

Another source of liquid waste, unique to the packaging of aerosol pesticides, is the hot water bath. This is required by the U.S. Department of Transportation to

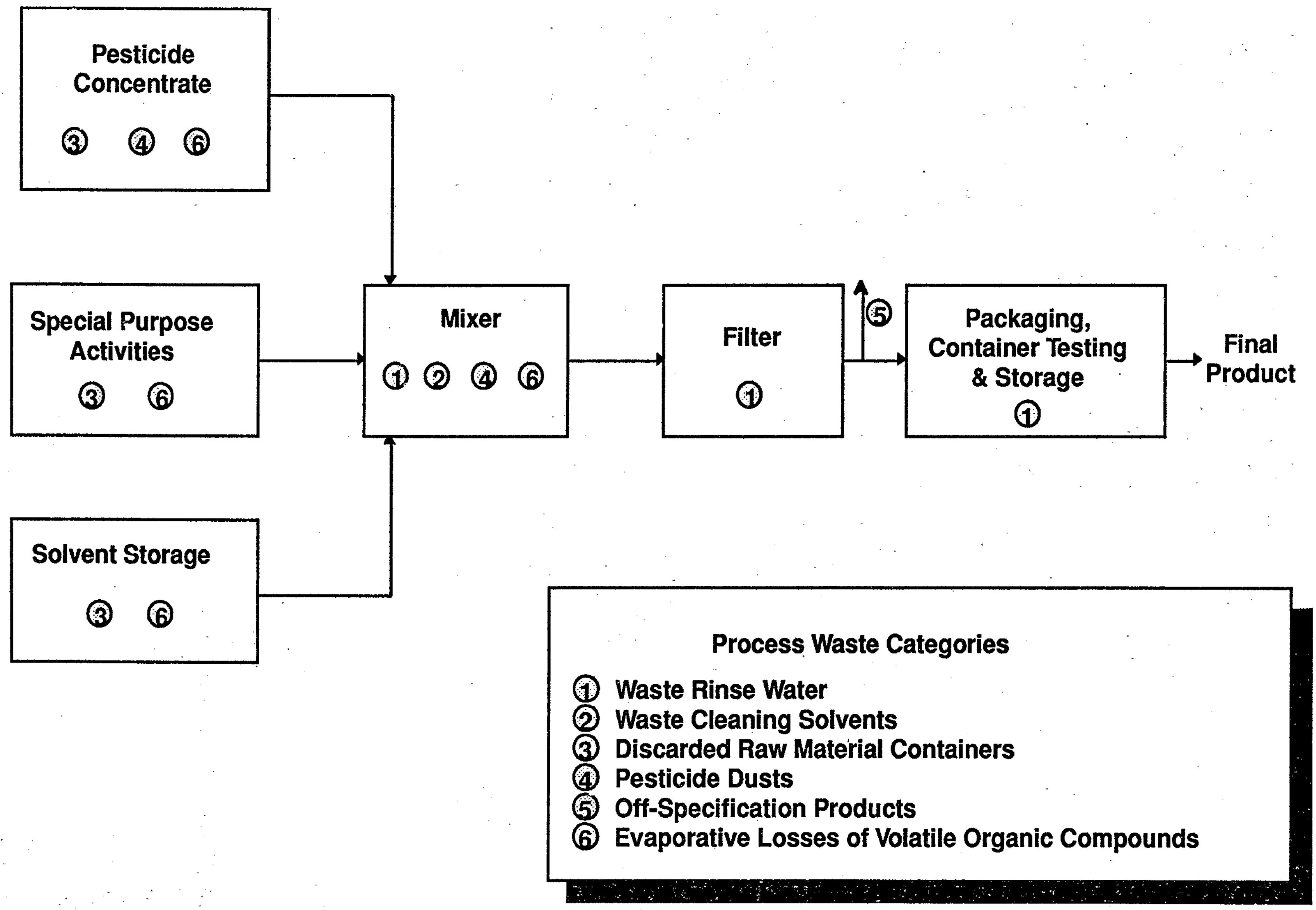


Figure 2. Liquid Pesticide Formulation Process

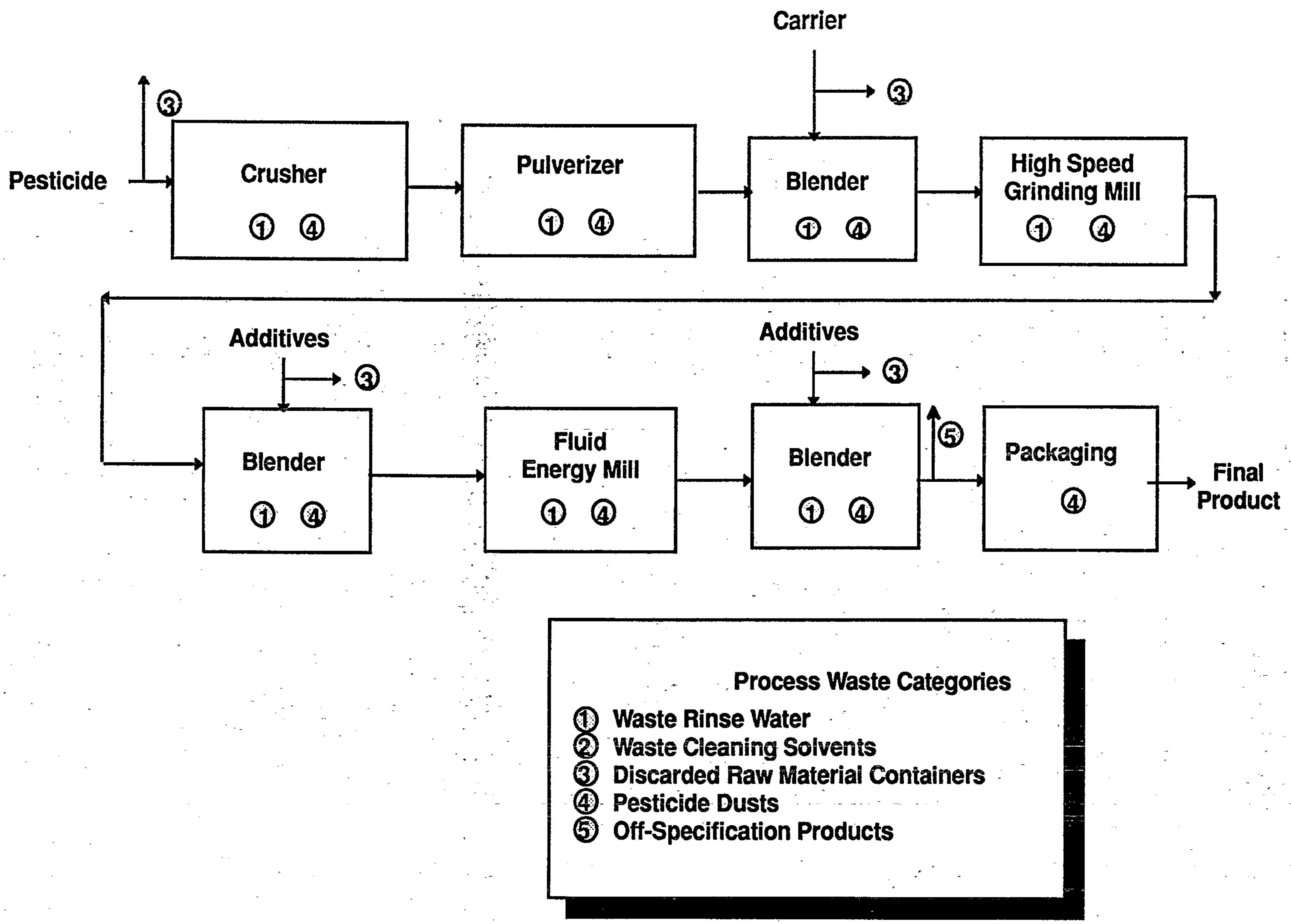


Figure 3. Dry Pesticide Formulation Process

Table 2. Pesticide Formulating Process Wastes

No.	Waste Description	Process Origin	Composition
1.	Leftover raw materials containers.	Unloading of materials into blending tanks.	Bags, fiber drums, steel drums with small amounts of residual raw material.
2.	Pesticide dust from air pollution equipment.	Unloading of dry pesticides into blending tanks.	Pesticide dust, inert carrier dust.
3.	Scrubber water from air pollution equipment.	Unloading of dry pesticides into blending tanks.	Pesticide-contaminated wastewater and solvents.
4.	Volatile organic compounds.	Air emissions from storage tanks and open processing equipment.	Solvents.
5.	Off-specification products and laboratory analysis wastes.	Formulating and testing.	Waste pesticide formulations.
6.	Spills.	Accidental discharge.	Waste pesticide formulations.
7.	Waste sands or clays.	Equipment cleaning.	Pesticide-contaminated sands or clays.
8.	Waste rinse water.	Equipment cleaning, area washdown, hot water bath for leak checking.	Pesticide-contaminatedwastewater.
9.	Waste solvent.	Equipment cleaning.	Pesticide-contaminated solvents.[1]
10.	Laundry waste water.	Laundering of protective clothing.	Pesticide-contaminated wastewaters.
11.	Stormwater runoff.	Pesticide spillage and fallout of pesticide dust in open process areas.	Pesticide-contaminated wastewaters.

[1]RCRA Codes F002 and F003.

check for leaking cans (49B CFR Part 178). Each filled aerosol can is immersed in the bath where bubbles can be seen if a container has not been sealed. Water from the hot water baths is discharged routinely to prevent turbidity.

Decontamination of the solid-based pesticide blending mills generates solid diluent contaminated with pesticides. The diluent typically consists of clay for dust mills and sand for granule mills.

Decontamination is performed in between batches of different types of formulations to prevent cross contamination of the subsequent batch. Decontamination is also performed prior to taking the equipment out of service for maintenance.

Most dust/granule blending mills are equipped with vacuum systems to collect fugitive dust. This provides for worker safety, for control of product loss, and for housekeeping in the process area. Some vacuum systems are dedicated to certain mills to facilitate reuse of the dust. Other systems are used to collect dust from a number of areas.

Conventional process technology unit operations are commonly used to treat wastewater from pesticide and related industries. Table 3 below presents a list of the unit operations commonly used to treat pesticide industry wastewaters. However, this list does not include all the applicable treatment unit operations for the many varied waste streams in the pestticide formulating industry. An appropriate combination of unit operations can remove or destroy pesticides and other toxic pollutants to levels which allow reuse of the treated wastewater, discharge to publicly owned treatment works (POTW), or direct discharge to surface waters.

Table 3. Unit Operations for Treatment of Pesticide Formulating Wastewaters

Filtration
Precipitation
Incineration
Coagulation/flocculation
Oil/water separation
Biological treatment
Flotation
Activated carbon adsorption
Evaporation
Hydrolysis
Stabilization
Chemical oxidation
Equalization
Resin adsorption
Decantation
Steam/air stripping

Source: ESE and TRW, 1983.

References

Atkins, P.R., 1972. *The pesticide manufacturing industry-current waste treatment and disposal practices.* Texas University, EPA-12020-FYE-01/72. Washington, D.C.: U.S. Environmental Protection Agency.

Dahlston, D.L. 1983. Pesticides in an era of IPM. *Environment.* 25(10):45-54.

Dillon, A.P. ed. 1981. *Pesticide disposal and detoxification processes and techniques.* New Jersey: Noyes Data Corp.

Environmental Science & Engineering, Inc., and TRW 1983. *Task 2 Interim Report - Wastewater Treatment Technology Evaluation and Application Study.* Prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Environmental Science & Engineering, Inc., Gainesville, Florida and TRW, Research Triangle Park, North Carolina.

Gruber, G.I., 1975. *Assessment of industrial hazardous waste practices, organic chemicals, pesticides and explosives industries.* TRW Systems Group. EPA-530-SW-118c. Washington, D.C.: U.S. Environmental Protection Agency.

Huisingh, D., L. Martin and H. Hilge. 1985. *Proven profit from pollution prevention.* Washington, D.C.: The Institute for Local Self-reliance.

Kryeger, R., ed. 1983. Treatment and disposal of pesticide wastes. In: *ACS Symposium Series 259.*

LWVM, 1985. League of Women Voters of Massachusetts. *Waste reduction, The untold story.* Conference at the National Academy of Sciences, Conference Center on June 19-21. Woods Hole, Mass.: Conference materials.

Metcalf, R.L., 1981. Insect control technology. In *Kirk-Othmer Encyclopedia of Chemical Technology.* 3rd ed., Vo. 13. New York, NY.: Wiley.

National Agricultural Chemicals Association. 1981a. Mimeograph: "Good warehousing practices for agricultural chemicals" and "Good workplace practices for the handling and storage of pesticides."

Parsons, T.B., 1977. *Industrial process profiles for environmental use.* Chapter 8: pesticide industry. Radian Corp. EPA-600-2-77-0234. Research Triangle Park, N.C.: U.S. Environmental Protection Agency.

USDC. 1985. U.S. Department of Commerce, Bureau of the Census. Agricultural Chemicals. In: *1982 Census of Manufacturers.* MC81-I-2886. Washington, D.C.: U.S. Government Printing Office.

USEPA. 1976. U.S. Environmental Protection Agency, Office of Water and Waste Management. *Development document for final effluent limitation guidelines for the pesticide chemical manufacturing industry.* EPA-440-1-73-060d. Washington, D.C.: U.S. Environmental Protection Agency.

Versar, Inc. and Jacobs Engineering Group Inc. 1986. *Waste Minimization — Issues and Options, Volume III.* PB87-114377. Prepared for U.S. Environmental Protection Agency, Washington, D.C.

SECTION 3
WASTE MINIMIZATION OPTIONS FOR PESTICIDE FORMULATORS

. This section discusses recommended waste minimization methods for pesticide formulating operations. These methods come from accounts published in the open literature and through industry contacts. The primary waste streams associated with pesticide formulation are listed in Table 4 along with recommended control methods. In order of occurrence at a facility, the waste streams are equipment cleaning wastes; spills and area washdowns; off spec product; empty bags and drums; air emissions and wastes from air emission control equipment; wastewater associated with laundering protective clothing; water used for aerosol leak testing, and stormwater runoff.

Waste Minimizations Options

The waste minimization methods listed in Table 4 can be classified generally as source reduction, which can be achieved through material substitution, process or equipment modification, or better operating practices; or as recycling. Source reduction through product substitution is not an easily implemented procedure. This is because of the high level of effort and cost associated with registering a new pesticide with EPA as required by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Registration of a new pesticide is required before it may be bought, solid, distributed, or otherwise handled. Pesticide registration involves the development and submission of a health and ecological risk database to EPA for review. Consequently, the waste minimization assessments of pesticide formulating firms focused on source reduction that relies on good operating practices and process modifications.

Better operating practices are procedural or institutional policies that result in a reduction of waste. They include:

- Waste stream segregation
- Personnel practices
  - Management initiatives
  - Employee training
  - Employee incentives
- Procedural measures
  - Documentation
  - Material handling and storage
  - Material tracking and inventory control
  - Scheduling

Many of these measures are used in industry to promote operational efficiency. In addition, they can often be implemented at little or no cost to the facility. When one considers the effects of reduced waste, increased efficiency, and little or no implementation cost, good operating practices usually provide a very high return on investment.

EQUIPMENT CLEANING WASTES

One of the most concentrated waste produced at pesticide formulation plants results from the cleaning of process equipment. As noted earlier, a typical formulation plant produces a variety of different pesticides, all on a batch basis. Between batches, the mixing tanks and all other equipment exposed to the pesticide must be cleaned to avoid contamination between different products.

If powders or other "dry" pesticides are formulated, then cleaning is accomplished using a dry, inert material, such as clay or sand. These inert materials are passed through the system where they pick up traces of pesticide dusts. Many facilities save this flush material and use it in the next production run of the same product.

In the formulating of liquid solvent-based pesticides, cleaning is normally performed by rinsing or flushing the equipment with the same type of solvent used in the formulation followed by a "bail-out" and rinse using water. Waste solvents are usually saved and reused in the next batch of similar product while the wastewater is disposed of as hazardous waste. For water-based pesticide formulations, only water is employed for cleaning. The following waste reduction methods are noted:

Maximize production runs. Production runs of a given formulation should be scheduled together so as to reduce the need for equipment cleaning between batches. Consideration should also be given to the potential for scheduling families of products in sequence; while some cleanup is still needed beween batches, it can be minimized.

Store and reuse cleaning wastes. Based on the results of several audits performed at pesticide formulators (Calif. DHS 1987, USEPA 1976) many facilities collect cleaning dusts and solvents for reuse as make-up in the next compatible formulation. Rinse water has also been saved and reused when the facility produces water-based formulations.

Table 4. Waste Minimization Methods for the Pesticide Formulating Industry

Waste Stream	Waste Minimization Methods
Equipment Cleaning Wastes	Maximize production runs. Store and reuse cleaning wastes. Use of wiper blades and squeegees. Use of low volume high efficiency cleaning. Use of plastic or foam "pigs".
Spills and Area Washdowns	Use of dedicated vacuum system. Use of dry cleaning methods. Use of recycled water for initial cleanup. Actively involved supervision.
Off-Specification Products	Strict quality control and automation. Reformulation of off-spec batches.
Containers	Return containers to supplier. Triple rinse containers. Drums with liners versus plastic drums or bags. Solid waste segregation.
Air Emissions	Control bulk storage air emissions. Dedicated dust collection system. Automatic enclosed cut-in hoppers.
Miscellaneous Wastewater Streams	Pave high spillage areas. Wastewater treatment.*

*This method can only be viewed as waste minimization if it allows the continued use of spent cleaning solutions.

If it is not practical to use the waste rinse water as make-up during a later formulation, it can be reused as rinse water. In those instances where more than one rinse is needed to clean the equipment, the first rinse can be performed using old rinse water from a previous formulation. This rinse will remove the bulk of the pesticide residue from the equipment, then a second rinse with fresh water can be used to complete the cleaning.

Use of wiper blades and squeegees. After a mix tank has been drained, some residual formulation remains clinging to the walls. To remove this clingage and to reduce the subsequent level of cleaning solvent/water contamination, mechanical wipers can be employed. For facilities where tanks are wiped with rags, use of wipers would reduce or eliminate waste rags. Use of wipers and squeegees usually requires manual labor; hence, the extent of waste reduction depends on the operator. Since the benefits will be offset by increased labor, mechanization/automation should be considered. Mixers designed with automatic wall scrapers are available (Weismantel and Guggilam 1985). These mixers can be used with any cylindrical mix tank (flat or conical bottom).

Use of low-volume high efficiency cleaning systems. High pressure spray nozzles can be used in place of the standard rinsing hoses. According to a study of equipment cleaning in the paint industry (USEPA 1979), water consumption can be cut by 80–90% when high pressure rinsing systems are used. Other types of low-volume high efficiency cleaning systems include water knifes and portable steam cleaners. Steam cleaners are a viable alternative to the "boil-out" procedure whereby a tank is filled with water and then heated to effect cleaning.

Use of a plastic or foam "pig" to clean lines. Many industries use "pigs" (fluid propelled pipe inserts) to clean piping. The "pig" is forced through the pipe from the mixing tank to the filling machine hopper. The "pig" pushes ahead paint left clinging to the walls of the pipe. This, in turn, increases yield and reduces the subsequent degree of pipe cleaning required. Inert gas is used to propel the "pig" and minimize drying of paint inside the pipe. The equipment (launcher and catcher) must be carefully designed so as to prevent spills, sprays, and potential injuries, and the piping runs must be free of obstructions so that the "pig" does not become stuck or lost in the system.

Self-draining piping design. Proper piping design in any liquid processing operation should be self draining and free of pockets.

SPILLS AND AREA WASHDOWNS

The cleanup of spills and area washdowns often contributes significantly to the total waste volume produced at formulation plants. Spills are caused by the accidental discharge of pesticides during transfer operations or from equipment failures such as leaks. Area washdowns with water hoses are performed routinely at some formulation plants, and are necessary in the event of contamination of the working area (USEPA 1976). Waste reduction methods available for these wastes include:

Use of recycled water for initial cleanup.

Use of impervious coatings on floors.

Use of dedicated vacuum system. For facilities producing dry formulations, spilled powders are usually cleanedup by vacuuming. The vacuum system employed ties in to the facility's main dust collection system where all collected dusts and powders are removed from the air stream by a baghouse. Recovered dust cannot be reused due to cross contamination and the material must be disposed of as hazardous waste. If a dedicated vacuum system were available for collecting spilled material, most (if not all) of the recovered material could be returned directly to the process for use.

Use of dry cleanup methods for liquid spills. Rather than cleaning spills with water and producing a hazardous waste, many formulating plants use dry absorbents for spill cleanups. This greatly decreases the waste volume associated with the cleanup. In addition, floor sweeping, mopping and use of squeegees can collect spills for product reformulation. Such practice was reportedly performed by Chevron Chemical Co. to reduce their waste generation volume (LWVM 1985) and has been mentioned in several recent studies (Calif. DHS 1987 and USEPA 1976).

OFF-SPECIFICATION PRODUCTS

Off-specification batches of pesticide formulations are produced as a result of poor process control and operation. Ideally, this waste source could be eliminated totally by making use of the following source control techniques:

Strict quality control and process automation. The formulation of pesticides is a relatively simple process. Nevertheless, process automation and control during formulation ensures repeatable high quality products and avoids generation of off-spec batches due to operator error.

Reformulation of off-specification batches. If a batch of off-specification pesticide is produced, it should be reformulated to an acceptable quality rather than discarded as a waste.

CONTAINERS

Pesticide ingredient containers can be cleaned for reuse or nonhazardous waste disposal. These include 30- and 55-gallon drums. Many pesticide formulating plants use the uncleaned empty drums to store and dispose of other hazardous wastes such as pesticide contaminated dusts and empty paper bags and cartons. Generally, the following options exist for minimizing container waste:

Return containers to the pesticide supplier for refilling with the same pesticide. While this option can be very effective and economical, few suppliers will accept used drums from formulators. Instead of drums, formulators should investigate the feasibility of receiving raw materials in returnable bulk containers. In the paint industry, where users of the formulation often return the empty container to the formulator for cleaning and disposal, use of recyclable "Tote bins" is becoming more common (Calif. DHS 1987). The formulator is able to clean the container, use the cleaning waste in the formulation, and fill the container with a new batch that goes back to the user. FMC Corp. in Fresno, CA has developed a reusable container called "U-Turn" for their pesticide formulations (Lewis 1988). This stainless steel container is equipped for use in "closed" use systems and is sealed to preclude contamination both before and after use. Pesticide formulators should investigate the feasibility of requesting these delivery methods from their raw material suppliers.

Triple rinse and 1) dispose of drums as non-hazardous; 2) sell drums to a scrap dealer or recycling firm (approved by the Department of Transportation) for reconditioning; or 3) recondition drums on-site. Triple rinsing of the drums is usually performed using a water spray or more effectively with steam. The volume of wastewater generated by the triple rinsing typically varies from about 10 to 20 gallons per drum.

Following triple rinsing, the drums are subject to firing to about 1200°C, sandblasting, and repainting. (Reconditioned drums may be reused for the same chemical class of pesticides previously contained and if reconditioned by a DOT-approved facility. However, there are no regulations covering reconditioning of smaller (1- to 2-gallon) containers, so this is not at present permitted.). By regulation (40 CFR 162.10), reconditioned containers may not be used to contain food, animal feed, beverages, drugs, or cosmetics.

The feasibility of recycling used pesticide drums varies from plant to plant based on site-specific conditions. The following factors will influence drum recycling feasibility:

- -- cost of transporting and disposing of drums at a Class I landfill;
- -- cost of triple rinsing, transporting, and disposing of drums at a Class III landfill, including treatment/disposal cost of rinse water;
- -- income to be realized by sale of triple-rinsed drums to scrap dealer or drum recycling firm;
- -- and potential savings that may be realized by on-site reconditioning, and reuse or sale of reconditioned drums.
- -- Use of drums with plastic liners in place of plastic drums or paper bags.

The use of plastic drums presents many difficult disposal problems. It is reported (Lewis 1988) that triple rinsing is often ineffective at removing traces of pesticide from the container. The plastic may absorb the pesticide and will always be hazardous. Another problem is that plastic drums have a "memory;" they retain their shape when crushed. This creates a large volume low bulk wastestream that is very expensive to dispose of. One way to reduce the volume of waste is to use drums lined with a disposable liner that can be removed when the drum is empty. Disposal of the plastic liner would be much easier than disposing of the drum and it eliminates the need for drum cleaning.

Solid waste segregation. The most effective way of reducing hazardous waste associated with bags and packages (or any other waste stream) is to segregate the hazardous materials from the non-hazardous materials. Economic benefits include reduced disposal costs and the potential sale of non-hazardous scrap paper to a recycler. Empty packages that contain hazardous materials should be placed into plastic bags (so as to reduce personnel exposure and eliminate dusting) and should be stored in a special container to await collection.

AIR EMISSIONS AND WASTES FROM AIR EMISSION CONTROL EQUIPMENT

The two major types of air emissions that occur in the pesticide formulating process are volatile organic compounds and pesticide dusts. Volatile organics may be emitted from the bulk storage of solvents and from their use in open tanks during formulation. Dusts generated during handling, grinding, and other formulation operations are a potential waste source. It is common practice to install dust collection equipment, such as hoods served by a baghouse filter, on all dust-generating operations. Some potentially effective waste reduction methods include:

Control bulk storage air emissions. Many methods are available for reducing the amount of emissions resulting from fixed roof storage tanks. Some of these methods include use of conservation vents, conversion to floating roof, use of nitrogen blanketing to suppress emissions and reduce material oxidation, use of refrigerated condensers, use of lean-oil or carbon absorbers, or use of vapor equilibration lines. When dealing with volatile materials, employment of one or more of these methods can result in cost savings to the facility by reducing raw material losses and improve compliance with local air quality requirements.

Dedicated dust collection systems. At Daly-Herring Co., in Kinston, N.C., dust streams from several different production areas were handled by a single baghouse. Since all of the streams were mixed, none of the waste could be recycled to the process that generated them. By installing separate dedicated baghouses for each production line, all of the collected pesticide dust could be recycled (Huisingh and Martin 1985).

At FMC Corp. in Fresno, CA., common dust collectors were used by multiple production systems. Due to the cross contamination of materials, recycling was impossible. To promote recycling, the company compartmentalized the dust collectors with each compartment serving a single source. All collected materials are analyzed for cross contamination and if none exists, they are reused in the succeeding product batch. Other work involved the installation of self-contained dust collectors at each inlet hopper dump station so that captured dust can be returned to the system (Lewis 1988). Similar work was discussed in the facility audits (Calif. DHS 1987).

Use of automatic enclosed cut-in hoppers. The manual opening and emptying of pesticide dust containers leads to the generation of dust which must be collected. One way to reduce the amount of dust generated is by use of an enclosed cut-in hopper which allows the bags to be opened and emptied while avoiding the release of dust.

MISCELLANEOUS WASTE STREAMS

Waste streams included in this section include wastewater associated with laundering of protective clothing, water used for aerosol leak testing, stormwater runoff and laboratory wastes. Control measures include:

Wastewater reuse after treatment.

Paving of high spillage areas. For facilities located outdoors, paving can be an effective means of reducing rainwater contamination by allowing the recovery of spilled materials.

Proper purchasing of chemicals and reagents for lab use. Purchase quantities of specialty items that are seldon used in the smallest available amount. This helps to reduce waste by insuring that the material will more likely be consumed before its shelf life expires. Purchasing agents should factor in the cost of disposal before deciding to purchase items in large quantities just because the per unit purchase price is less.

Use of micro-scale glassware. Many tests can be redesigned to utilize micro-scale glassware so as to reduce the generation of waste. Micro-scale testing volumes to range from 1 to 10 ml as compared to conventional testing which may employ 50 to 100 ml.

References

Calif. DHS. 1987. *Waste audit study: Pesticide formulating industry*. Report to California Department of Health Services, Alternative Technology Section. Prepared by Environmental Science and Engineering, Inc. Sacramento, Calif. November 1987.

Huisingh, D., L. Martin and H. Hilge. 1985. *Proven profit from pollution prevention*. Washington, D.C.: The Institute for Local Self-Reliance.

Lewis, D.A. 1988. *Waste minimization in the pesticide formulation industry*. Draft report by FMC Corporation, Fresno, Calif. August 1988. 20 pp.

USEPA. 1979. U.S. Environmental Protection Agency, Office of Water and Waste Management. *Development document for proposed effluent guidelines, new source performance standards, and pretreatment standard for the paint formulation point source category*. EPA-440-1-79-0496. Washington, D.C.: U.S. Environmenal Protection Agency.

USEPA. 1976. U.S. Environmental Protection Agency, Office of Water and Waste Management. *Development document for final effluent limitation guidelines for the pesticide chemical manufacturing industry*. EPA-440-1-73-060d. Washington, D.C.: U.S. Environmental Protection Agency.

LWVM. 1985. League of Women Voters of Massachusetts. *Waste reduction, the untold story*. Conference, Woods Hole, Mass., June 19-21, 1985. Conference materials..

Weismantel, G., and S. Guggilam. 1984. Mixing and size reduction (a chemical engineering special advertising section). *Chem. Eng.* 92(13):71-109.

SECTION 4
GUIDELINES FOR USING THE WASTE MINIMIZATION ASSESSMENT WORKSHEETS

Waste minimization assessments were conducted at several pesticide formulating plants. The assessments were used to develop the waste minimization worksheets that are provided in the following section.

A comprehensive waste minimization assessment includes a planning and organizational step, an assessment step that includes gathering background data and information, a feasibility study on specific waste minimization options, and an implementation phase.

The worksheets provided in this section are intended to assist pesticide formulating firms in systematically evaluating waste generating processes and in identifying waste minimization opportunities. These worksheets include only the waste minimization assessment phase of the procedure described in the *EPA Manual for Waste Minimization Opportunity Assessments*. For a full description of waste minimization assessment procedures, refer to the EPA Manual.

Table 5 lists the worksheets that are provided in this section.

Table 5. List of Waste Minimization Assessment Worksheets

Number	Title	Description
1.	Waste Sources	Typical wastes generated at pesticide formulating plants.
2.	Waste Minimization: Material Handling	Questionnaire on general material handling techniques.
3.	Waste Minimization: Material Handling	Questionnaire on procedures used for bulk liquid handling.
4.	Waste Minimization: Material Handling	Questionnaire on procedures used for handling drums, containers and packages.
5.	Option Generation: Material Handling	Waste minimization options for material handling operations.
6.	Waste Minimization: Material Substitution/ Dry Blending Operations	Questionnaire on material substitution and dry blending operations.
7.	Waste Minimization: Liquid Blending Operations	Questionnaire on liquid blending operations.
8.	Option Generation: Material Substitution/ Blending Operations	Waste minimization options for material substitution and modification of blending operations.
9.	Waste Minimization: Filtering and Filling	Questionnaire on filtering and filling.
10.	Option Generation: Filtering and Filling	Waste minimization options for filtering and filling.
11.	Waste Minimization: Good Operating Practices	Questionnaire on use of good operating practices.
12.	Option Generation: Good Operating Practices	Waste minimization options that are good operating practices.
13.	Waste Minimization: Reuse and Recovery	Questionnaire on opportunities for reuse and recovery of wastes.

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet ___ of ___ Page ___ of ___

WORKSHEET
1

WASTE SOURCES

Waste Source: Material Handling	Significance at Plant		
	Low	Medium	High
Off-spec materials			
Obsolete raw materials			
Obsolete products			
Spills & leaks (liquids)			
Spills (powders)			
Empty container cleaning			
Container disposal (metal)			
Container disposal (paper)			
Pipeline/tank drainage			
Laboratory wastes			
Evaporative losses			
Other			
Waste Source: Process Operations			
Tank cleaning			
Container cleaning			
Mill cleaning			
Mixer cleaning			
Filling equipment cleaning			
Baghouse fines			
Laundry wastewater			
Aerosol container water bath			
Stormwater runoff			
Contaminated cooling tower blowdown			
Other			

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
2

WASTE MINIMIZATION: Material Handling

A. GENERAL HANDLING TECHNIQUES

Are all raw materials tested for quality before being accepted from suppliers? ☐ yes ☐ no

Describe safeguards to prevent the use of materials that may generate off-spec product: ______

______

______

______

______

Is obsolete raw material returned to the supplier? ☐ yes ☐ no
Is inventory used in first-in first-out order? ☐ yes ☐ no
Is the inventory system computerized? ☐ yes ☐ no
Does the current inventory control system adequately prevent waste generation? ☐ yes ☐ no

What information does the system track? ______

______

______

______

______

______

Is there a formal personnel training program on raw material handling, spill prevention, proper storage techniques, and waste handling procedures? ☐ yes ☐ no
Does the program include information on the safe handling of the types of drums, containers and packages received? ☐ yes ☐ no

How often is training given and by whom? ______

______

______

______

Is dust generated in the storage area during the handling of raw materials? ☐ yes ☐ no
If yes, is there a dedicated dust recovery system in place? ☐ yes ☐ no
Are methods employed to suppress dust or capture and recycle dust? ☐ yes ☐ no
Explain: ______

______

______

______

______

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet ___ of ___ Page ___ of ___

WORKSHEET
3

WASTE MINIMIZATION: Material Handling

B. BULK LIQUIDS HANDLING

What safeguards are in place to prevent spills and avoid ground contamination during the filling of storage tanks?

High level shutdown/alarms ☐ Secondary containment ☐

Flow totalizers with cutoff ☐ Other ☐

Describe the system: ______

Are air emissions from solvent storage tanks controlled by means of:

Conservation vents ☐ Absorber/Condenser ☐

Nitrogen blanketing ☐ Other vapor loss control system ☐

Describe the system: ______

Are all storage tanks routinely monitored for leaks? If yes, describe procedure and monitoring frequency for above-ground/vaulted tanks: ______

Underground tanks: ______

How are the liquids in these tanks dispensed to the users? (i.e., in small containers or hard piped.) ______

What measures are employed to prevent the spillage of liquids being dispensed? ______

Are pipes cleaned regularly? Also discuss the way pipes are cleaned and how the resulting waste is handled: ______

When a spill of liquid occurs in the facility, what cleanup methods are employed (e.g., wet or dry)? Also discuss the way in which the resulting wastes are handled: ______

Would different cleaning methods allow for direct reuse or recycling of the waste? (explain): ______

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
6

WASTE MINIMIZATION: Material Substitution Blending Operations

A. MATERIAL SUBSTITUTION

Are any of the formulation and preparation materials used in the pesticides considered hazardous (e.g., chlorinated solvents)? ☐ yes ☐ no

If so, can other non-hazardous materials substitute for the hazardous materials? ☐ yes ☐ no

Describe results of any substitution attempts: ______

B. DRY BLENDING

Are dust suppression/collection systems employed during dry pesticide formulation? ☐ yes ☐ no

Is this dust collected and recycled or reused? ☐ yes ☐ no

Would the installation of a dedicated baghouse or other type of dust collection system allow for reuse? ☐ yes ☐ no

Explain how dusts are handled and the potential for reuse: ______

Are the sand and clay diluents that are used to flush the granule and dust mills collected, tested for reuse potential and re-used to flush the mills? ☐ yes ☐ no

Describe results of attempts to reuse diluents: ______

Is diluent flushing done on a once-through basis between batches of pesticides? ☐ yes ☐ no

Has repeated diluent flushing with a smaller volume of diluent been attempted, to reduce overall diluent use? ☐ yes ☐ no

Describe the results of attempts to use smaller volumes of diluent, in repeated flushing.: ______

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET 7

WASTE MINIMIZATION: Blending Operations

C. LIQUID BLENDING

What methods are used to clean mixing tanks?:

	Solvent-Based	Water-Based
Dry Clean-up (rags)	☐	☐
Sand/Dust Cleaning	☐	☐
Solvent Cleaning	☐	☐
Water Cleaning	☐	☐
Caustic Cleaning	☐	☐
Solvent Rinse	☐	☐
Water Rinse	☐	☐

Explain how these wastes are handled and the potential for their reuse: ______

______

______

______

To reduce the generation of waste, has the facility attempted to:	☐ yes	☐ no
Employ vapor recovery systems to reduce solvent air emissions?	☐ yes	☐ no
Equip tanks with wipers to reduce clingage?	☐ yes	☐ no
Employ pressure washers to reduce cleaning solution usage?	☐ yes	☐ no
Reuse cleaning solutions for primary cleaning or as part of a compatible formulation ?	☐ yes	☐ no
Equip hoses with spray nozzles to reduce water used for floor washing?	☐ yes	☐ no
Collect and reuse rinse water?	☐ yes	☐ no
Drain or pig lines between blending equipment rather than flush with solvent or water?	☐ yes	☐ no
Dedicate equipment to reduce the need for cleaning?	☐ yes	☐ no
Use some of the solvent or water that should be added to the formulation to clean the preceding equipment before adding to the mix tank?	☐ yes	☐ no
Segregate wastes so that their reuse potential is increased?	☐ yes	☐ no

Discuss the results of methods employed or attempted: ______

______

______

______

Firm ______ Site ______ Date ______	**Waste Minimization Assessment** Proc. Unit/Oper. ______ Proj. No. ______	Prepared By ______ Checked By ______ Sheet ___ of ___ Page ___ of ___

WORKSHEET
8

OPTION GENERATION: Material Substitution Blending Operations

Meeting format (e.g., brainstorming, nominal group technique) ______

Meeting Coordinator ______

Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Substitution/Reformulation Techniques		
Solvent Substitution		
Product Reformulation		
Other Raw Material Substitution		
B. Dry Blending		
Dust Suppression/Collection		
Dedicate Baghouse		
Use Less Cleaning Media		
Test for Reuse Potential		
C. Liquid Blending		
Vapor Recovery		
Tank Wipers		
Pressure Washers		
Reuse Cleaning Solutions		
Spray Nozzles on Hoses		
Mops and Squeegees		
Reuse Rinsewater		
Pig or Drain Lines		
Dedicate Equipment		
Clean with Part of Batch		
Segregate Wastes for Reuse		

Firm ______	**Waste Minimization Assessment**	Prepared By ______
Site ______		Checked By ______
Date ______	Proj. No. ______	Sheet ___ of ___ Page ___ of ___

WORKSHEET 9

WASTE MINIMIZATION: Filtering & Filling

FILTERING & FILLING

Is the dust generated during the packaging of dry formulations collected? ❑ yes ❑ no

If yes, can the material be recycled/reused? ❑ yes ❑ no

Discuss: ______

Are any of the filter units dedicated to a particular product line? ❑ yes ❑ no

Would increased dedication reduce the need for filter replacement or cleaning? ❑ yes ❑ no

Has the facility attempted to replace disposable cartridge filters with reusable filters such as bags or metal mesh? ❑ yes ❑ no

What type of reusable filter was tried and what were the results: ______

How are the wastes from spent filter cartridges or reusable filter cleaning handled? ______

Are any of the filling units dedicated to a particular product line? ❑ yes ❑ no

Would increased dedication reduce the need for cleaning? ❑ yes ❑ no

Describe the filling unit cleaning procedures and how cleaning wastes are handled. ______

Firm ______	Waste Minimization Assessment	Prepared By ______
Site ______	Proc. Unit/Oper. ______	Checked By ______
Date ______	Proj. No. ______	Sheet ___ of ___ Page ___ of ___

WORKSHEET
10

OPTION GENERATION: Filtering & Filling

Meeting format (e.g., brainstorming, nominal group technique) ______

Meeting Coordinator ______

Meeting Participants ______

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
Filtering & Filling Techniques		
Dedicate Filter Units		
Use Wire Screen Filters		
Use Bags, Not Cartridges		
Reuse Filter Bags		
Dedicate Filling Units		

Firm ____________ Site ____________ Date ____________	**Waste Minimization Assessment** Proj. No. ____________	Prepared By ____________ Checked By ____________ Sheet ___ of ___ Page ___ of ___

WORKSHEET **11**

WASTE MINIMIZATION: Good Operating Practices

A. PRODUCTION SCHEDULING TECHNIQUES

Is the production schedule varied to decrease waste generation? (For example, do you attempt to increase size of production runs and minimize cleaning by accumulating orders or production for inventory?)
Describe: ____________

Does the production include sequential formulations that do not require cleaning between batches?
If yes, indicate results: ____________

Are there any other attempts at eliminating cleanup steps between subsequent batches? If yes, results: ____________

B. AVOIDING OFF-SPEC PRODUCTS

Is the batch formulation attempted in the lab before large scale production?	☐ yes	☐ no.
Are laboratory QA/QC procedures performed on a regular basis?	☐ yes	☐ no.

C. GOOD OPERATING PRACTICES

Are plant material balances routinely performed?	☐ yes	☐ no
Are they performed for each material of concern (e.g. solvent) separately?	☐ yes	☐ no
Are records kept of individual wastes with their sources of origin and eventual disposal? (This can aid in pinpointing large waste streams and focus reuse efforts.)	☐ yes	☐ no
Are the operators provided with detailed operating manuals or instruction sets?	☐ yes	☐ no
Are all operator job functions well defined?	☐ yes	☐ no
Are regularly scheduled training programs offered to operators?	☐ yes	☐ no
Are there employee incentive programs related to waste minimization?	☐ yes	☐ no
Does the facility have an established waste minimization program in place?	☐ yes	☐ no
If yes, is a specific person assigned to oversee the success of the program?	☐ yes	☐ no

Discuss goals of the program and results: ____________

Has a waste minimization assessment been performed at the facility in the past? If yes, discuss: ____________

Firm ____________	**Waste Minimization Assessment**	Prepared By ____________
Site ____________	Proc. Unit/Oper. ____________	Checked By ____________
Date ____________	Proj. No. ____________	Sheet ___ of ___ Page ___ of ___

WORKSHEET
12

OPTION GENERATION: Good Operating Practices

Meeting format (e.g., brainstorming, nominal group technique) ____________

Meeting Coordinator ____________

Meeting Participants ____________

Suggested Waste Minimization Options	Currently Done Y/N?	Rationale/Remarks on Option
A. Production Scheduling Techniques		
Increase Size of Production Run		
Sequential Formulating		
Avoid Unnecessary Cleaning		
Maximize Equipment Dedication		
B. Avoiding Off-Spec Products		
Test Batch Formulation in Lab		
Regular QA/QC		
C. Good Operating Practices		
Perform Material Balances		
Keep Records of Waste Sources & Disposition		
Waste/Materials Documentation		
Provide Operating Manuals/Instructions		
Employee Training		
Increased Supervision		
Provide Employee Incentives		
Increase Plant Sanitation		
Establish Waste Minimization Policy		
Set Goals for Source Reduction		
Set Goals for Recycling		
Conduct Annual Assessments		

Firm ____	Waste Minimization Assessment	Prepared By ____
Site ____		Checked By ____
Date ____	Proj. No. ____	Sheet ___ of ___ Page ___ of ___

WORKSHEET
13

WASTE MINIMIZATION: Reuse and Recovery

A. SEGREGATION

Segregation of wastes reduces the amount of unknown material in waste and improves prospects for reuse & recovery.

Are different solvent wastes due to equipment clean-up segregated? ☐ yes ☐ no
Are aqueous wastes from equipment clean-up segregated from solvent wastes? ☐ yes ☐ no
Are spent alkaline solutions segregated from the rinse water streams? ☐ yes ☐ no
If no, explain: ____

B. ON-SITE RECOVERY

On-site recovery of solvents by distillation is economically feasible for as little as 8 gallons of solvent waste per day.

Has on-site distillation of the spent solvent ever been attempted? ☐ yes ☐ no
If yes, is distillation still being performed? ☐ yes ☐ no
If no, explain: ____

C. CONSOLIDATION/REUSE

Are many different solvents are used for cleaning? ☐ yes ☐ no
If too many small-volume solvent waste streams are generated to justify on-site distillation, can the solvent used for equipment cleaning be standardized? ☐ yes ☐ no
Is spent cleaning solvent reused? ☐ yes ☐ no
Are there any attempts at making the rinse solvent part of a batch formulation (rework)? ☐ yes ☐ no
Are any attempts made to blend various waste streams to produce marketable products? ☐ yes ☐ no
Are spills collected and reworked? ☐ yes ☐ no
Describe which measures were successful: ____

Is your solvent waste segregated from other wastes? ☐ yes ☐ no
Has off-site reuse of wastes through Waste Exchange services been considered? ☐ yes ☐ no
Or reuse through commercial brokerage firms? ☐ yes ☐ no
If yes, results: ____

APPENDIX A
PESTICIDE FORMULATING FACILITY ASSESSMENTS
CASE STUDIES OF PLANTS A, B AND C

CASE STUDIES OF PESTICIDE FORMULATING FACILITIES

In 1986 the California Department of Health Services commissioned a waste minimization study (DHS 1987) of three pesticide formulating plants. The objectives of the waste minimization assessments were to:

- Gather site-specific information concerning the generation, handling, storage, treatment, and disposal of hazardous waste;
- Evaluation existing waste reduction practices;
- Develop recommendations for waste reduction through source control, treatment, and recycling techniques; and
- Assess costs/benefits of existing and recommended waste reduction techniques.

In addition, the results of the waste assessments were used to prepare waste minimization assessment worksheets to be completed by other pesticide formulators in a self-audit process.

The first steps in conducting the assessments were the selection of the pesticide formulating plants, and contacting the plants to solicit voluntary participation in the audit study. Plant selection emphasized small businesses which generally lack the financial and/or internal technical resources to perform a waste reduction audit. One relatively large plant was also selected for study because it offered the opportunity to evaluate a wide variety of pesticide formulating operations, as well as a number of in-place waste reduction measures. A total of three plants was audited.

This Appendix section presents both the results of the assessments of the plants here identified as A, B and C and the potentially useful waste minimization options identified through the assessments. Also included are the practices already in use at the plants that have successfully reduced waste generation from past levels.

During each of the plant audits, the audit team observed pesticide formulating operations; inspected waste management facilities; interviewed the plant manager, environmental compliance personnel, and operations supervisors; and reviewed and copied records pertinent to waste generation and management. The audits were performed by one or two engineers over a 1- to 3-day period depending on the size and complexity of the formulating and waste management operations.

PLANT A WASTE MINIMIZATION ASSESSMENT

Assessment Phase: Process and Facility Data

Plant A was audited on September 24, 1986. The audit consisted of a review and copying of plant records, a plant inspection tour and an interview with the Plant Manager. During the audit, sources of hazardous waste generation were identified, and methods of hazardous waste handling and disposal were reviewed. In addition, existing waste minimization techniques were evaluated.

Facility Description

Plant A mainly formulates granule and dust fertilizers, but also formulates three herbicide/fertilizer mixtures in granule/dust form. These mixtures are commonly referred to as weed and feed products. The three herbicides used in formulating these three products are:

1. Liquid Trimec
2. Trimec dust, and
3. Dimethyl - T dust.

Raw Material Management/Process Description

The liquid Trimec is injected into a vermiculite/granule fertilizer mixture, and the Trimec and Dimethyl-T dusts are mixed with various formulations of granule and dust fertilizers. The weed and feed formulation is performed in one mixer which has a capacity equivalent to 500 pounds (lb) of product. The granule/dust fertilizer and herbicide dust are loaded into the top of the mixer through a port, and the mixer is equipped with an internal mixing bar which rotates to provide the required mixing action. The mixing bar is constructed of steel pipe, and is also used to convey liquid Trimec through ports in the mixing bar into the fertilizer contained in the mixing tank. Mixing procedures for each weed and feed formulation are described in the following sections.

Liquid Trimec

Liquid Trimec is received at the plant as a raw material in 55-gallon (gal) steel drums. During formulations with the liquid Trimec, a drum of the Trimec is placed adjacent to the mixing tank. After the granule/dust fertilizer has been loaded into the mixer, the Trimec is pumped from the drum into the tank through the mixing bar. For each 500-lb batch of weed and feed product, 2 quarts of liquid Trimec are added and mixing is performed for 15 minutes.

After mixing, the product is transferred through a hopper in the bottom of the mixing tank into a transfer box located underneath the mixing tank. The transfer box is then transported by a forklift to the packaging hopper where the product is loaded into the hopper. The product is then gravity fed from the hopper into 16-lb paper bags for storage in an onsite warehouse and ultimate distribution. On an average annual basis, two to three drums of the liquid Trimec are used in weed and feed formulation.

Trimec Dust

The Trimec dust is received at the plant in 24-lb paper bags as a raw material. In formulating Trimec dust products, one 24-lb bag of the Trimec dust is added for each 500-lb batch of weed and feed product. The Trimec dust is added to the mixer through the same top loading port that is used to load the fertilizer into the mixer. Following a 15-minute mixing time, the product is transferred to the packaging hopper and packaged the same as the liquid Trimec formulations. On an average annual basis, approximately 7,200 lb of Trimec dust are used in weed and feed formulations.

Dimethyl-T Dust

The Dimethyl-T dust is received at the plant in 24-lb plastic-lined cardboard cartons as a raw material. Six lb of the Dimethyl-T dust are weighed out on a scale located adjacent to the mixing tank, and added to the fertilizer in the tank through the top loading port. Mixing of the Dimethyl-T dust and the fertilizer is performed for 20 minutes. Transfer of the formulated product from the mixer and packaging of the Dimethyl-T products is the same as that for the Trimec dust products. On an average annual basis, approximately 1,800 lb of Dimethyl-T dust are used in weed and feed formulations.

WASTE GENERATION, HANDLING, AND DISPOSAL

There are four sources of hazardous waste generation at Plant A:

- Dust collected from the product transfer and packaging areas;
- Empty dust product bags and cartons;
- Empty drums of liquid Trimec; and
- Wastewater generated by the annual steam cleaning of the mixing tank.

Information relative to the generation, handling, and disposal of each of these wastes is described in the following sections.

Vacuum System Dust

A vacuum system, which is dedicated to the herbicide mixing line, collects dust generated in two areas of this mixing line. The first area is above the transfer box which is used to transport the formulated product from the mixing tank to the packaging hopper. When the formulated product is released from the mixing tank through the hopper into the transfer box, dust is generated as the product falls into the transfer box. A flexible vacuum hose connected to the vacuum system is manually held over the transfer box to collect the dust generated during product transfer.

The second dust collection area is located at the bottom of the packaging hopper. In this area, two vacuum system intake lines are mounted along the side of the bottom of the packaging hopper just above the packaging conveyor belt. These intake lines collect dust generated as product is released from the packaging hopper into bags on the conveyor belt.

The dust collected from above the transfer box and underneath the packaging hopper is directed to a 55-gal collection drum located outside of the building in a totally enclosed steel housing. This dust is reused in subsequent formulations of weed and feed product. The quantity of dust that is collected on an average annual basis is roughly 10 drums. This dust quantity is only a rough estimate because the vacuum system has been in place for less than a year, and a long-term database of dust quantity data does not exist to allow a more accurate estimate.

Empty Dust Product Containers

The empty paper bags and cartons of the Trimec dust and Dimethyl-T dust are collected in a steel 55-gal drum. The containers are manually compacted in the drums to optimize the number of bags per drum. An average of approximately five drums of empty product bags are generated annually, and the drums are hauled by a licensed hazardous waste transporter to an approved offsite hazardous waste disposal facility.

Empty Drums

When a drum of liquid Trimec is totally consumed in the formulating process, the empty drum is used to collect empty dust product containers as described above.

Wastewater

Wastewater is generated by the periodic steam cleaning of the mixing tank and internal mixing rod with a portable steam jenny. This cleaning operation, which is usually performed once per year, generates approximately 20 gal of wastewater. This wastewater is collected in a dedicated 55-gal drum and injected into subsequent product formulations of Dimethyl-T dust product.

AUDIT FINDINGS AND RECOMMENDATIONS

The current methods of waste management at Plant A are successful in minimizing the quantity of hazardous waste requiring disposal. As described earlier, the dust collected in the vacuum system and the wastewater generated by steam cleaning of the mixing tank are reused in subsequent product formulations. Because of the additional operational requirement to collect and inject the wastewater into product formulations at a controlled rate, minimization of the volume of wastewater generated is an inherent component of the waste management process.

The only hazardous waste that requires disposal is the drums of compacted empty product containers. As described earlier, the product containers are manually compacted in the drums. It is recommended that consideration be given to mechanical compaction to reduce the number of drums for disposal. A reduction from the annual average of five drums to four drums is conceivable if mechanical compaction were utilized. A compaction device for use by a forklift could be manufactured for a cost of about $300. At present, Plant A incurs a cost of $70 per drum for transportation and disposal at an approved hazardous waste disposal facility. Therefore, the period of return on the investment on the mechanical compaction device would be between 4 and 5 years.

In addition to the recommendation presented above, a general recommendation to improve the plant's environmental management of the herbicide mixing operation was also developed. At present,the flooring in the herbicide mixing area consists of compacted native soil. Any fugitive dust from the formulation process that has deposited on the ground is subject to migration outside the building on the tires of the forklift and on employees shoes. The paving of this area would allow collection of the dust with the vacuum system for reuse in subsequent product formulations, and minimize the amount of dust migration outside of the building. The paving of this area would cost approximately $2,000.

PLANT B WASTE MINIMIZATION ASSESSMENT

Assessment Phase: Process and Facility Data

Plant B was audited by the consulting firm on September 24, 1986. The audit consisted of a plant inspection tour and an interview with the Plant Manager. During the audit, sources of hazardous waste handling and disposal were reviewed.

FACILITY DESCRIPTION

Plant B is mainly engaged in the formulation and distribution of fertilizer, but it also formulates a small quantity of liquid pesticides. The pesticides formulated are primarily insecticides consisting of malathion and diazinon in a xylene carrier solution. On an average annual basis, approximately 400 gallons of pesticide is formulated.

RAW MATERIAL MANAGEMENT/PROCESS DESCRIPTION

The mixing of the active ingredients with the xylene is performed in a 40-gallon (gal) stainless steel mixing tank equipped with a portable mixing propeller. The active ingredients and the xylene are received at the plant in 55-gal drums, and are added to the mixing tank by using a pump. Following mixing, the mixing tank is raised by a forklift, and the formulated product is drained through a spigot on the side of the tank into a 55-gal drum. The drum is then transported to the packaging area where the pesticide is pumped into 8-ounce bottles for distribution.

WASTE GENERATION, HANDLING, AND DISPOSAL

The only sources of hazardous waste generation at Plant B relating to the pesticide formulating operation are rags used to wipe down the 40-gal mixing tank and small spills following formulation of each batch. An estimated 10 to 20 pounds (lbs) of pesticide contaminated rags are generated annually. The rags are disposed of in the dumpster and ultimately in a sanitary landfill.

AUDIT FINDINGS AND RECOMMENDATIONS

The pesticide-contaminated rags generated by cleaning the mixing tank and small infrequent spills are possibly classified as a hazardous waste, depending primarily on the quantity of pesticide in the rags. Sampling and analysis of the rags to determine the content of pesticide and carrier solvent in the rags would be required to determine if their content exceeds the hazardous waste criteria set forth in Article 11, Title 22, California Administrative Code.

If the rags are determined to be a classified hazardous waste, they should not be disposed of in a sanitary landfill. One alternative is to collect the rags in a 55-gal drum for ultimate disposal at an approved hazardous waste disposal facility. If the rags are not accumulated longer than 90 days prior to disposal, then a hazardous waste storage facility permit will not be required. However, the drum must be stored and transported in accordance with the requirements for generators of hazardous waste (Article 6, Title 22, California Administrative Code). If Plant B generates less than 100 kilograms (kg) during any calendar month, the 90-day accumulation time limit identified above would begin when the amount of pesticide-contaminated rags reached 100 kg. At a maximum generation rate of approximately 20 lbs or 9 kg of rags per year, the rags could be accumulated up to 11 years before the small quantity exclusion limit of 100 kg would be exceeded. Assuming that up to 220 lb of contaminated rags could be placed in a 55-gal drum, only one drum would be required to store the rags over the 11-year period. However, because of the future landfill disposal ban of hazardous wastes and the potential risk associated with possible spontaneous combustion of the rags due to solvent carrier solution content, disposal of the rags on a more frequent basis would be prudent. Additionally, the above 100 kg limitation is reduced to 1 kg for waste classified as extremely hazardous. The current disposal cost for one drum is approximately $70.

As the costs for hazardous waste disposal increase, an alternative method of cleaning the pesticide mixing tank that generates a reusable product may be considered. An example of such an alternative is the use of a small pressure washer to apply carrier solution and a squeegee to clean the tank, with collection of the resulting spent solution for reuse in subsequent formulations. This alternative also includes the placement of a shallow stainless steel pan underneath the mixing tank to catch any small spills which may occur during formulation or transfer operations. The pan should be slightly elevated and equipped with a spigot, so spills could be collected for reuse in pesticide formulation.

The capital and additional operating costs to implement this alternative are estimated to be approximately $200 and $150 per year, respectively.

These costs estimates are based on the following assumptions:

- Capital cost of catchment pan and portable pressure washer = $200.
- Additional operational requirement of 10 labor hours per year for tank cleaning.
- Labor rate of $15 per hour.

PLANT C WASTE MINIMIZATION ASSESSMENT

Introduction

Plant C was audited by a team of two consulting engineers on September 3 and 4, 1986. The 2-day effort included review and copying of records, plant inspection tours, and interviews with plant personnel. Special attention was given to the plant's hazardous waste generation sources; handling, treatment, and disposal methods; and existing and proposed hazardous waste minimization techniques. Waste minimization techniques potentially applicable to the plant, and to pesticide formulators and repackagers in general, were identified. The potential economic benefits of the hazardous waste minimization techniques were identified.

PLANT DESCRIPTION

The plant consists of two areas, a 12.5-acre developed area encompassing the production and office areas, and a 5-acre undeveloped tract. The plant was constructed in 1930, primarily for sulfur grinding. The operations at that time consisted of a single Raymond mill. Since then, the plant has grown to include two Raymond mills, five dust mills, three granular mills, and a variety of liquid pesticide formulation operations. The plant was renovated, in 1980, with addition of process equipment from a closed plant, new buildings to house equipment, and paving of much of the remaining undeveloped production area.

The production area currently consists of 16 large buildings, a percolation pond, several bulk product and waste storage areas, and pallet and drum storage areas. The balance of the production area is open pavement.

In the developed area of the plant, stormwater runoff from the office and parking lot areas, which total approximately 2 acres, drains to the percolation pond. Runoff from the process and storage areas, which total approximately 10.5 acres, drains to centrally located sumps for collection and storage as hazardous waste. Stormwater runoff from the 5-acre undeveloped area of the plant is contained onsite in the natural drainage system.

RAW MATERIALS AND PRODUCTS

Because the plant is a pesticide formulator and repackager, raw materials are limited to bulk technical-grade pesticides, diluents, various additives, and sulfur. Technical-grade pesticides include concentrated or pure pesticides in liquid, powder, and granular forms. Diluents include water, solvents, oils, sands, and clays.

Some bulk pesticides are shipped to the plant for repackaging into smaller containers. Dust mill 2A and the paraquat packaging mill are examples of dedicated repackaging process areas. Technical-grade materials are typically received by truck. The materials are distributed for processing, which involves mixing with diluents and packaging as finished product.

The plant can currently formulate over 600 different registered formulations. In 1986, the plant produced 2.1 million gallons of liquid pesticides and more than 40 million pounds of dry pesticides.

Approximately 60 percent of production results from contracts for custom and specialty formulations for outside clients. The remaining 40 percent of products produced includes a full line of proprietary insecticides, herbicides, fungicides, and rodenticides.

PROCESS DESCRIPTIONS

The plant consists of four main process areas: the sulfur, dust, granular, and liquids areas. Finished product is stored in the main warehouse for eventual distribution.

Sulfur Formulation Process

The sulfur process is the largest volume dry material, continuous production process area at the plant. In 1986 the sulfur process produced 22.5 million pounds of finished product.

The sulfur process begins with the unloading of bulk crude sulfur from trucks into a belowground hopper. A screw conveyor moves material on an elevator system to one of six large sulfur storage silos. Upon demand, crude sulfur is moved by screw conveyor to a small ribbon mixer. The mixer is used for the addition of resins and magnesium conditioners to prevent static charges. After mixing, the crude sulfur is conveyed to a holding bin in the mill building. As detailed in Figures A-1 and A-2, the sulfur is then milled in one of two Raymond mills and cycloned to another holding bin before being conveyed to a bagging machine.

Dust from the milling process is drawn off the cyclone system and collected for eventual recycle. Natural-gas-fired boilers generate carbon dioxide for inert gas blanketing of the milling process to reduce the chance of fire. Continuous monitoring systems monitor and record oxygen content throughout the process equipment and buildings.

A secondary operation in the sulfur process area is the sulfur x-mill. Figure A-3 presents a schematic diagram of the sulfur x-mill. The x-mill blends sulfur and bentonite under heat to form an insoluble sulfur product. Sulfur from the Raymond mills is blended with bentonite from a cut-in hopper. The material is elevated to a holding bin and then conveyed through a series of sterilizers. After sterilization, the material is crushed, passed through shaker screens, and packaged in bags.

Both sulfur and x-mill product are bagged, placed on pallets, and shipped to a warehouse for eventual distribution.

The boiler and cooling tower are auxiliary operations in the sulfur area. Blowdown from both units is pumped to the bulk hazardous waste storage tank. Spilled or "wet" sulfur is a mixture of sulfur and condensate from the inert gas system. It is recycled to the head of the process.

Granular Formulation Process

By volume, the granular formulation operation is the second-largest process at the plant. In 1986, 11 million pounds of granular pesticides were produced as finished product.

The granular process area includes three mills, T-3, T-4, and T-5. Figures C.2-4 and C.2-5 detail the granular formulation process. Mill T-3 differs from mills T-4 and T-5 by the addition of a rotary dryer. Raw materials, including technical-grade pesticides and clay and/or sand diluents, are loaded into cut-in hoppers and elevated to holding bins. The materials are blended in rotary mixers while being inoculated with liquid pesticides. The granular material is formed during this mixing. After mixing, the materials are screened in a shaker screen and packaged in bags. Mill T-3 is equipped with a natural-gas-fired rotary dryer, positioned after the second holding bin.

Products from all three mills are packaged, placed on pallets which are covered with a plastic outer wrap, and shipped to the warehouse for storage.

At the completion of a product formulation run, the mills are flushed with diluent sand or clay to remove residual pesticide.

All three granular mills have dedicated dust collectors. Dust is collected from the various mill components and recycled to the previous component. For example, dust drawn from the mixer is recycled to the cut-in hopper. In addition to the dedicated dust collection systems in the granular mills, a central vacuum system also serves the granular mill area, as well as the dust formulating area. The central vacuum system is used to collect product spills and general fugitive dust emissions that occur in both the granule and dust formulating buildings.

Dust Formulation Process

In 1985 the dust process formulated about 18 percent, or 7 million pounds, of the total dry product formulated at the plant. The dust area uses five dust mills and one repackaging mill. Process flow diagrams for a dust mill and repackager are included as Figures A-6 through A-9. A typical dust mill begins with a cut-in hopper for loading dry technical material and diluent clays. These materials are conveyed to a holding bin before being loaded into a ribbon mixer. Liquid additives may be injected during mixing. After mixing, the materials are elevated to a second holding bin before being packaged in the bagging machine.

The repack mill shown in Figure A-10 involves only a cut-in hopper, elevator, holding bin, and bag machine. The repack mill does not blend materials. It is used only for repackaging products.

Product from all six mills is packaged, placed on pallets, and shipped to the warehouse for distribution.

Each dust mill has a dedicated dust collector which draws dust from the cut-in hopper and the bagging machine. As described in the preceding section, the central vacuum system is used to collect spilled product and general fugitive dust emissions in the dust mill area.

Liquids Formulation Process

The liquids processing area includes the sinox, two main liquids, micronutrients and oils buildings. In 1986, the liquids area formulated 1.7 million gallons of liquid pesticides.

The sinox process located in Building 48 houses two process mills, the sinox mill and the paraquat repackaging mill. Sinox mill processes are diagramed in Figures A-11 and A-12.

The sinox technical material is dinitrobutyl phenol. It is stored in a closed bulk storage tank located over a large sump adjacent to the building. The tank area is roofed. Technical material and diluents are added to a mixer via a barrel dump. They are mixed in a 2,500-gallon (gal) mixer and pumped to one of two batch holding tanks for dispensing and packaging. The diluents consist of water, xylene, methanol, and diesel fuel. Paraquat is only repackaged in the sinox building. Vapors drawn off the mixer and

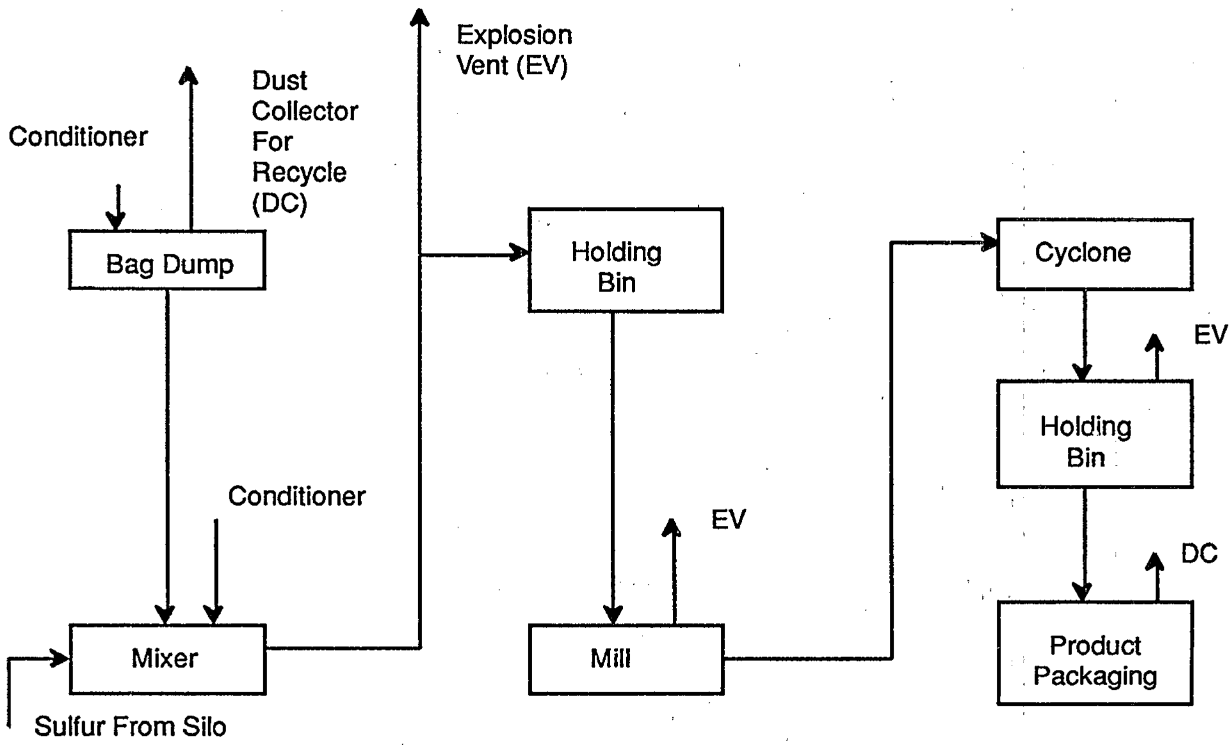


FIGURE A-1. FLOW DIAGRAM FOR RAYMOND MILL-1

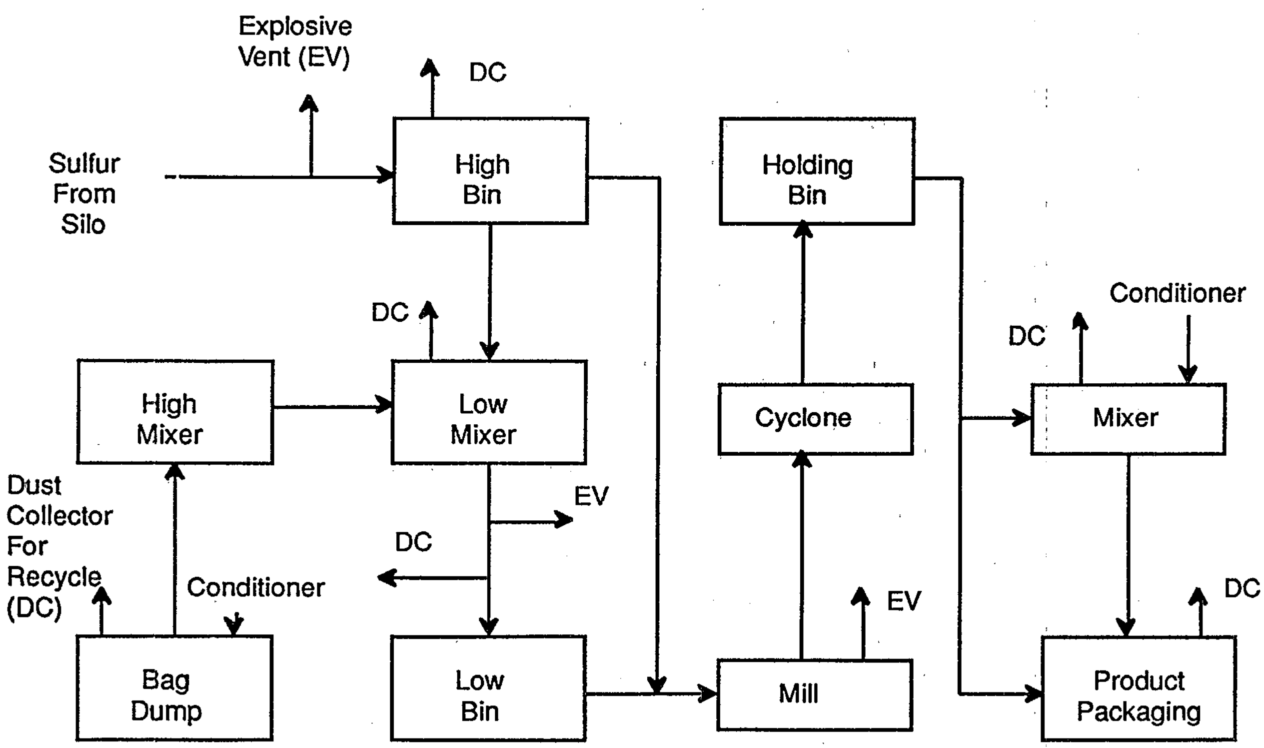


FIGURE A-2 FLOW DIAGRAM FOR RAYMOND MILL-2

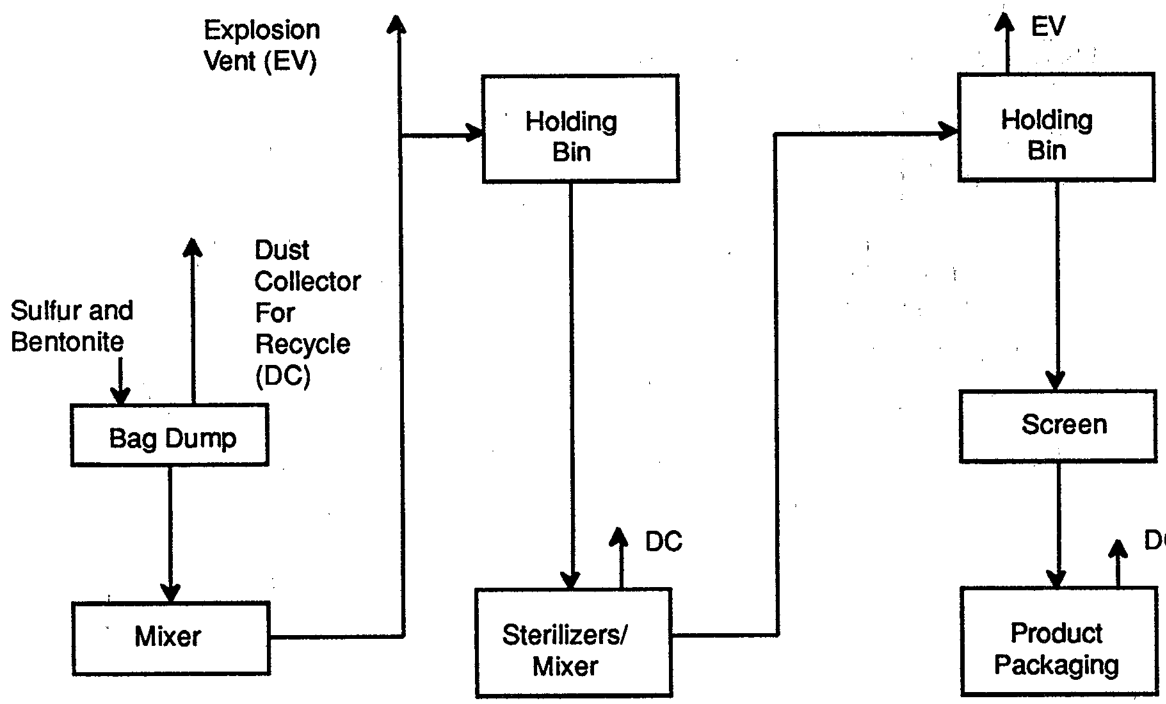


FIGURE A-3. FLOW DIAGRAM FOR SULFUR X-MILL

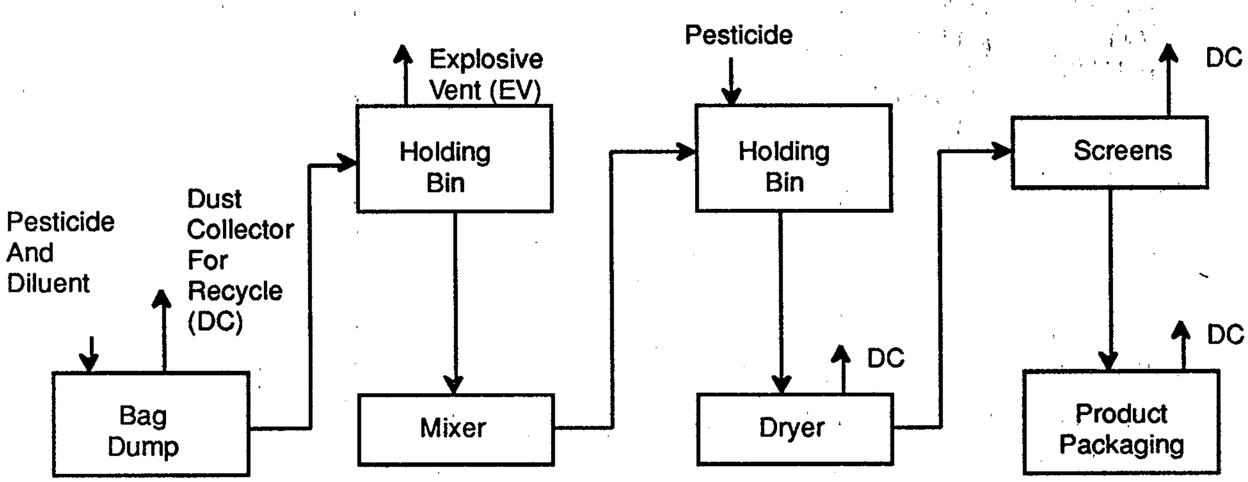


FIGURE A-4. FLOW DIAGRAM FOR GRANULE MILL T-3

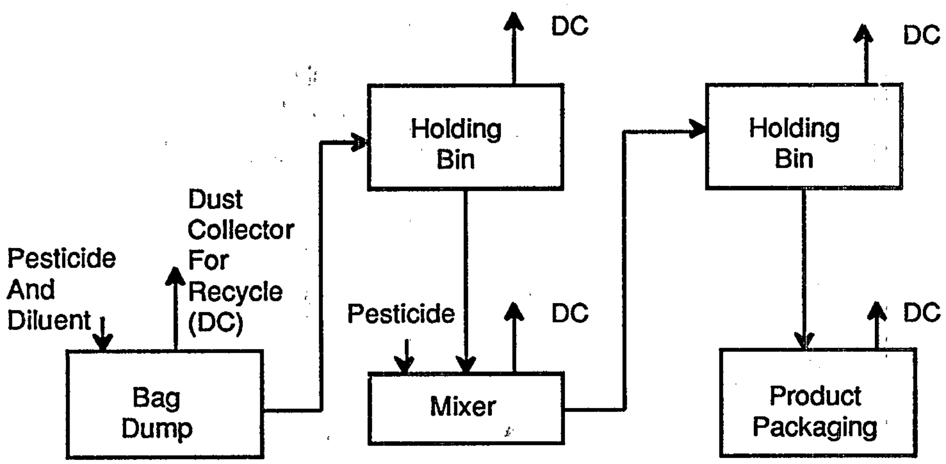


FIGURE A-5. FLOW DIAGRAM FOR GRANULE MILL T-4

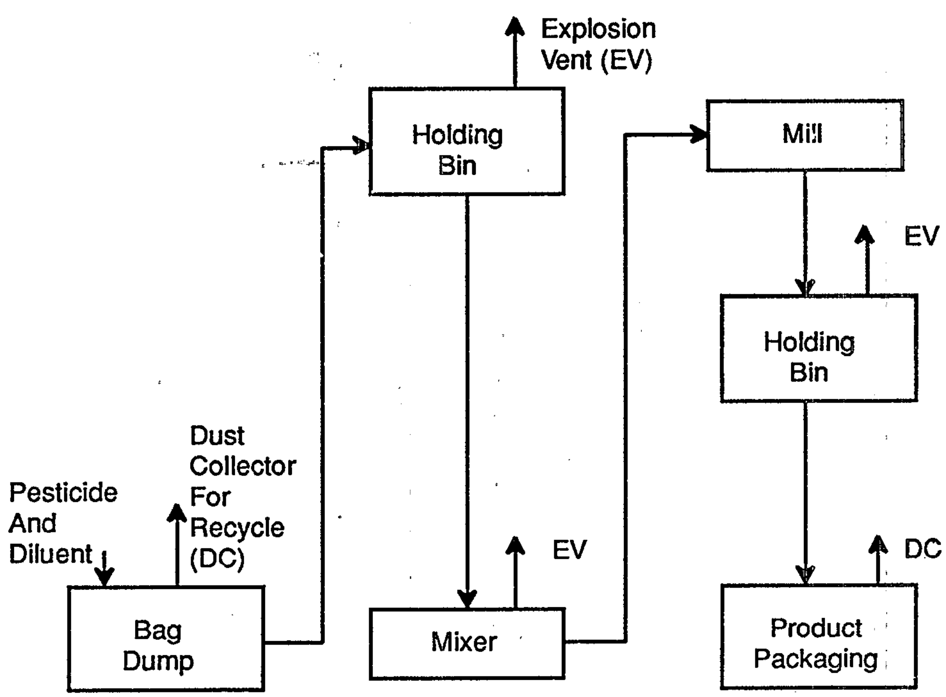


FIGURE A-6. FLOW DIAGRAM FOR DUST MILL NOS. 1 AND 5

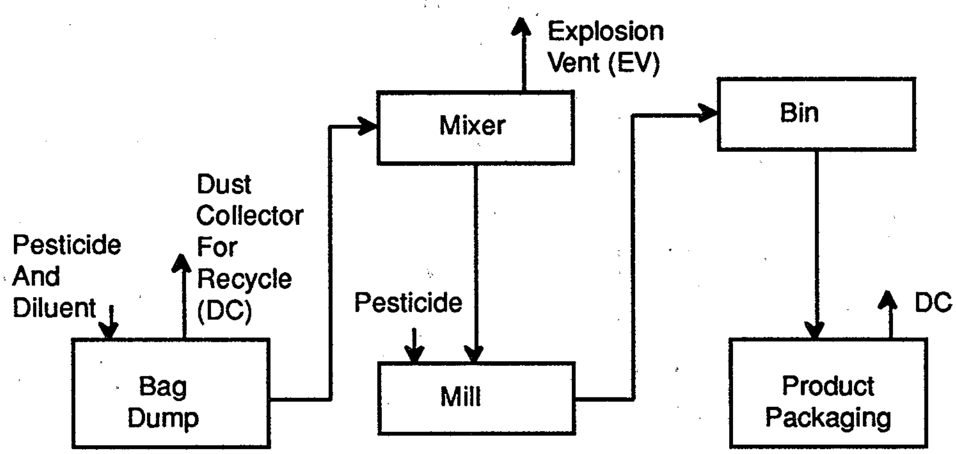


FIGURE A-7. FLOW DIAGRAM FOR DUST MILL-NO. 2

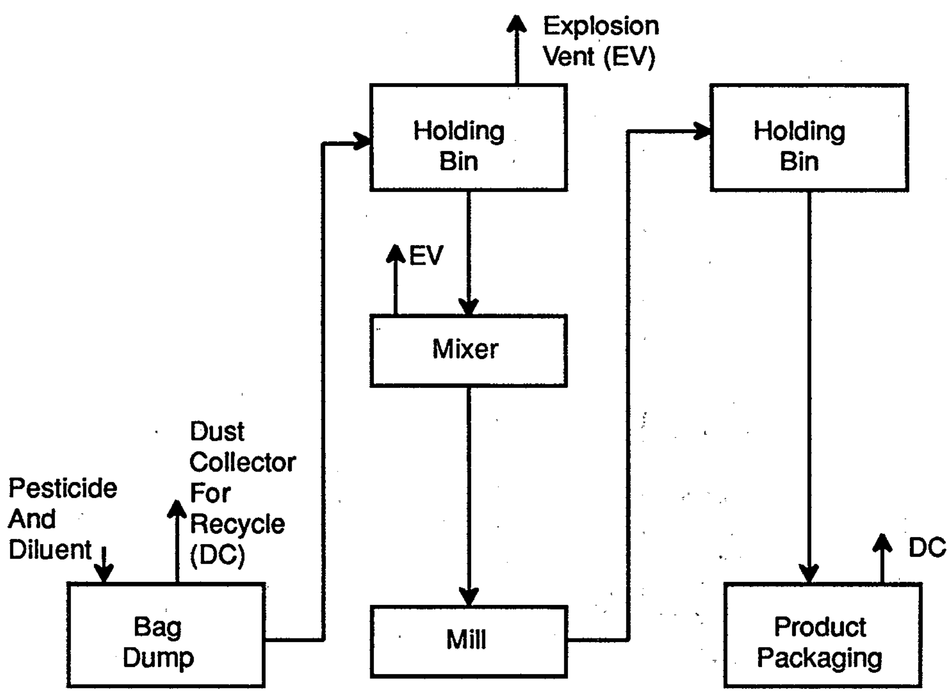


FIGURE A-8. FLOW DIAGRAM FOR DUST MILL-NO. 3

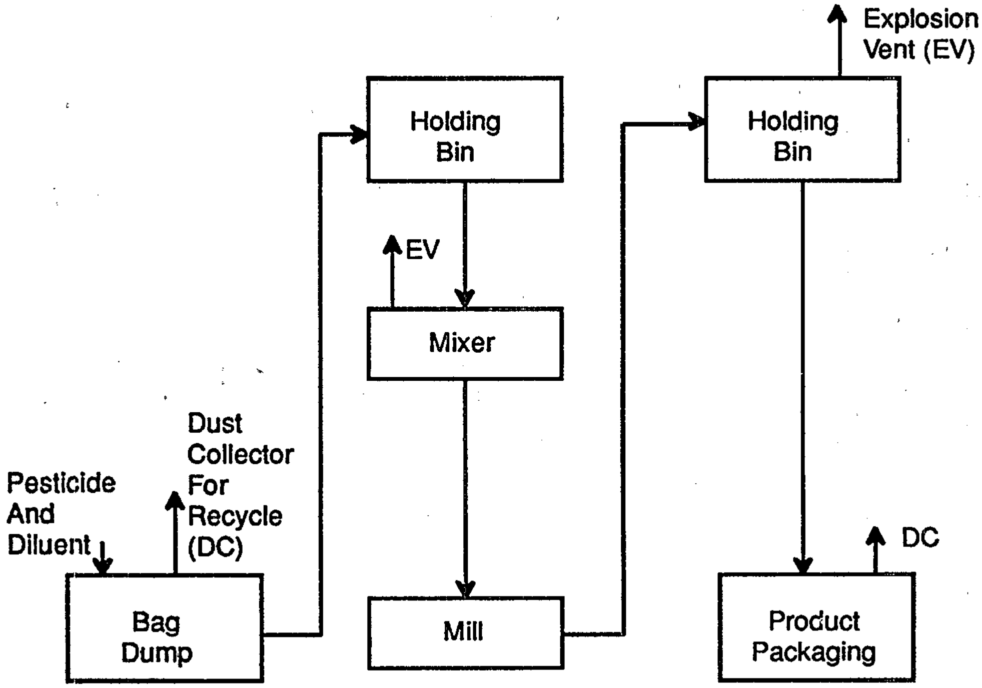


FIGURE A-9. FLOW DIAGRAM FOR DUST MILL-NO. 4

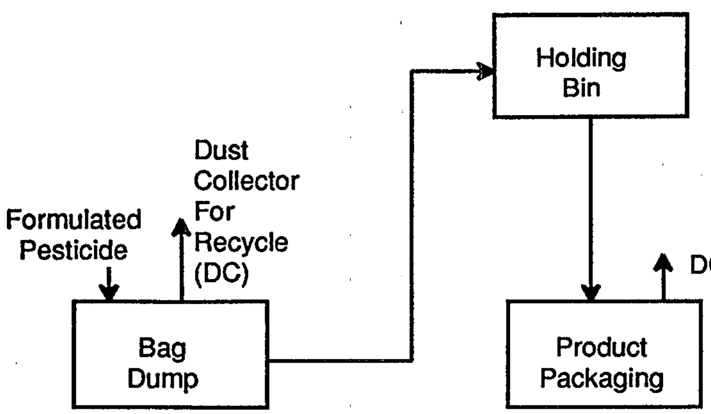


FIGURE A-10. FLOW DIAGRAM FOR DUST REPACK MILL (MILL NO. 2A)

batch holding tanks for both the sinox and paraquat processes pass through activated carbon unit filters.

One of the two main liquids buildings contains four liquid formulation mills. The liquid mill process is diagramed in Figure A-13. Technical materials and diluents are loaded via a barrel dump station and gravity fed into the mixer. The diluents consist of oils, solvents, and water. After mixing, the pesticide is pumped to a holding tank for dispensing and packaging. Pesticide vapors are drawn off all portions of the liquids process and passed through an activated carbon filter. The other main liquids building was formerly used to formulate kelthane, but was being renovated at the time of the audit to provide various liquid formulating facilities similar to those described above and depicted in Figure A-13. Likewise, the micronutrients building was being renovated during the audit to provide similar formulating processes.

The oils building contains the oil blending process. In 1986, 200,000 gal of oil products were formulated at the plant. Various oils are shipped to the plant in bulk and are blended in a series of mixing tanks and packaged in smaller containers, typically 30-gal drums. Dedicated integral piping and tank draining practices prevent contamination of subsequent batches. However, because of poor market conditions, the oils operation was discontinued in September, after the onsite audit.

Supplemental to the oil blending operation is a drum or barrel washing/painting operation which is located adjacent to the oils building. Figure A-14 presents a schematic diagram of the barrel washing/painting operation. Barrels are first manually washed with a high-pressure hose to remove labels and excess oil. The barrels are then cleaned in a barrel washer, dried, painted in a water-curtain spray booth, and again dried. With the discontinuation of the blending operation, the barrel washing/painting operation has also been discontinued.

Support operations at the plant include a uniform laundry, steam cleaner, maintenance shop, quality control laboratory, bulk storage areas, and warehouses. The steam cleaner, which is portable, is mainly used for cleaning formulating equipment prior to performing maintenance on the equipment. It is also used to clean liquid mixing tanks in-place between formulating operations.

Waste Generation, Handling, And Disposal

This chapter identifies the sources of hazardous waste generation at the plant and describes the existing methods for waste handling and disposal. This information is presented by each major type of waste generated including dust, dust/granule mill flushing diluents, other solid wastes, and liquid wastes. Other solid wastes consist of empty packaging materials, lab wastes, and activated carbon filters.

The disposal costs for each of these wastes are also presented.

DUST

Each dust and granular pesticide formulation mill is equipped with a dedicated dust collection system. This system draws fugitive dust generated by the various mill components and recycles it to the previous component. For example, dust drawn from the mixer is routed to the cut-in hopper. Excess dust generated during the final phase of batch formulation is collected in a hopper. This excess dust is emptied from the hopper into a drum located underneath the hopper in an enclosed housing. The drum is normally a 30-gallon (gal) drum. The dust is sampled and analyzed for technical material from the current batch as well as technical material from the differing previous batch. If the dust contains technical material from the current batch and does not contain unacceptable amounts of the differing technical material from the previous batch, then the dust is held for recycling in subsequent formulations. However, if the dust cannot be recycled within a practical time because of product orders, then the dust is disposed of as hazardous waste at an offsite approved hazardous waste disposal facility. Likewise, non-recyclable dust is disposed of as a hazardous waste at an offsite disposal facility. In addition to the individual mill dust collection systems, a central vacuum system serves both the granular and dust formulation buildings. Vacuum ports for this system are located near each dust and granular mill and dust collector hopper. During product formulation, operators will attach a hose to the port and vacuum dust and spilled product from around the mill area. When individual mill dust collector hoppers are emptied, a vacuum hose is attached to the drum housing under the hopper to draw off fugitive dust emissions. Material collected in the central vacuum system is emptied in the same manner as mill dust. Because the dust collected by the central vacuum system contains a variety of technical materials, recycling of the dust in subsequent formulations is not feasible. Therefore, it is disposed of as a hazardous waste at an offsite hazardous waste disposal facility.

The drums of non-recyclable dust are first transferred from the individual mill dust collectors and the central dust collection system to the hazardous waste accumulation area in the main warehouse. As a result of drum vibration during transport and gravity settling of the dust, the dust level drops in the drums. The drums are topped off with additional waste dust in the drum accumulation area and are then transported to an offsite ha zardous waste disposal facility.

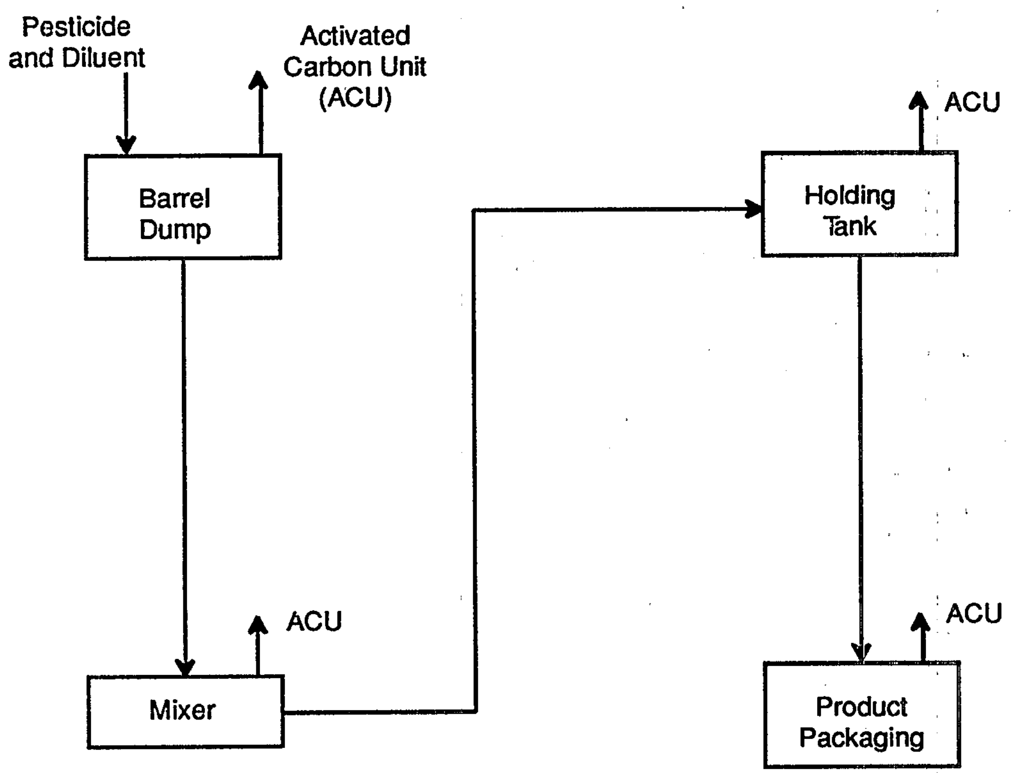


FIGURE A-11. FLOW DIAGRAM FOR SINOX PROCESS

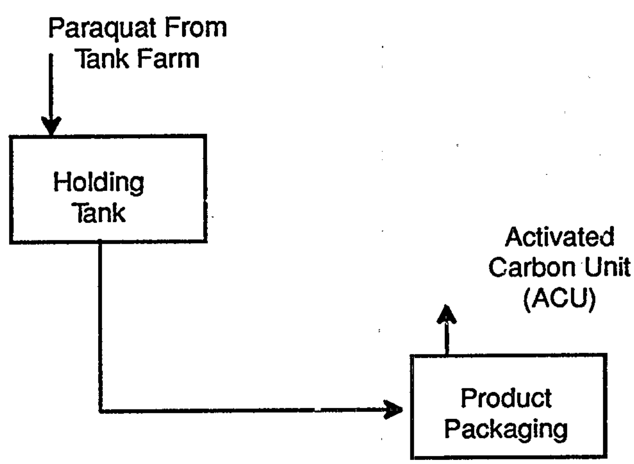


FIGURE A-12. FLOW DIAGRAM FOR PARAQUAT REPACKAGING PROCESS

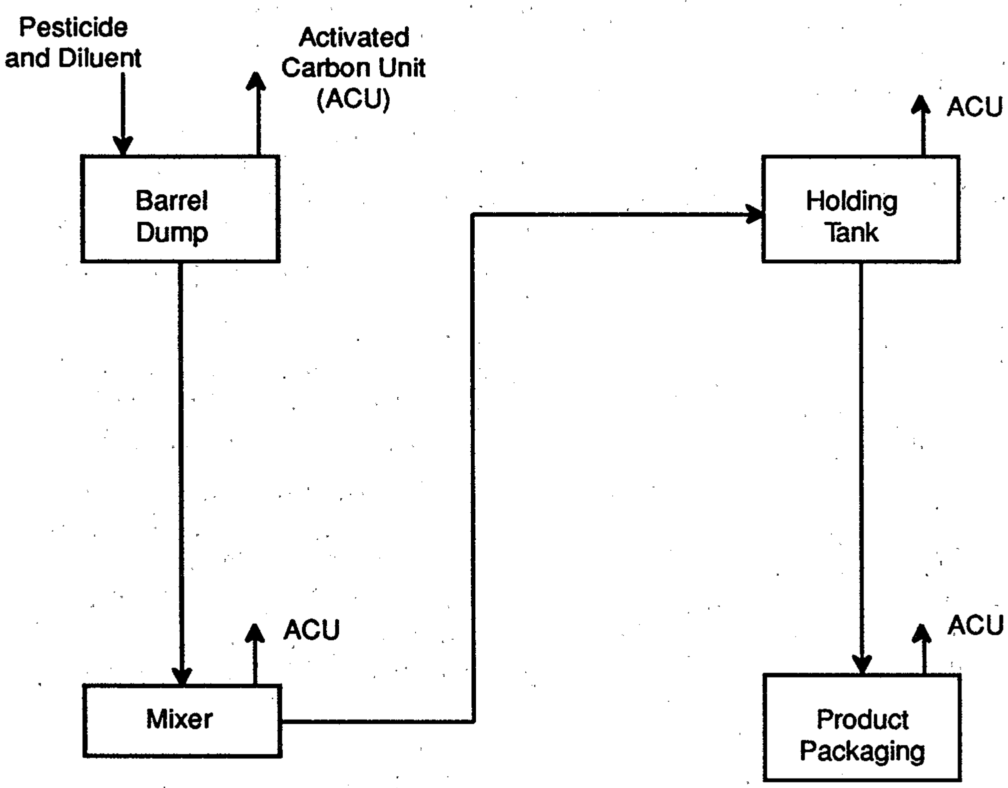


FIGURE A-13. FLOW DIAGRAM FOR MAIN LIQUID PROCESS

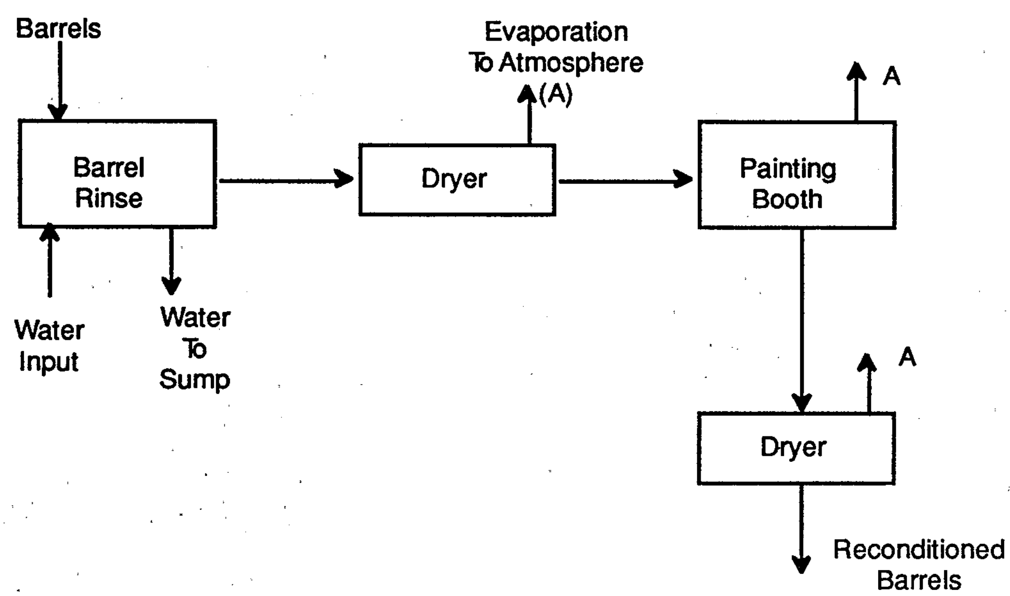


FIGURE A-14. FLOW DIAGRAM FOR BARREL WASHING OPERATION

DUST/GRANULE MILL FLUSHING DILUENTS

Sand and clay diluents are used to flush the granule and dust mills, respectively, after a product formulation run to remove residual pesticides. The diluent is collected in drums and empty paper bags which previously contained inert materials. The diluent is sampled and analyzed in the same manner as that for dusts collected by the vacuum systems. Likewise, the diluent is recycled or disposed of in the same manner as the dust based on the analytical results.

OTHER SOLID WASTES

Other solid wastes consist of emptied paper bags, cartons, and steel drums; activated carbon filters from ventilation systems; floor sweepings; and laboratory wastes.

The emptied paper bags and cartons and activated carbon filters are collected daily from process areas and compacted in a 40 cubic yard (cy) compactor. The compacted wastes are hauled "piggy back" in the 40-cy bins to an off-site, approved hazardous waste disposal facility. The bins typically contain between 12,000 and 15,000 pounds of bulk waste.

The 30- and 55-gal drums are reused for collecting hazardous dusts and flushing diluents as described previously. Any drums which cannot be reused for collection of hazardous wastes are cleaned at the steam cleaning pad and are transported offsite to a drum recycling firm.

Spilled product floor sweepings are collected in drums and disposed of as a hazardous waste. Likewise, laboratory wastes are lab packed and disposed of as a hazardous waste.

LIQUID WASTES

Liquid wastes consist of process wastewater, stormwater runoff, and sanitary wastewater. A description of each of these waste streams including a discussion of the handling and disposal methods is presented in the following sections.

Process Wastewater

Process wastewater consists of mill clean-out rinse water, equipment washdown water, laundry wastewater, floor wash water, boiler blowdown, cooling tower blowdown, and steam cleaning pad wastewater. Process wastewaters are generally routed to building floor drains and/or centrally located sumps. They flow by gravity or are pumped to the main wastewater sump. From there, the wastewater is pumped to the above ground bulk liquid hazardous waste storage tank. The tank has a capacity of approximately 589,000 gal. The process wastewater is periodically hauled by tanker trucks to an off-site hazardous waste disposal facility.

A discussion of each individual source of process wastewater is presented in the following paragraphs.

Mill Clean-Out Rinse Water and Equipment Washdown Water

The liquid formulation tanks and mixing equipment are cleaned using the portable steam cleaner and water hoses between formulations of different pesticides. In addition, whenever a piece of equipment is removed from service for maintenance, it is decontaminated using the portable steam cleaner. Decontamination is performed either inplace or at the steam cleaning pad prior to transporting the equipment to the maintenance building. The wastewater generated by these cleaning operations is collected and directed to the bulk hazardous waste storage tank.

Laundry Wastewater

The plant operates a laundry with two industrial grade washers and dryers on site for the cleaning of process employee overalls. The laundry wastewater is discharged to a nearby above ground tank. From this tank the wastewater is pumped to the bulk hazardous waste storage tank.

Floor Wash Water

To clean up spills in the liquids formulating buildings, water hoses and the steam cleaner are used to wash down the spills to floor drains which lead to sumps. From the sumps, the wastewater is pumped to the bulk hazardous waste storage tank.

Boiler and Cooling Tower Blowdown

Blowdown from the boiler and cooling tower is pumped to the bulk hazardous waste storage tank. The cooling tower blowdown is handled as a hazardous waste because of the potential for fugitive pesticide dust emissions to become entrained in the cooling tower water. Although the boiler blowdown is very likely not a hazardous waste stream, it is treated as such only because no other discharge options are readily available. The on-site septic tank/drainfield system reportedly does not have adequate capacity to accept the blowdown. In addition, plant personnel are reluctant to apply for a discharge permit because of past difficulties experienced in the application for discharge of treated process wastewater.

Steam Cleaning Pad Wastewater

Wastewater generated by the cleaning of drums and other equipment at the steam cleaning pad is routed to the bulk hazardous waste storage tank.

Stormwater Runoff

Of the 12.5-acre developed area of the plant, stormwater runoff from the 2-acre plant parking lot drains to a percolation pond located near the main gate of the plant. Stormwater runoff from the remaining 10.5-acre process area is collected through the central sump system and pumped to the bulk hazardous waste storage tank for disposal as hazardous waste. The exception to this runoff pattern is the runoff from the north side of the m aintenance building roof. The roof downspouts discharge to gravel splashpans in a grassy area adjacent to the building.

Sanitary Wastewater

Sanitary wastewater generated at the plant is discharged to two on-site septic tank/drainfield systems. The sanitary waste stream includes wastewater generated by the employee shower. Employees engaged in formulating operations are required to shower and change cotton overalls before lunch and shower again before leaving after work. The number of employees engaged in formulating operations ranges from approximately 60 to 120, depending on seasonal fluctuations in production.

WASTE QUANTITIES AND DISPOSAL COSTS

Quantities and disposal costs for the hazardous wastes identified in the preceding sections are presented in this section. The waste quantities are based on summary data provided by the plant which consist of annual quantities of solid and liquid wastes for the period of 1981 through 1985. In addition, best engineering judgement was applied to estimate quantities of specific types of process wastes. Table A-1 presents the annual waste quantity summary data by waste media. As shown in this table, the annual quantity of solid waste generated has decreased from 2,080.8 tons in 1981 to 467 tons in 1985, a 78 percent decrease. This reduction in solid waste generation resulted from aggressive waste minimization efforts by the plant, particularly relative to dust generation. Numerous equipment modifications and procedural changes were implemented to control the gen eration of hazardous dust.

Table A-1. Annual Waste Quantity Summary Data

Hazardous Waste Media	Waste Quantity (tons)				
	1981	1982	1983	1984	1985
Solid	2080.8	1001.2	747.4	526.0	467
Liquid[a]	3921.2	6444.2	15,259.8[b]	6024.9	7,000
Total	6002.0	7445.4	16,007.2	6550.9	7,467

[a] Includes stormwater runoff from plant area.
[b] Includes 1,666 tons from pre-1982 storage.

Source: Plant C, 1985 and 1986.

Because considerable waste minimization had already occurred relative to solid hazardous waste, and minimal potential for further solid waste minimization was found to exist at this plant, additional waste quantification efforts focused on the liquid waste streams. Quantification of the various liquid process waste streams was based primarily on reported typical wastewater generation rates. In addition, best engineering judgement was used to estimate waste quantities in the absence of available waste generation information. Table A-2 presents the estimated annual volume of each process waste stream and stormwater runoff. As shown in Table A-2, almost 90 percent of the total process wastewater volume consists of laundry wastewater. Each of the other process waste streams contributes less than 5 percent. On an average annual basis, stormwater runoff contributes about 75 percent of the total liquid waste volume, and approximately 97 percent of the total liquid waste volume consists of runoff and laundry wastewater.

Table A-3 presents annual waste disposal costs, based on 1984 waste quantities as this database was the most recent and complete. However, 1986 unit disposal costs were used to reflect more current overall costs. As shown in Table A-3, the cost for disposing process wastewater including stormwater runoff is approximately 75 percent of the total. The remaining 25 percent consists of solid waste disposal costs.

Table A-2. Estimated Volume of Liquid Process Waste Streams and Stormwater Runoff

Waste Stream	Estimated Annual Volume		
	Gal	% of Total Process Wastewater	% of Total Liquid Waste
Mill Cleanout rinsewater and equipment washdown water	11,000	2.2	0.6
Floor wash water	9,000	1.8	0.4
Steam cleaning pad wastewater	15,000	3.0	0.8
Laundry wastewater	441,000	88.2	22.0
Boiler and cooling tower blowdown	24,000	4.8	1.2
Total Process Wastewater	500,000	100.0	25.0
Stormwater Runoff[a]	1,500,000	—	75.0
Total liquid Waste	2,000,000	—	100.0

[a] Based on average annual rainfall of 10.52 inches per year recorded at a nearby airport.

Table A-3. Annual Waste Disposal Costs

Waste Type	Annual Waste Quantity[a]	UnitDisposal Cost	Annual Disposal Cost	% of Total Cost
Drummed Solids	2,057 drums	$65/drum	$133,705	9.4
Compacted Solids	36 bins	$5,400/bin	$194,400	13.7
Pallets of Solids[b]	93 pallets	$260/pallet	$ 24,180	1.7
Process Waste water[c]	1,445,300 gal	$0.72/gal	$1,040,616	75.2
TOTAL COST		$1,392,901		

[a]1984 data.
[b]Palletized and plastic wrapped paper bags containing contaminated flushing diluents.
[c]Including stormwater runoff.

Source: Plant C, 1984; ESE, 1986

AUDIT FINDINGS AND RECOMMENDATIONS

This chapter presents the findings of the audit in terms of hazardous waste minimization techniques recently implemented by the plant. Recommendations for further waste reduction through source controls, recycling, and treatment are also presented. Where information was available, cost/benefit data are presented for the various waste minimization techniques implemented by the plant.

EXISTING WASTE MINIMIZATION TECHNIQUES

The most prominent waste minimization techniques implemented at the plant are those which control the generation of hazardous dusts in the formulation of dust and granular pesticides. These techniques consist of the installation of dedicated dust collection baghouses on each dust/granule formulating mill; the installation of enclosed cut-in hoppers, conveyors, elevators, mixers, and holding tanks; the recycling of dust collected from each mill component to the preceding component; and the reuse of the dust collected in the baghouse hopper for subsequent formulations to the maximum extent that is practically feasible.

As described in the Waste Generation section, the significant reduction in the volume of solid hazardous waste generated since 1981 is mainly attributable to the implementation of these dust control techniques.

Other solid waste reduction techniques employed by the plant consist of the use of returnable bulk diluent containers; the installation of a compactor to reduce the volume of bulky wastes such as emptied paper bags, cardboard drums and spent activated carbon filters; and the recycling of empty drums. The returnable bulk diluent containers are used primarily for the sand and clay diluents used in formulating dust and granular pesticides.

The compactor was installed mainly because the disposal costs for the bins of bulk waste are based on a unit volume basis rather than a unit weight basis, and waste volume reduction would result in reduced disposal cost. The compactor was installed in 1983 for a cost of approximately $60,000. The savings realized from the reduced disposal costs offset the capital cost of the compactor in 4 months.

Any empty 55-gallon drum which previously contained pesticide is either reused for collecting hazardous waste, or washed and shipped to an offsite drum recycler. As described previously, drums shipped to the offsite recycler are first cleaned at the steam cleaning pad.

Waste reduction measures that have been implemented relative to liquid process wastes include the use of portable steam cleaners to clean mixing tanks rather than using the batch-boil method; the use of spray nozzles on hoses used for rinsing mixing and other process equipment, and floor washing; and recycling of equipment rinse waster as diluent for subsequent formulations when practicable. The reduction in liquid process wastes resulting from the implementation of these techniques is not known as historical waste volume data are not available for the specific liquid waste streams.

Inspection of the liquid formulating areas indicated that not all hoses used for equipment washdown and floor washing were equipped with nozzles. Some were not even equipped with threaded fittings for nozzles. Consequently, further liquid waste volume reduction could be achieved by installing nozzles on all hoses at the plant. A high pressure water knife nozzle could significantly reduce the liquid volume. This would generate a more conc entrated wastewater that could be used in subsequent formulations.

A general observation of the waste minimization audit was that past waste minimization efforts apparently focused more on the generation and disposal of solid wastes than on liquid process waste generation and disposal. This observation is based on the extent of capital improvements of hazardous dust collection equipment compared to that related to liquid waste minimization. In the absence of historical waste volume data for specific liqui d waste steams, it is not possible to further substantiate this observation by comparing the percentage reduction of liquid waste streams versus solid waste streams.

Another significant audit finding is that many of the higher strength liquid process wastes, such as equipment rinse water, are generated in almost negligible volumes compared to the volume of plant stormwater runoff that is collected and handled as a hazardous waste. Consequently, any reductions in process wastewaters that have occurred through the implementation of waste minimization measures are masked by the volume of stormwater runoff that is commingled with the process wastewater.

According to plant personnel, past efforts to obtain a discharge permit for the stormwater runoff have been unsuccessful because of concern over pesticide levels in the runoff. Consequently, the plant is currently conducting treatability testing of activated carbon for pesticide removal from process wastes, including the runoff.

RECOMMENDED WASTE SOURCE REDUCTION TECHNIQUES

The recommendations presented below were developed for minimizing or eliminating hazardous waste at the source of generation.

Liquid Waste Sources

1. Use mopping of floors in liquid pesticide formulating areas with dedicated mops and squeegees to minimize the use of water hosing for floor washing. This practice will minimize the volume of floor wash water generated.

2. Install spray nozzles on all hoses to increase equipment rinsing efficiency thereby minimizing the volume of spent rinse water. This recommendation could include the use of a water-knife type spray nozzle equipped with a high pressure booster pump. The resulting wastewater would be more concentrated and could be used in subsequent formulations. The use of wiper blades to physically wipe down the inside of the mixing tanks could also be included as part of this recommendation.

3. Collect and reuse equipment rinse water for repetitive rinsing to minimize the volume of spent rinse water. This recommendation would involve the installation of rinse water holding tanks to facilitate its reuse, and possible two stage rinsing using more contaminated rinse water for the first stage of rinsing, and less contaminated rinse water for the final rinse.

4. Install flow meters on process water lines in each liquid pesticide formulating area to monitor water usage and the effects of various waste minimization techniques during trial implementation periods. Maintain a formal waste minimization program requiring operators to routinely record meter readings and waste quantities, and periodically review this data with management.

5. Use disposable coveralls, such as Tyvek suits, instead of cotton overalls for personnel engaged in formulating operations to minimize laundry wastewater.

6. Collect and analyze samples of boiler and cooling tower blowdowns to determine if these waste streams are characteristic hazardous wastes. If nonhazardous, dispose of by discharge to one of the septic tank/drainfield systems.

7. Monitor stormwater runoff flow and quality. This monitoring may indicate that the runoff is uncontaminated during the latter part of the wet season because of the contaminant flushing. If so, the runoff should be handled as a nonhazardous waste during this time period. This will require that the runoff control system be modified to allow segregation of the runoff from process wastewater.

Solid Waste Sources

In the granule and dust mill flushing operation between batches, change from once through diluent flushing to repetitive flushing with a smaller volume of diluent. This recommendation may involve the installation of dedicated holding tanks for the used diluents, and could also include the use of two stage flushing. Furthermore, the establishment of a formal waste minimization program to periodically review waste generation by granule and d ust mill operations should be considered.

RECOMMENDED WASTE RECYCLING TECHNIQUES

The findings of the audit indicated that the plant is effectively recycling diluents used for decontaminating formulating equipment between batches to the extent that is practically feasible. This applies to clays and sand for dust/granule formulations, and water and solvents for liquid formulations. It was also determined that the plant is currently conducting pilot-scale activated carbon treatability studies for the combined process was tewater, including plant runoff, to produce an effluent that could be reused in the plant. It is recommended that these studies be continued and expanded as necessary to evaluate other applicable treatment technologies to evaluate reuse of the effluent in the plant. These studies should also be designed to support the discharge of the effluent to surface water or to a publicly-owned treatment works (POTW) should the sewer system be extended near the plant in the future.

RECOMMENDED MANAGEMENT/EMPLOYEE INITIATIVES

The recommendations presented below were developed for minimizing hazardous waste at the source through management and employee initiatives.

1. Provide routine waste reduction training for operating employees.

2. Establish an incentive compensation system whereby employees are rewarded for reducing waste generation, in

proportion to the reduction in the company's waste management costs.

POTENTIAL ECONOMIC BENEFITS

The potential economic benefits of implementing the recommended waste source reduction and recycling techniques, described above were assessed by comparing the annual implementation costs and the resulting annual savings in waste disposal costs. The estimated implementation costs include the capital cost for any new equipment or plant improvements, as well as the operation and maintenance costs associated with the recommended technique. The capital cost was annualized using an interest rate of 10 percent and a 30 year period. The annual implementation cost is the sum of the annualized capital cost and the annual operation and maintenance costs.

Recommendations 1 through 4 under Liquid Waste Source reduction techniques were combined for the economic benefit assessment because they are all closely related and pertain to the reduction of equipment rinse water and floor wash water. The estimated implementation cost for these techniques is approximately $8,400 per year, the majority of which is for the installation, operation, and maintenance of spent rinse water collection systems to facilitate repeat use of the rinse water. Based on a unit disposal cost of $0.72/gallon, the implementation of these techniques would have to result in a wastewater reduction of almost 11,700 gallons per year to offset the implementation cost. This reduction represents approximately 60 percent of the current wastewater generation by equipment rinsing and floor washing operations. The success of these waste reduction techniques will mainly hinge on the effectiveness of repetitive use of the spent equipment rinse water, and consideration should be given to trial implementation of this technique on one of the pesticide formulating operations. The trial implementation would involve the installation of a temporary collection and storage system for the spent rinse water for subsequent reuse. It would also involve testing of repetitive use of the spent rinse water to determine the number of rinse cycles that could be used before the rinse water becomes too contaminated to allow effective rinsing.

Recommendation 5 under Liquid Waste Source reduction techniques involves the use of disposable coveralls such as Tyvek suits, rather than cotton coveralls, to minimize the volume of laundry wastewater. Because the disposable coveralls do not generally breathe as well as the cotton coveralls, they would likely be too uncomfortable during the warmer months of June through September. However, the use of disposable coveralls during the remain ing months would minimize the volume of laundry wastewater. Assuming the use of 120 Tyveks per day for 165 days per year, the annual cost for the Tyveks would be approximately $47,000. The disposal cost for the used Tyveks as a hazardous waste would be about $12,000 per year. In addition, the disposal cost for the laundry wastewater generated during the months of June through September based on a unit disposal cost of $0.72/gallon would b e approximately $106,000. Therefore, the total cost of using disposable coveralls except during the four warmer months of the year would be about $165,000. At present, the annual disposal cost for the laundry wastewater is approximately $318,000, based on a unit disposal cost of $0.72/gallon. Consequently, the use of the disposable coveralls as described above would result in an annual savings of about $153,000. Although this recommendat ion appears to be very economically beneficial, Plant C should regularly evaluate the impact of the landfill ban program which could eventually prohibit landfill disposal of the contaminated Tyvek suits. In evaluating this recommendation, Plant C should also consider the waste classification of the Tyvek suits. Characterization of the contaminated Tyveks should be performed, as recommended for the pesticide-contaminated rags generated by Plant B, to determine the waste classification and appropriate waste disposal method.

Recommendation 6 under Liquid Waste Source reduction techniques consists of the sampling and analysis of the boiler and cooling tower blowdowns to determine if these waste streams are characteristic hazardous wastes. At present, these waste streams, which combined amount to 24,000 gallons per year, are disposed of as a hazardous waste at an annual cost of approximately $17,000. The collection and analysis of four samples of each of the two waste streams are recommended to provide a representative database for the hazardous waste determination. The estimated cost for collecting and analyzing eight samples for pesticides analysis is approximately $8,000. If these waste streams are found to be nonhazardous, then these waste streams could possibly be discharged to one of the existing septic tanks/drainfield systems. The installation of plumbing required for directing these waste streams to the septic tanks is estimated to be about $4,000 (annualized cost of approximately $400 per year). Therefore, as nonhazardous wastes, these waste streams could be disposed of at a cost of about $400 per year, with a first year sampling and analysis cost of $8,000. These cost represent a savings of $8,600 during the first year of implementation, and an annual savings of over $16,000 per year thereafter.

Recommendation 7 under Liquid Waste Source reduction techniques involves monitoring of stormwater runoff flow and quality throughout the wet season. The purpose of this monitoring program is to determine if the runoff is nonhazardous, which may be the case particularly in the latter portion of the wet season. In order to develop a meaningful cost estimate for monitoring the stormwater runoff, an analysis of the drainage systems would be required. This analysis may indicate that numerous monitoring locations may be warranted to adequately investigate the potential contaminant source areas in the drainage systems. Even though the costs of such a monitoring program may be considerable, it is possible that it could be easily offset by the savings that may be realized in the event that some of the runoff is determined to be nonhazardous.

Under the Solid Waste Source reduction techniques, the use of repetitive diluent flushing of granule and dust mills rather than once through flushing was recommended. The repetitive flushing would be performed with a smaller volume of diluent than that used for the once through flushing to minimize the volume of spent diluent generated. A meaningful cost analysis of this recommended technique is not possible until a limited amount of trial implementation is performed. Trial implementation would involve the collection and repeated reuse of the diluent to determine the number of flushes that can be performed before the diluent becomes too contaminated to allow effective cleaning of the mill.

Process wastewater treatability studies are currently being performed to evaluate reuse of the treated effluent as process water. The recommendation of continuing and possibly expanding these studies is based on the significant economic benefit that could potentially be obtained considering the high cost of liquid waste disposal as a hazardous waste. If not currently being considered, the segregation and treatment of the lower strength wastewaters, particularly stormwater runoff, may also be a very economically attractive option compared to the option of treating the combined process waste streams. This is supported by the large volume of stormwater runoff, which averages about 1,500,000 gallons per year and represents approximately 75 percent of the combined liquid waste volume.

At present, about $1.4 million is spent each year for the disposal of the process wastewater, including runoff, as a hazardous waste. Completion of the treatability and associated engineering feasibility studies will be required to perform a meaningful economic analysis of the various wastewater segregation/treatment/recycle options relative to the current wastewater disposal practice.

The recommended management/employee initiatives to minimize hazardous waste generation presented involve the provision of waste reduction training and incentive compensation programs for operating employees. The cost of these programs will depend on the level of training to be provided, and the type and magnitude of the incentive compensation systems. Further evaluation of the employee training needs and overall compensation system at Plant C, as well as the anticipated waste management savings resulting from the implementation of these programs, is required to perform a meaningful cost/benefit analysis of this recommendation. Nevertheless, it is reasonable to assume that some long term benefit would be gained in the form of reduced waste management costs by implementing these types of employee programs.

APPENDIX B
WHERE TO GET HELP
FURTHER INFORMATION ON POLLUTION PREVENTION

Additional information on source reduction, reuse and recycling approaches to pollution prevention is available in EPA reports listed in this section, and through state programs (listed below) that offer technical and/or financial assistance in the areas of pollution prevention and treatment.

In addition, waste exchanges have been established in some areas of the U.S. to put waste generators in contact with potential users of the waste. Four waste exchanges are listed below. Finally, EPA's regional offices are listed.

EPA REPORTS ON WASTE MINIMIZATION

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Corrosive and Heavy Metal Waste Minimization Audit at a Specialty Steel Manufacturing Complex." Executive Summary.*

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Minimization of Solvent Waste for Parts Cleaning and from Electronic Capacitor Manufacturing Operation." Executive Summary.*

U.S. Environmental Protection Agency. "Waste Minimization Audit Report: Case Studies of Minimization of Cyanide Wastes from Electroplating Operations." Executive Summary.*

U.S. Environmental Protection Agency. Report to Congress: Waste Minimization, Vols. I and II. EPA/530-SW-86-033 and -034 (Washington, D.C.: U.S. EPA, 1986).**

U.S. Environmental Protection Agency. Waste Minimization - Issues and Options, Vols. I-III EPA/530-SW-86-041 through -043. (Washington, D.C.: U.S. EPA, 1986).**

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* Executive Summary available from EPA, WMDDRD, RREL, 26 West Martin Luther King Drive, Cincinnati, OH, 45268; full report available from the National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161.

** Available from the National Technical Information Service as a five-volume set, NTIS No. PB-87-114-328.

WASTE REDUCTION TECHNICAL/ FINANCIAL ASSISTANCE PROGRAMS

The EPA's Office of Solid Waste and Emergency Response has set up a telephone call-in service to answer questions regarding RCRA and Superfund (CERCLA):

(800) 242-9346 (outside the District of Columbia)

(202) 382-3000 (in the District of Columbia)

The following states have programs that offer technical and/or financial assistance in the areas of waste minimization and treatment.

Alabama
Hazardous Material Management and Resources Recovery Program
University of Alabama
P.O. Box 6373
Tuscaloosa, AL 35487-6373
(205) 348-8401

Alaska
Alaska Health Project
Waste Reduction Assistance Program
431 West Seventh Avenue, Suite 101
Anchorage, AK 99501
(907) 276-2864

Arkansas
Arkansas Industrial Development Commission
One State Capitol Mall
Little Rock, AR 72201
(501) 371-1370

California
Alternative Technology Section
Toxic Substances Control Division
California State Department of Health Service
714/744 P Street
Sacramento, CA 94234-7320
(916) 324-1807

Connecticut
Connecticut Hazardous Waste Management Service
Suite 360
900 Asylum Avenue
Hartford, CT 06105
(203) 244-2007

Connecticut Department of Economic Development
210 Washington Street
Hartford, CT 06106
(203) 566-7196

Georgia

Hazardous Waste Technical Assistance Program
Georgia Institute of Technology
Georgia Technical Research Institute
Environmental Health and Safety Division
O'Keefe Building, Room 027
Atlanta, GA 30332
(404) 894-3806

Environmental Protection Division
Georgia Department of Natural Resources
Floyd Towers East, Suite 1154
205 Butler Street
Atlanta, GA 30334
(404) 656-2833

Illinois

Hazardous Waste Research and Information Center
Illinois Department of Energy of Energy and Natural Resources
1808 Woodfield Drive
Savoy, IL 61874
(217) 333-8940

Illinois Waste Elimination Research Center
Pritzker Department of Environmental Engineering
Alumni Building, Room 102
Illinois Institute of Technology
3200 South Federal Street
Chicago, IL 60616
(313) 567-3535

Indiana

Environmental Management and Education Program
Young Graduate House, Room 120
Purdue University
West Lafayette, IN 47907
(317) 494-5036

Indiana Department of Environmental Management
Office of Technical Assistance
P.O. Box 6015
105 South Meridian Street
Indianapolis, IN 46206-6015
(317) 232-8172

Iowa

Center for Industrial Research and Service
205 Engineering Annex
Iowa State University
Ames, IA 50011
(515) 294-3420

Iowa Department of Natural Resources
Air Quality and Solid Waste Protection Bureau
Wallace State Office Building
900 East Grand Avenue
Des Moines, IA 50319-0034
(515) 281-8690

Kansas

Bureau of Waste Management
Department of Health and Environment
Forbes Field, Building 730
Topeka, KS 66620
(913) 269-1607

Kentucky

Division of Waste Management
Natural Resources and Environmental Protection Cabinet
18 Reilly Road
Frankfort, KY 40601
(502) 564-6716

Louisiana

Department of Environmental Quality
Office of Solid and Hazardous Waste
P.O. Box 44307
Baton Rouge, LA 70804
(504) 342-1354

Maryland

Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200 A
Annapolis, MD 21401
(301) 974-3432

Maryland Environmental Service
2020 Industrial Drive
Annapolis, MD 21401
(301) 269-3291
(800) 492-9188 (in Maryland)

Massachusetts

Office of Safe Waste Management
Department of Environmental Management
100 Cambridge Street, Room 1094
Boston, MA 02202
(617) 727-3260

Source Reduction Program
Massachusetts Department of Environmental Quality Engineering
1 Winter Street
Boston, MA 02108
(617) 292-5982

Michigan
Resource Recovery Section
Department of Natural Resources
P.O. Box 30028
Lansing, MI 48909
(517) 373-0540

Minnesota
Minnesota Pollution Control Agency
Solid and Hazardous Waste Division
520 Lafayette Road
St. Paul, MN 55155
(612) 296-6300

Minnesota Technical Assistance Program
W-140 Boynton Health Service
University of Minnesota
Minneapolis, MN 55455
(612) 625-9677

(800) 247-0015 (in Minnesota)
Minnesota Waste Management Board
123 Thorson Center
7323 Fifty-Eighth Avenue North
Crystal, MN 55428
(612) 536-0816

Missouri
State Environmental Improvement and Energy Resources Agency
P.O. Box 744
Jefferson City, MO 65102
(314) 751-4919

New Jersey
New Jersey Hazardous Waste Facilities Siting Commission
Room 614
28 West State Street
Trenton, NJ 08608
(609) 292-1459
(609) 292-1026

Hazardous Waste Advisement Program
Bureau of Regulation and Classification
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

Risk Reduction Unit
Office of Science and Research
New Jersey Department of Environmental Protection
401 East State Street
Trenton, NJ 08625

New York
New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518) 457-3273

North Carolina
Pollution Prevention Pays Program
Department of Natural Resources and Community Development
P.O. Box 27687
512 North Salisbury Street
Raleigh, NC 27611
(919) 733-7015

Governor's Waste Management Board
325 North Salisbury Street
Raleigh, NC 27611
(919) 733-9020

Technical Assistance Unit
Solid and Hazardous Waste Management Branch
North Carolina Department of Human Resources
P.O. Box 2091
306 North Wilmington Street
Releigh, NC 27602
(919) 733-2178

Ohio
Division of Solid and Hazardous Waste Management
Ohio Environmental Protection Agency
P.O. Box 1049
1800 WaterMark Drive
Columbus, OH 43266-1049
(614) 481-7200

Ohio Technology Transfer Organization
Suite 200
65 East State Street
Columbus, OH 43266-0330
(614) 466-4286

Oklahoma
Industrial Waste Elimination Program
Oklahoma State Department of Health
P.O. Box 53551
Oklahoma City, OK 73152
(405) 271-7353

Oregon
Oregon Hazardous Waste Reduction Program
Department of Environmental Quality
811 Southwest Sixth Avenue
Portland, OR 97204
(503) 229-5913

Pennsylvania
Pennsylvania Technical Assistance Program
501 F. Orvis Keller Building
University Park, PA 16802
(814) 865-0427

Center of Hazardous Material Research
320 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5320

Bureau of Waste Management
Pennsylvania Department of
Environmental Resources
P.O. Box 2063
Fulton Building
3rd and Locust Streets
Harrisburg, PA 17120
(717) 787-6239

Rhode Island
Ocean State Cleanup and Recycling Program
Rhode Island Department of Environmental Management
9 Hayes Street
Providence, RI 02908-5003
(401) 277-3434
(800) 253-2674 (in Rhode Island)

Center for Environmental Studies
Brown University
P.O. Box 1943
135 Angell Street
Providence, RI 02912
(401) 863-3449

Tennessee
Center for Industrial Services
102 Alumni Hall
University of Tennessee
Knoxville, TN 37996
(615) 974-2456

Virginia
Office of Policy and Planning
Virginia Department of Waste Management
11th Floor, Monroe Building
101 North 14th Street
Richmond, VA 23219
(804) 225-2667

Washington
Hazardous Waste Section
Mail Stop PV-11
Washington Department of Ecology
Olympia, WA 98504-8711
(206) 459-6322

Wisconsin
Bureau of Solid Waste Management
Wisconsin Department of Natural Resources
P.O. Box 7921
101 South Webster Street
Madison, WI 53707
(608)267-3763

Wyoming
Solid Waste Management Program
Wyoming Department of Environmental Quality
Herchler Building, 4th Floor, West Wing
122 West 25th Street
Cheyenne, WY 82002
(307) 777-7752

WASTE EXCHANGES

Northeast Industrial Exchange
90 Presidential Plaza, Syracuse, NY 13202
(315) 422-6572

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

Great Lake Regional Waste Exchange
470 Market Street, Grand Rapids, MI 49503
(616) 451-8922

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

U.S. EPA REGIONAL OFFICES

Region 1 (VT, NH, ME, MA, CT, RI)
John F. Kennedy Federal Building
Boston, MA 02203
(617) 565-3715

Region 2 (NY, NJ)
26 Federal Plaza
New York, NY 10278
(212) 264-2525

Region 3 (PA, DE, MD, WV, VA)
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-9800

Region 4 (KY, TN, NC, SC, GA, FL, AL, MS)
345 Courtland Street, NE
Atlanta, GA 30365
(404) 347-4727

Region 5 (WI, MN, MI, IL, IN, OH)
230 South Dearborn Street
Chicago, IL 60604
(312) 353-2000

Region 6 (NM, OK, AR, LA, TX)
1445 Ross Avenue
Dallas, TX 75202
(214) 655-6444

Region 7 (NE, KS, MO, IA)
756 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2800

Region 8 (MT, ND, SD, WY, UT, CO)
999 18th Street
Denver, CO 80202-2405
(303) 293-1603

Region 9 (CA, NV, AZ, HI)
215 Fremont Street
San Francisco, CA 94105
(415) 974-8071

Region 10 (AK, WA, OR, ID)
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-5810

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati, OH 45268

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