WASTEWATER TREATMENT TECHNOLOGY DOCUMENTATION

for

ALDRIN/DIELDRIN, DDT, ENDRIN, AND TOXAPHENE FORMULATION

Office of Water Planning and Standards

U. S. Environmental Protection Agency

401 M Street, S.W.

Washington, D. C. 20460

June 1976

Preface

This is a report on wastewater management and associated costs at facilities formulating the pesticides aldrin/dieldrin, DDT, endrin and/or toxaphene. The information included was developed under EPA Contract No. 68-01-3524 (MRI No. 41227-C) by the Midwest Research Institute and particularly Section V by the Environmental Protection Agency.

Contents

Sections		Page
I.	Summary	1
II.	Industry Characterization	5
	The Pesticide Formulation Industry	6
	Designated Pesticide Formulations	11
	Aldrin/Dieldrin	24
	DDT	25
	Endrin	26
	Toxaphene	27
III.	Wastewater Characterization	29
	Water Use	29
	Wastewater Sources	34
	Wastewater Characteristics	39

Sections		Page
IV.	Wastewater Management Method	43
	In-Plant Control Technology	43
	Current Wastewater Management Practices	50
V.	Technology and Estimated Costs	61
	Options for Compliance	62
	Selection of Operation Models for Cost Estimation	65
	Estimate of Model Plant Compliance Cost Impacts	68
	References	72

TABLES

No.	Title
1.	Estimated Roof Area, Model Formulation Plant, Liquid and Dust Operations
2.	Estimated Installed Capital Equipment Costs, Model Formulation Plants, Roof, Slabs and Curbs
3.	Estimated Total Annual Operating Costs, Model Formulation Plants, Roof, Slabs and Curbs

FIGURES

No.	Title
1.	Large formulation plant locations
2.	Product distribution for large formulation plants
3.	Distribution of plants by age
4.	Liquid formulation unit
5.	Typical sulfur grinding unit
6.	Process for formulating dust
7a.	Aldrin/dieldrin formulation plants (1973)
7b.	DDT formulation plant (1973)

7c. Endrin formulation plants (1973)

7d. Toxaphene formulation plants (1973)

8. Formulation plants using evaporation treatment systems

APPENDICES

A	-	Holding-Evaporation Systems Design, Technology and Estimated Associated Costs, Worst Case Situation
B 1		Summary of Contracts with Pesticide Formulators (January-February 1976)
B 2		Memoranda of Plant Visits
Oct 27, 75		Stauffer Chemical Company, Omaha, Neb.
Feb 11, 76		Triangle Chemical Company, Macon, Ga.
Feb 11, 76		The Helena Chemical Corp., Cordele, Ga.
Feb 11, 76		Parramore and Griffin Co., Valdosta, Ga.
Feb 12, 76		FMC Corporation, Jacksonville, Fla.
Feb 13, 76		Asgrow Florida Company, Plant City, Fla.
Feb 13, 76		Helena Chemical Company, Tampa, Fla.

SECTION I

SUMMARY

Control of the four pesticides designated as toxic pollutants affects only a small segment of the total pesticide formulation industry. In 1975 5,300 plants produced pesticide formulations nationwide. Only 182 plants produced formulations of the designated pesticides: aldrin/dieldrin, 9 plants; DDT, 1 plant; endrin, 39 plants; and toxaphene, 133 plants.

Unlike manufacture of the technical pesticides, formulation of products containing aldrin/dieldrin, DDT, endrin or toxaphene cannot be segregated readily from the rest of the pesticide formulation industry. It is necessary, therefore, to characterize the entire pesticide formulation industry as well as that segment formulating products containing the specified pesticides in order to assess applicable wastewater treatment technology.

This report provides a discussion of the pesticide formulation industry and is divided into four sections: (a) industry characterization; (b) wastewater characterization; (c) wastewater management methods; and (d) formulation wastewater management costs. Sections (a), (b) and (c) discuss both the total formulation industry and the segment of the industry to

be affected by proposed standards. Section (d) presents estimated costs of wastewater management technology determined by this study to be the most feasible methods for controlling discharges of the designated pesticides to the navigable waters.

(a) The industry is characterized according to its structure, the number and types of formulations and the kinds of formulating processes. The structure study shows the ownership patterns, the geographic distribution of the total industry and the geographical location of the affected formulators.

The total number of formulated products produced in 1975 was 23,633, including emulsifiable concentrates, powders, granules and aerosols. These formulation processes are discussed in general along with examination of products and processes applicable to the four pesticides of particular interest here.

Formulated pesticide products registered in 1973 included: 37 containing aldrin or dieldrin, of which 35 to 40% were emulsifiable concentrates and 35 to 40% were granules; 5 containing DDT, about 90% of which were wettable powders; 27 containing endrin, about 90% of which were emulsifiable

concentrates; and 161 containing toxaphene, about 90% of which were emulsifiable concentrates and wettable powders.

(b) The usage of water and the sources of wastewater in formulation plants are examined and methods for their reduction or elimination discussed.

(c) Wastewater treatment methods used throughout the pesticide formulation industry are examined. A discussion is presented of in-plant control technology to eliminate use of water and to minimize contamination of any wastewater generated. Past and present practices such as evaporation systems, sewer systems, landfill, contract disposal, activated carbon adsorption, and incineration, are described. Process wastewater management methods are described which are intended to achieve zero discharge of aldrin/dieldrin, DDT, endrin, or toxaphene. These systems include (1) elimination of process water, (2) evaporation systems, and (3) contract disposal. Rainwater runoff management methods are described which are intended to achieve zero discharge of the designated pollutants. These include the covering over of all formulation operations, the removal or paving over of contaminated soils, and diversion of "clean" runoff.

(d) Model formulating plants are developed using the technology of complete elimination of wastewater generation

combined with roof cover requirement over all processes to prevent contamination of stormwater runoff. Estimates of installed capital equipment and annual operating costs, based upon the models, are presented.

SECTION II

INDUSTRY CHARACTERIZATION

Pesticide formulation is the segment of the agricultural chemical industry (SIC 2879) that transforms bulk technical active ingredient into packaged forms ready for use. Two major operations are required to effect this transformation: the technical material must be blended (formulated) with the additives and inert carriers appropriate for each registered use; and the formulated material must be packaged in appropriate containers for each kind of user. The term "formulation industry" is used here to include both of these operations because they are sequential steps normally conducted in the same plant.

For purposes of evaluating wastewater treatment technology, however, formulating that is done at the same plant site as the production of the active ingredient (i.e., satellite units of a production facility), has not been included here. Such activity is considered as part of a pesticide manufacturing plant since the wastewaters are normally treated together.

Unlike manufacture of the technical pesticide, formulation of products containing a specific pesticide cannot be readily segregated from the rest of the pesticide formulation industry. It is necessary, therefore, to characterize the total pesticide formulation industry as well as that segment formulating products containing aldrin/dieldrin, DDT, endrin, or toxaphene in order to assess applicable wastewater treatment technology.

Much of the general industry characterization contained herein has been taken from Ferguson (1975). Information developed during this study has been used to characterize the appropriate segment of the formulation industry.

The formulation industry characterization is discussed in two sections: (a) the overall pesticide formulation industry; and (b) formulation of products containing aldrin/dieldrin, DDT, endrin and toxaphene. Major considerations in each of the two sections are: industry structure; pesticide formulations; and formulation processes.

THE PESTICIDE FORMULATION INDUSTRY

Industry Structure

Historically, the formulation industry has been such a dynamic one that detailed characterization of its organization and operation is difficult. The question, "Who formulates a given active ingredient, and in what quantity?," will have a different answer almost every year. According to Shiroishi (1975), there are currently about 5,300 plants producing pesticide formulations. The companies owning these facilities range in size from those who have one registered product to those who have hundreds.

Ownership Patterns - Formulation plants can be categorized into three groups: the active ingredient producer-formulator, the independent formulator, and the small packager.

The producer-formulator is also referred to as an integrated producer. Such a company not only manufactures the pesticidal chemicals, but also formulates them in its own facilities. Frequently, formulating is done on the same plant site as the production of the active ingredient. Such formulation plants (i.e., satellite units of a production facility) have not been included in this study because their wastewater, if any, is treated with the manufacturing wastewater. Producer-formulator plants may also be located

away from the production site of the active ingredient, e.g., close to or within the regions where the company's products are used. These companies may formulate the company's own products exclusively, or may formulate other products on accustom basis.

The independent formulator typically produces a number of different products for sale under his own brand name and may also formulate products under a contractual arrangement. A number of the large pesticide manufacturers do not formulate any of their own products and are, therefore, prime customers for the independent formulator. Under contractual agreement, the pesticide manufacturer furnishes the technology, active ingredient, and operational assistance to the formulator. The products are then sold under the basic manufacturer's labels. It is not uncommon for an independent formulator to have this type of contract with more than one basic manufacturer at the same time.

Most independent formulators also have pesticide formulations that they produce for sale under their own labels. Products marketed under the formulator's own label can account for a small part of his production or it can account for all of it.

In addition to contract formulation for basic active ingredient manufacturers, the independent formulator frequently has contracts with independent companies to formulate under their private labels.

The last major category of formulator is the small independent packager for whom pesticide formulations are only a small part of his business. According to Ferguson (1975), these companies typically have one to five registrations in their own name. Many of these small packagers actually formulate their labeled products in their own facility. A more practical arrangement for many, however, is to contract with one of the local independent formulators to do the actual formulating.

Geographical Distribution - The locations of large pesticide formulation plants identified during a study by Ferguson (1975) are shown in Figure 1. These plants were identified in 1973 from information provided through the National Agricultural Chemicals Association (NACA) as well as from two earlier studies of the formulation industry and do not include those formulation plants that are integral parts of pesticide manufacturing facilities.

Individual Formulation Plant Characteristics - Individual formulation plants are designed to meet the specific needs of the company and location. A wide range exists in the type of products formulated, the rates of production and the age of the facilities in which they are manufactured.

The types of pesticides produced can be classified in two ways: by the chemical class of pesticide processed, or by the form of the product. Both measures are important when considering wastewater characteristics and volumes.

A recent study (Lawless, Ferguson, and Meiners, 1975) categorized 550 pesticidal chemicals into seven major categories, which were further divided into 42 subcategories. For the purpose of characterizing formulation plants, however, pesticidal chemicals can be classed as: inorganics, organophosphates, nitrogen-based, chlorinated hydrocarbons, and all others. Figure 2a illustrates the distribution of product mixtures found for 96 large formulation plants.

Pesticide formulations can also be classified as liquids, granules, dusts and powders, and all other forms. Figure 2b

shows the distribution of 92 major formulation plants according to this classification.

The scale on which pesticides are formulated varies greatly among companies. Many of the small firms that have only one or two product registrations produce only a few hundred pounds of formulated pesticides each year. In contrast, at least one plant has been identified by Ferguson (1975) that made about 100 million pounds of formulated product per year. The bulk of pesticide formulations is apparently produced by independent formulators operating in the 20 to 40 million pounds per year range.

The ages of formulation plants identified during the study by Ferguson (1975) ranged from 1 to 53 years. Distribution according to age for 102 large formulation plants is shown in Figure 3.

DESIGNATED PESTICIDE FORMULATIONS

Pesticide Formulations

Pesticidal chemicals are normally manufactured in high concentration (80 to 99+%) that cannot be used without being further processed into other forms. The usable forms (formulations) of pesticides must be biologically effective as well as safe for the applicator to handle and use. These characteristics are obtained by dilution of the technical active ingredient with inert materials and conversion to appropriate physical forms designed for a particular method of application and end use.

The number and types of pesticidal products sold, as well as the major types of formulations, are briefly discussed in the following.

Number of Products - The number of pesticide formulations produced and sold in the United States is difficult to determine accurately. Estimates have been made by Mrak (1969) that as many as 900 pesticidal chemicals are formulated into over 60,000 products. A more recent survey by Lawless, et al. (1975) identified 550 pesticidal chemicals that are currently or have recently been commercially available in the United States.

Accurate data are available on the number of pesticidal products having Federal registration for interstate sale. In 1975 there were 23,633 products being produced under Federal registration (Carlton, 1975).

Emulsifiable Concentrates - Emulsifiable concentrate (EC) formulations are solutions of active ingredients and emulsifiers in a solvent. These formulations are diluted with water or oil before application. Concentrations are typically 15 to 50 percent for a single active ingredient, to as high as 80 percent for formulations containing an active ingredient mixture. The concentration of emulsifiers is generally 5 percent or less.

Organic solvents which are used include deodorized kerosene, xylenes, methyl isobutyl ketone, and amyl acetate. The specific solvent selected for use depends on many factors including solvency, specific gravity, flash point, safety to plants and animals, volatility, compatibility, odor, corrosiveness, and cost (Hersey, 1966).

Water is used as the solvent for some of the water-soluble pesticides. The use of water is limited, however, and normally

only certain herbicides are formulated with a water base. No water is used as a solvent for any formulation of aldrin/dieldrin, DDT, endrin, or toxaphene.

Powders - Wettable or water-dispersible powders are mixtures of active ingredients, inert carriers, surfactants, and adjuvants that can be suspended in water for application. These powders generally contain a high concentration of active ingredient (15 to 95%), with 1 to 5 percent concentration of surfactant to improve wetting and suspendability characteristics.

Soluble powders are similar to wettable powders except that they will completely dissolve in the appropriate diluent used in spraying. Normally, this diluent is water.

Dusts - The active ingredient concentration in dust formulations is usually low (0.1 to 20%), and therefore, the toxicity of these formulations is relatively low.

Dusts have long been used becaused they are relatively inexpensive and simple to apply. Winchester and Yeo (1968) report that in the past few years, however, dust has become a less important formulation because of its inherent dependence

on climatological factors that cause variability in performance, as well as problems with drift.

Granules - Granules are prepared by the impregnation of active ingredient on inert granular carriers such as clay, vermiculite, bentonite, sand, ground corncobs, carbon or diatomaceous earth. The granules are uniform in size, ranging from 15 to 60 mesh (15 to 30, 24 to 48, or 30 to 60 mesh) in diameter. The content of fine particles is tightly controlled in order to avoid creation of dust during application.

Aerosols - Aerosol formulations normally contain low concentrations (less than 2%) of active ingredient in a suitable solvent solution with the necessary adjuvants. Solvents commonly used are organics such as deodorized kerosene.

Miscellaneous Formulations - In addition to these major pesticide formulations, a wide range of smaller volume products are manufactured. These other forms include baits (strips, grain, cubes, etc.), pastes, vapor and smoke generators, impregnated fertilizer, tablets, and treated seed.

Formulation Processes

Most pesticides are formulated in mixing equipment that is used only to produce pesticide formulations. Generally, the same formulation equipment is used to produce products containing a number of different active ingredients. The most important unit operations involved are dry mixing and grinding of solids, dissolving solids, and blending. Formulation systems are virtually all batch mixing operations. Formulation units (lines) are usually completely or partially enclosed within a building, but may be out in the open, depending somewhat on the geographical location of the plant.

Individual formulation units are normally not highly sophisticated systems that require design and construction by an outside engineering firm. Rather, they are comparatively uncomplicated batch-blending systems.

Liquid Formulation Units - A typical liquid unit is depicted in Figure 4. Technical pesticide is usually stored in its original shipping container in the warehouse section of the plant until it is needed. When technical material is received in bulk, however, it is transferred to holding tanks for storage. The technical material is transferred (frequently by gravity) to a scale, where the proper quantity is weighed out

for a batch. The technical material is then pumped into a batch mixing tank. This tank is frequently an open-top vessel with a standard agitator. The mix tank may or may not be equipped with a heating/cooling system. When solid technical material is to be used, a melt tank is required before this material is added to the mix tank. Solvents are normally stored in bulk tanks located well away from the operating area of the plant. The necessary quantity of an appropriate solvent is either metered into the mix tank or determined by measuring the tank level. Necessary adjuvants (emulsitiers, synergists, etc.) are added directly from their original container to the mix tank through the open top or manhole. The components of the formulation are blended in the mix tank using its agitator and heating/cooling system as required. From the mix tank, the formulated material is frequently pumped to a hold tank before being put into containers for shipment. Before being packaged many liquid formulations must be filtered by conventional cartridge or plate-and-frame filters.

Air pollution control equipment used on liquid formulation units typically involves an exhaust system at all potential sources of emission. Storage and holding tanks, mix tanks, and container-filling lines are normally provided with an exhaust

connection or hood to remove any vapors. The exhaust from the system normally discharges to a scrubber system or to the atmosphere.

Dusts and Wettable Powders - Dusts and powders are manufactured by mixing the technical material with the appropriate inert carrier, and grinding this mixture to obtain the correct particle size. Mixing can be effected by a number of rotary or ribbon blender type mixers. Grinding is done in hammer, impact, roller or fluid energy (air) mills. As is the case with liquid formulation units, the exact configuration of a specific dust or powder unit depends on the production characteristics of the individual plant site.

Sulfur powder, for example, can be prepared in a rather simple unit (see Figure 5). Crude sulfur is transported from storage in open pits or in a warehouse, and loaded into a feeding hopper which feeds a roller mill. The material is then finely ground. The combustible nature of sulfur in air requires that the mill system be blanketed with an inert gas. The milled sulfur then goes to a cyclone collector from which the finished product is discharged into holding bins before being packaged.

Some production methods involve the use of a volatile solvent to impregnate the active ingredient on an inert carrier. After impregnation, the active ingredient-carrier mixture is ground, separated in a cyclone, and packaged.

One formulation process that has been used for DDT is a good example of more extensive processing required to produce some products: a two-stage process is used (see Figure 6). The first part of the process is the initial grinding of the active ingredient (Figure 6) with silica. Flakes of technical material are emptied from bags into a hopper, conveyed into a crusher and mixed with finely ground silica before being pulverized. The coarse silica-active ingredient mixture is then mixed in a ribbon blender. This DDT formulation requires aging at this point before further grinding. The mixture is then fed into a ribbon blender where additional silica as well as wetting agents are added. This mix is conveyed to a high-grinding mill. A pneumatic system conveys the material to a cyclone separator which discharges into another blender. The blended material is finely ground by a high-pressure air mill and conveyed to a reverse-jet baghouse that discharges into another blender. Final air grinding is repeated before the finished product is packaged.

Air pollution control in dust formulation units is accomplished primarily by baghouse systems. In some plants, however, water scrubbers are used. Pazar (1970) reports that water requirements for these systems are very low because the scrubbing water can be largely recirculated.

Granules - Granules are formulated in systems similar to the mixing sections of dust plants. The active ingredient is adsorbed onto a sized, granular carrier such as clay or a botanical material. This is accomplished in mixers of various capacity that generally resemble cement mixers.

If the technical material is a liquid, it can be sprayed directly onto the granules. Solid technical material is usually melted or disolved in a solvent in order to provide adequate dispersion on the granules. The last step in the formulation process, prior to intermediate storage before packaging, is screening to remove fines.

Packaging and Storage - The last operation conducted at the formulation plant is packaging the finished pesticide into a marketed container. This is usually done in conventional filling and packaging units. Frequently, the same liquid

filling line is used to fill products from several formulation units; the filling and packaging line is simply moved from one formulation unit to another. Packages of almost every size and type are used, including 1-, 2-, and 5-gal. cans, 30- and 55-gal. drums, glass bottles, bags, cartons, and plastic jugs.

On-site storage, as a general rule, is minimized. The storage facility is very often a building completely separate from the actual formulation and filling operation. In almost all cases, the storage area is at least located in a part of the building separate from the formulation units in order to avoid cross contamination and other problems. Technical material, except for bulk shipments, is usually stored in a special section of the product storage area.

A few formulators are able to ship formulated products in bulk containers to users in their immediate area. This technique, however, is limited to a few agricultural formulations.

Formulation Processes

The formulation processes used in the general pesticide formulation industry as described in the preceding discussion

are applicable to aldrin/dieldrin, DDT, endrin, and toxaphene formulations. Formulation plants produce a number of registered products. A given formulation line is rarely dedicated, that is, used for one product only. In fact, the same line is often used to process all products formulated in a small plant. Even in large plants, multiple products are often formulated in the same equipment. Thus, the formulation processes and equipment in general use by the pesticide formulation industry are applicable to the production of products containing aldrin/dieldrin, DDT, endrin, and toxaphene.

Formulation Wastewater

Ferguson (1975) did not report data on the quantity or quality of wastewater generated by aldrin/dieldrin, DDT, endrin or toxaphene formulation. Contacts with appropriate Federal and State regulatory agencies failed to yield any specific data on the quality or quantity of wastewater generated by the formulation plant identified by David (1975) and mentioned above.

Industry Structure

In 1975, as previously noted, 9 plants formulated products containing aldrin/dieldrin, one plant formulated DDT-containing products, 39 plants formulated endrin-containing products and 133 plants formulated toxaphene-containing products. The geographical distribution of the plants is shown in Figures 7a thru 7d which also indicate the relative amounts of these products made at the plant shown. (The Shell Chemical Company facilities at Denver, Colorado; the Montrose Chemical Corporation of California facility at Torrence, California; and the Velsicol Chemical Corporation facilities at Memphis, Tennessee, are not included because these plants manufactured, as well as formulated, aldrin/dieldrin, DDT and endrin, respectively.

Figures 7a thru 7d are, however, a static representation of a dynamic industry. Production rates, products formulated, and the formulation plants have apparently changed annually in recent years. Farm Chemicals Handbook, for example, shows the dynamic nature of the industry: the 1973 edition lists 19 formulators of aldrin/dieldrin products, 16 of DDT products, 11 of endrin products and 20 of toxaphene products; the 1975 edition, however, lists 13 formulators of aldrin/dieldrin, 1 of DDT, 3 of endrin and 13 of toxaphene-containing products. To depict the current status of an industry as dynamic as this one is thus virtually impossible, but Figures 7a thru 7d present the best information available at this time. Precise information on the age of these plants, their size, and their total production is not available.

TYPES OF FORMULATIONS

Aldrin/Dieldrin

The Farm Chemicals Handbook (1973) shows that aldrin/dieldrin products were available in seven types of formulations: emulsifiable concentrates, wettable powders, granules, dusts, seed dressings, oil solutions, and fertilizer mixtures. The data supplied by David (1975) indicated that the

relative amounts (by weight) of aldrin/dieldrin products, by type of formulation in 1973 were as follows:

Type of formulation	Percent of total formulated products
Emulsifiable concentrate	35-40
Wettable powder	10
Granule	35-40
Dust	10
Seed dressing	10
Oil solution	10
Fertilizer mixture	10
TOTAL	100%

David (1975) further reported that formulators produced 37 registered products containing aldrin or dieldrin in 1973.

DDT

The Farm Chemicals Handbook (1973) shows the DDT products were available in six types of formulations: emulsifiable concentrates, wettable powders, granules, dusts, oil solutions, and aerosols. The data supplied by David (1975) indicated that the relative amounts (by weight) of DDT products, by type of formulation in 1973 were as follows:

Type of formulation	Percent of total formulated products
Emulsifiable concentrate	5
Wettable powder	90+
Granule	5
Dust	5
Oil solution	5
Aerosol	5
TOTAL	100%

David (1975) further reported that formulators produced five registered products containing DDT in 1973.

Endrin

The Farm Chemicals Handbook (1973) and Handbook of Aldrin, Dieldrin, and Endrin Formulations (1959) show that endrin products were available in three types of formulations: emulsifiable concentrates, wettable powders, and granules. The data supplied by David (1975) indicated that the relative amounts (by weight) of endrin products, by type of formulation in 1973 were as follows:

Type of formulation	Percent of total formulated products
Emulsifiable concentrate	90%
Wettable powder	5
Granule	5
TOTAL	100%

David (1975) further reported that formulators produced 27 registered products containing endrin in 1973.

Toxaphene

The Farm Chemicals Handbook (1973) shows that toxaphene products were available in four types of formulations: emulsifiable concentrates, wettable powders, dusts, and oil solutions. The data supplied by David (1975) indicated that the relative amounts (by weight) of toxaphene products, by type of formulation in 1973 were as follows:

Type of formulation	Percent of total formulated products
Emulsifiable concentrate	90
Wettable powder	90
Dust	10
Oil solution	10
TOTAL	100%

David (1975) further reported that formulators produced 161 registere products containing toxaphene in 1973.

SECTION III

WASTEWATER CHARACTERIZATION

The quantity and quality of wastewater generated by a pesticide formulation plant are determined by factors such as the type of formulations produced, the active ingredients used, the age and size of the facility, the plant's production schedule, and the company's operating philosophies and procedures. The ranges over which these factors can vary have been previously discussed. In this section, the effects these factors have on wastewater generation and the characteristics of the wastewater produced are reviewed. The discussion in the following subsections addresses water use, wastewater sources, and wastewater characteristics.

WATER USE

Water has been used for a number of purposes in pesticide formulation plants. The trend is to use less water to avoid water pollution problems and to control loss of active

ingredients. The goal is to eliminate the discharge of water that might become contaminated in formulating processes.

Formulation Equipment Cleanup

Formulation lines, including filling equipment, are cleaned out periodically to prevent cross contamination of one product with another. Infrequently, equipment must also be cleaned out so that needed maintenance may be performed. Water or steam has been commonly used for these cleaning operations, but solvents are also used as a substitute for water.

Liquid formulation lines are cleaned out most frequently. All parts of the system that potentially contain pesticidal ingredients must be cleaned. More than one rinsing of process vessels and piping is required to get the system clean. As a general rule, the smaller the capacity of the formulation unit, the more critical cleanup becomes in order to avoid cross contamination. Thus, larger volumes of wash water and solvents are required, relative to production quantity, for smaller units.

Granule as well as dust and powder lines also require cleanup. Liquid washouts are generally required; however, only in that portion of the units where liquids are normally present, that is, the active ingredient pumping system, scales, and lines. The remainder of these production units can normally be cleaned out by "dry washing" with an inert material, such as clay.

Drum Washing A few formulation plants still process used pesticide drums so that the drums can be sold to a drum reconditioner or reused by the formulator for appropriate products, or simply to decontaminate the drums before disposal. Drum washing procedures have ranged from a single rinse with a small volume of caustic solution or water, to complete decontamination and reconditioning processes. Awareness of the water pollution control problems caused by use of drums has led to use of less costly, disposable, smaller containers as well as direct transfer from tanks (truck and railroad) to on-site storage in bulk.

Building Washdown

For housekeeping purposes, most formulators clean out the buildings housing formulation units on a routine basis, frequently once each year. This could be accomplished by careful dry vacuum cleaning and in proper circumstances, solvents instead of water.

Air Pollution Devices

Water scrubbers are often used to control emissions to the air, but particulates can be removed by other means such as bag houses.

Spills

Spills of technical material or process material are normally absorbed by dry clean materials, but are sometimes cleaned up by washing down the contaminated area. The latter practice is being phased out as management and labor become aware of its limitations.

Boiler Water

Steam is frequently used for (a) space heating, (b) formulation processing, and (c) formulation equipment cleaning. In some cases steam is used to accelerate the evaporation of stored wastewater.

Cooling Water

Cooling water is used by several processes found in pesticide formulation plants. One of the most common uses is to cool air compressors used in conjunction with air mills that produce wettable powders. Cooling water is also required by many of the roller mills used for dust production.

Control Laboratories

Most of the larger formulation plants have some type of control lab on the plant site. The control analyses performed range from simple determinations of specific gravity to complete spectrophotometric analyses. Water use in the control laboratories can range from an insignificantly small amount to a rather large amount, depending upon many circumstances.

Sanitary Wastes

Sanitary wastes are generated at virtually all formulation plants. This category may include not only toilet and sink wastes, but also the wastewater generated from shower facilities and wash water from work clothes processed on the plant site.

Formula Water

Some liquid formulations contain water as their base. Primarily, herbicides are formulated in this manner. The formula water used in these formulations accounts for a major part of the water consumed by many formulation plants. However, aldrin, dieldrin, endrin, DDT and toxaphene are not marketed as water-based formulations.

WASTEWATER SOURCES

The sources of wastewater produced by a formulation plant include not only the plant's use of water, but also the natural occurrence of rain water runoff. Both can be significant sources of contamination that must then be disposed of without

causing water pollution. Each of the water uses given above and runoff are examined below to show the pollution potential of each wastewater source.

Formulation Equipment Cleanup

The major source of contaminated wastewater from pesticide formulation plants has been equipment cleanup. Solvents instead of water can be used to clean mixing tanks, formulation lines, filling equipment, etc.

Drum Washing

Wastewaters from drum washing operations are contaminated and must be added to other processing wastewater for treatment. The volume of water for this operation is not usually large, but the water is usually highly contaminated with pesticide. Highly caustic solutions have been used for some washing operations, and this factor must be considered in disposing of the wastewaters. As stated earlier, reuse of drums or other containers requiring cleaning is disappearing.

Building Washdown

New, higher standards of cleanliness and general good housekeeping are being accepted in plants thereby reducing the need to wash down formulation unit space following thorough sweeping and vacuuming.

Air Pollution Control Devices

Water scrubbing devices generate a wastewater stream that is potentially contaminated with pesticidal materials. One type of widely used air scrubber is the roto-clone separator. In this device, air is cleaned by the combined action of centrifugal force and mixing. Although the quantity of water in the system is relatively high (about 20 gal/1,000 cfm), Pazar (1970) reported that water consumption can be kept low by a recycle-sludge removal system. Effluent from air pollution control equipment should be combined with other contaminated wastewater for ultimate disposal.

Spills

If the spill area is dry cleaned instead of washed down, an increment to plant wastewaters is eliminated.

Boiler Water

Blowdown water from the boiler system, as well as steam condensate that is not recycled, is generally free of toxicant contamination. These streams, if kept isolated, can be disposed of with other noncontaminated streams.

Condensate from steam cleaning equipment is not returned to the heating cycle, since it is contaminated and must be managed properly to preclude water pollution. Solvent cleaning is one substitute for steam cleaning.

Cooling Water

Effluent from the cooling water loop is generally free from significant contamination, and if kept isolated, can be discharged from the plant site in the sanitary waste or conventional drainage system.

Control Laboratories

Wastewater from the control laboratories can be discharged into the sanitation system provided the noncontaminated wastewater (sanitary facilities, water fountains, etc.) is segregated from the contaminated wastewater (laboratory sinks, floor drains, etc.). The contaminated wastewater must be managed to avoid discharge to water courses.

Sanitary Wastes

Normally, this waste stream is treated as conventional sanitary waste and discharged into municipal sewage treatment or septic tank systems. It is usually uncontaminated.

Runoff

Natural runoff from the plant sites can be significant. In some plants, formulation units, filling lines, and storage areas are located in the open. The runoff from these potentially contaminated areas, as a rule, cannot be assumed to be free of pollutants and should not be allowed to flow freely from the plant site. Runoff from areas previously contaminated

can contain high levels of pesticide even when the particular product is no longer being formulated.

Runoff presents a problem even if it is intercepted and diverted into a holding-evaporation or treatment facility since it can readily overburden the system because of hydraulic loading.

Areas demonstrated to be free of contamination can be allowed to drain naturally from the plant site.

WASTEWATER CHARACTERISTICS

This section of the report summarizes available information on the wastewater characteristics of pesticide formulation plants.

General Characteristics

Data on the volume and quality of process wastewater from pesticide formulation plants are virtually nonexistent. Only two literature sources were found in this study that specifically address the subject of wastewater characteristics

of pesticide formulation plants. Ferguson (1975) performed a study on formulators and packagers for the Environmental Protection Agency.

Ferguson (1975) examined 10 formulation plants and found that these plants generated from less than 1 to more than 25 gal. of wastewater per ton of formulated product. Volumes of wastewater near the top of this range were generated by plants that isolated the runoff as well as those who did not. Details of the methods used to conserve water are lacking.

Formulation Process Wastewater

Ferguson (1975) did not report data on the quantity or quality of wastewater generated by aldrin/dieldrin, DDT, endrin or toxaphene formulation. Contacts with appropriate Federal State Regulatory agencies failed to yield any specific data on the quality or quantity of wastewater generated by formulation plants.

Rain Water Runoff

The volume of runoff that might need to be intercepted, held and disposed of is influenced by several natural factors. These include:

(a) Areas subject to runoff

(b) Balance between long-term rainfall versus evaporation rates

(c) Extraordinary, heavy precipitation events

(d) Surface imperviousness of runoff area

The degree of contamination of runoff by pesticides is largely a factor of surfaces that have been contaminated and the extent of that contamination.

Some idea of the large volume of rain water runoff involved can be gained by examination of the table below. For each inch of stormwater falling on each acre (net rainfall plus a design storm event occurrence of precipitation during a 24-hour period

once every 10 years) 75 gallons of water would accumulate and need to be disposed of on an everage day.

$$\frac{\frac{43{,}560}{\text{acre}} \text{ sq. ft.} \times \frac{1}{12} \text{ ft.} \times 7.5 \text{ gal/cu ft}}{365 \text{ days/yr}} = 75 \text{ gal/day/acre/inch}$$

	Precip. Inches	Evap. Inches	Design Storm Inches	Total Inches
Riverside, TX	52	-52	8.5	8.5
Denver, CO	16	-34	1.5	19.5
Los Angeles, CA	16	-46	8.0	38.0
Vicksburg, MS	55	-44	7.0	18.0
Jacksonville, FL	50	-45	7.5	12.5

SECTION IV

WASTEWATER MANAGEMENT METHODS

The methods of treating the wastewater produced by pesticide formulation plants are examined in this section. The discussion is divided into the following sections: In-Plant Control Technology; Current Wastewater Treatment Practices; Potential Wastewater Treatment Methods; and Comparison of Treatment Methods.

IN-PLANT CONTROL TECHNOLOGY

Good operational techniques and careful consideration of equipment design and use dramatically affect the quantity and quality of wastewater generated in a pesticide formulation plant. The need for wastewater treatment systems can be very substantially reduced and in most cases eliminated if excellent in-plant controls are established to accomplish these two goals: (a) reduce the quantity of contaminated wastewater to absolute minimums; and (b) reduce the raw waste loading of the wastewater requiring disposal. In most cases, the degree to

which good control techniques are applied is a more significant factor in determining the wastewater volume and raw waste loading than is the scale of production.

A number of techniques can help minimize wastewater treatment requirements, if they are made a part of the routine operation of a formulation plant. These techniques involve water conservation and contaminant minimization and the more important are noted below.

Water Conservation

Minimization of the water usage and wastewater effluent in a formulation plant reduces the contaminated effluent discharge and necessary treatment and disposal requirements. Some of the more common methods of reducing water usage and water effluent are:

- Eliminate all direct contact condensers (as in a vacuum jet system where water is sprayed into the jet outlet) and replace them with surface condensers.

- Replace water cooled heat exchangers with air heat exchangers.

- Eliminate stripping operations that use sparged steam as the heat source and use an indirect heat source such as a boiler.

- Use organic solvents for cleaning equipment, instead of water. The solvent can be stored in drums and added to the next production batch as part of the material input.

- Schedule production runs to minimize the number of equipment cleanups required. Technique is limited, however, because of the frequency with which formulation plant production schedules are revised.

- Dry clean solid product formulation units by processing an appropriate inert carrier through the system to reduce the need for wash water. The inert carrier can be retained for use in the next similar batch, or can be disposed of with other potentially toxic solid wastes.

- Consolidate formulation by producing all of a given product at one or two plant locations, thereby simplifying overall operations and reducing the number of cleanouts required (this applies to a company having several formulation plants). The economic disadvantage of increased transportation costs may be balanced by reduced disposal requirements.

- Dedicate certain formulation lines, where possible, to specific formulations or active ingredients, to reduce cleanout requirements.

- Install sumps to collect and contain contaminated wastewater. When used in conjunction with curbing around formulation units, sumps minimize area cleanup and wash water requirements as well as contain the wash water.

In general, every measure should be used to keep water out of all operations. When water is used for cleanup or washdown of the equipment and facilities, the use of specified volumes of water, rinsing out rather than filling and flushing, and use of timers on water lines should be employed to minimize the volume of water required.

Contaminant Minimization

A most obvious consideration is to keep the toxic material confined within the process equipment. Some of the most common methods of reducing the amount of active ingredient that is discharged in the wastewater effluent are:

- Segregate the "clean" streams, such as cooling water, boiled water, and sanitary wastes, from those streams which are contaminated. These streams should be kept isolated from contaminated areas and should not come into contact

with the active ingredient so that they can be discharged directly from the plant site without treatment.

. Prevent spills and leaks of active ingredient. Spills and leaks can be minimized by overdesigning process equipment to allow for higher safety valve discharge pressure; carefully choosing and installing pump seals and gaskets; installing curbs and drainage systems around all process equipment; providing emergency dumping capacity if the need to empty the process equipment arises; keeping storage and handling of formulated products to a minimum; and installing no process lines less than 1-1/2 in. to prevent leakage from lines damaged by maintenance or operating people stepping or standing on them.

. Reduce equipment cleanout to a minimum by the same methods previously described.

. Prevent escape of dusts in solid product formulation plants by using vacuum conveying systems, by keeping solids handling equipment inside an enclosure that operates under several inches of water vacuum; and by delaying complete drying of the solids until immediately before packaging.

Dusts which escape the process equipment and fall to the ground at the plant site are then potential contaminants of wash water and runoff.

- Collect wash water used to clean drums and formulation equipment, and when prossible, recycle it back into the process as a material input, if feasible.

- Maintain constant vigilance on the process to detect any leaks that may occur and correct them immediately.

- Inform all employees of the constant need for good housekeeping practices to minimize losses of active ingredient into the surrounding environment.

In summary, the preceding techniques must be used to minimize the wastewater effluent of a formulation plant, and at the same time, minimize the amount of active ingredient. Constant attention to achieving these two goals will greatly reduce or eliminate the pollution potential and wastewater treatment and disposal requirements for pesticide formulation plants.

CURRENT WASTEWATER MANAGEMENT PRACTICES

Wastewater treatment techniques being used in formulation plants have been reviewed by Ferguson (1975). These techniques can be grouped into several general categories: evaporation, sewer system, landfill, contract disposal, activated carbon adsorption, incineration, and miscellaneous pretreatment processes. The following discussions of these techniques are arranged according to their decreasing frequency of use by large formulation plants, as reported by Ferguson (1975).

Evaporation

Evaporation is the wastewater treatment technique most frequently employed. Evaporative systems range from those that just concentrate wastes by partial wastewater evaporation, to processes that evaporate all wastewater produced.

Evaporative systems can be used in most parts of the country (see Figure 8), depending primarily on the characteristics of the individual plant's operation. Systems range in size from 2,000 to over 1 million gallons of wastewater evaporation per year.

Designs of the systems vary with the plant. General considerations in all designs, however, revolve around the need to maintain an adequate evaporation rate.

A pretreatment step is sometimes required to break emulsions. This is usually done by batch-wise addition of a demulsifying agent followed by gravity separation of the organic layer. This layer is usually disposed of by incineration.

After pretreatment, the wastewater is pumped into an evaporation pond where it is allowed to evaporate. These range from shallow, concete pads to large (1 acre or more) man-made earthen ponds. When earthern ponds are used, they should be sealed with bentonite, plastic, or other lining materials to prevent percolation into the soil.

The natural rate of evaporation is normally not adequate to accommodate all process wastewater in a pond of reasonable size. In addition, few parts of the country have net annual evaporation of rain water. For these reasons, almost all wastewater evaporation systems employ additional techniques to obtain adequate evaporation.

Roofs - Many of the small evaporation ponds (up to 50 ft x 50 ft) use roofs to keep out rain water. Permanent roofs, even those made of "transparent" plastic materials, however, reduce the rate of natural evaporation.

Awning-type coverings, that can be moved when not needed, overcome this deficiency, but obviously add to installation and operation costs.

Aeration Systems - To aid natural evaporation, aeration systems are frequently used. These are normally simple, low cost pumping systems used to spray the wastewater into the air. A number of variations are possible, including the use of burlap strips, waterfalls, etc., to increase the effective evaporative area. Aeration has the added advantage or oxygenating the water and thereby accelerating the decomposition of many pesticide chemicals.

Supplemental Heat - Supplemental heating also is used to aid the evaporation rate. Most frequently, this is done by the addition of conventional electrical or gas powered immersion heat exchangers to the evaporation pond. Supplemental heat is normally required for only a few months each production season.

One of the major limitations of this system is the uncertainty of air pollution problems that may be created. Transfer of a water pollution problem to an air pollution problem cannot be tolerated. Some areas have established legal air emission limits for the pesticides of interest.

Sewer Systems

Many smaller and a few large formulation plants discharge into local municipal or industrial sewer systems. Pretreatment techniques used by the formulation plant in conjunction with these systems are presently minimal. pH of the effluent is normally adjusted to neutrality. Effluents from a few plants are filtered before discharge. Limitations have been established by some local authorities on the concentration as well as the daily quantity of toxicants that can be discharged. Some municipal sewer systems, however, have not established criteria on the toxicant (pesticide) content of wastewater that can be discharged to their treatment systems.

Landfills

Small formulation plants as well as larger plants producing small volumes of wastewater (less than 10,000 gal/year) are frequently able to dispose of their wastewater in landfills. The landfill facilities in use include cut-and-fill operations located on the plant site as well as a wide range of municipally and industrially operated sites.

The actual disposal procedures used at the landfill also are quite varied. Most frequently, the small volume of wastewater is sealed in used 55-gal. drums. The wastewater drums are then treated like any other item of solid waste.

Sites in which formulation wastewaters are disposed of normally have not established criteria on the quality of wastewater allowed and do not maintain records of the quantity or location of wastewater in the fill.

Almost all of the landfill sites apparently operate under some type of permit, either local or State. Very few, if any, of these sites, however, qualify as "specially designed landfill" operations that have been defined by the

Environmental Protection Agency (1974) for use in pesticide waste disposal.

Contract Disposal

The next most frequently practiced method for disposing of process wastewater is the use of a contract disposal service. The availability of this service in the immediate area, as well as the cost involved, are major factors in its selection. The user of such services must be aware that the wastewater is processed by the contractor in accordance with State and local requirements and be prepared to take alternative measures promptly in the event the service system fails.

Activated Carbon Adsorption

The effectiveness of activated carbon in removing low concentrations of many pesticides in water has been well documented by Edwards (1970), Robeck, *et al.* (1965), and Goodrich and Monke (1970). A limited number of formulation plants have attempted to apply activated carbon adsorption technology to treatment of their effluent streams according to Ferguson (1975).

Most of the plants using carbon, however, apparently are doing so only on an experimental basis. None of the formulation plants identified during the study by Ferguson (1975) are considered by the operating firms to be in full-scale operation; rather, they are in various stages of development.

Incineration

Incineration in appropriate facilities is the method which was prescribed by the Environmental Protection Agency (1974) for disposal of all pesticides except for organometallics and inorganic compounds. Adequate facilities, however, are generally not available to the independent and contract pesticide formulators. In fact, the only formulation plants identified by Ferguson (1975) as using incineration to dispose of their process wastewaters were those in chemical manufacturing complexes. Incinerators used by contract waste disposal services are subject to approval by State and local regulation.

Miscellaneous Pretreatment Processes

According to Ferguson (1975), a small number of plants are using an assortment of miscellaneous unit operations to treat their formulation wastewater. None of these, however, can be considered a complete treatment process; rather, they are pretreatment processes used to treat wastewater before it is disposed of. Only four of these are practiced to any significant degree by the pesticide formulation industry.

Neutralization - Many plants treat their wastewater with caustic before it is discharged. This has been done primarily to produce a neutral effluent, or because it is thought that this will help detoxify the pesticidal chemicals. The frequently used generalization that alkaline conditions reduce the toxicity of pesticidal chemicals by hydrolysis, however, is not universally true according to Lawless, Ferguson, and Meiners (1975). The formulator should determine the desirability of high alkalinity based on the active ingredients being formulated before adopting this practice.

Chemical Precipitation - Many inorganics can be removed from wastewater by precipitation. Lawless, von Rumker, and Ferguson

(1972) reported that one plant that formulates primarily mercurial pesticides, for example, uses sodium hydrozide to precipitate the mercury, which is then filtered and recovered for reprocessing. Use of chemical precipitation processes, however, is not commonly practiced.

Solids Separation - Some plants filter their wastewater before discharge. When used in conjunction with precipitation or flocculation, this process apparently can effect some reduction of pesticide content of the wastewater.

Equalization - Equalization, i.e., elimination of wide variations in wastewater quantity and quality before discharge, is practiced by some plants. As this is essentially a retention and dilution system, it does not effect a significant reduction in the total quantity of toxic pollutants that is eventually disposed of. It can, however, prevent short slugs of highly toxic wastes.

POTENTIAL WASTEWATER MANAGEMENT METHODS

Zero Discharge of Pollutants

The complete elimination of contaminated process wastewater resulting from formulation of pesticide products can be

effected by combinations of the following techniques as appropriate to the specific formulation plant.

Elimination of Process Uses of Water - The elimination of practically all, if not all, uses of water in the formulation plants that generate pesticide-containing wastewaters can be achieved by using the in-plant control techniques previously described.

Segregation of Contaminated Wastewater - When generation of contaminated wastewater cannot be completely eliminated, these waters can be isolated from the wastewater produced by all other formulation operations, and can be separately disposed of without discharge to surface waters. Such segregation might effect a proportionate reduction of the amount of contaminated wastewater; i.e., only about 20% of the process wastewater would be contaminated by a pesticide from a formulation plant for which that pesticide constituted only 20% of its production.

Evaporation - Evaporation of process wastewater is the treatment technique most frequently practiced, according to Ferguson (1975). However, natural evaporation is normally not adequate to accommodate all formulation wastewater. Almost all process wastewater evaporation systems studied by Ferguson (1975) employed additional techniques to obtain adequate

evaporation, such as roofs, aeration, etc. These evaporation systems have been previously described in detail.

Contract Disposal Services - Contract disposal, especially for small quantities of wastewater, is a method of achieving "zero" discharge used by many formulators. Ultimate disposal methods used by service contractors include incineration and landfill. The feasibility of the method for use by a specific formulation plant depends on the availability and nature of the service at that location and its cost.

SECTION V

TECHNOLOGY AND ESTIMATED COSTS

This section discusses the current status of technology employed by the formulators of aldrin/dieldrin, DDT, endrin and toxaphene; identifies available technology for eliminating certain discharges by formulators; and presents the estimated cost of employing such technology. To support standards proposed under Section 307, technology and associated costs are largely a matter of carefully avoiding the use of water in operations and preventing losses of pesticide in certain areas subject to stormwater runoff. The technology to effect these measures is relatively uncomplicated and presently in use.

The standards will be applicable to registered formulators of aldrin/dieldrin, DDT, endrin and toxaphene, both existing and new sources. The registered formulators of the four pesticides who were active in 1975 are listed below:

	Actually Formulated in 1975
Aldrin	3
Dieldrin	6
DDT	1
Endrin	39
Toxaphene	133
TOTAL	182

These formulators comprise only a small segment of the total pesticide formulation industry, and the major effect will be imposed upon formulators of endrin and toxaphene.

OPTIONS FOR COMPLIANCE

Technology is available and presently in use to avoid discharge of aldrin/dieldrin, DDT, endrin and toxaphene in process water and stormwater runoff. Individual situations at applicable formulation plants will dictate a variety of options.

Process Water:

Technology is available which, by avoiding the use of water in production processes, will eliminate contaminated process waters.

Operating methods are available which can reduce water use and pesticide losses. These include (a) segregation of "clean"

cooling water, boiler water and most sanitary wastes, (b) scheduling production runs to reduce the need to clean equipment between runs or to dedicate equipment to specific formulations, (c) strict management and accountability of water use and disposal, (d) use of solvents for washouts, (e) installation of sumps to collect and dispose of contaminated water and spills and (f) methods for dry cleaning of spills and equipment. In some cases where water use or spill potential has not been eliminated entirely, it will be necessary to segregate, collect and dispose of contaminated process water, equipment and area cleaning wastes, drum washing wastes, safety shower water, air pollution control scrubber water and laboratory sink drainage without discharge to navigable waters.

Disposal-without-discharge options include evaporation of all water, on-site and offsite incineration, landfill and disposal by commercial contractors. Solar and "assisted" evaporation are in use extensively, but are subject to limitations such as (a) climatological conditions, (b) groundwater and air pollution potential, and may be fuel use intensive in some situations. Incineration of large volumes of wastewater is impractical except in some exceptional instances. Contract disposal of pesticide formulation

wastewaters is not generally feasible for runoff but is an option at plants where volume of water is minimal and where transportation costs are not prohibitive. Careful determination should be made that contract disposal is carried out in compliance with Federal, State and local regulations.

Runoff:

Available to the formulator is technology capable of essentially eliminating contamination of stormwater runoff. The alternative to such elimination is to collect, hold and dispose of runoff that is contaminated by the specified pesticides. Among the most obvious runoff preventive measures that can be taken singly or in combination are:

(a) conduct all operations under cover on curbed slabs or within roofed, walled structures,

(b) avoid losses of pesticide dust, mist or vapor to the air,

(c) eliminate the pollution in areas which have been contaminated in the past by such measures as removal and replacement of contaminated soil and paving of contaminated areas, and

(d) divert "clean" runoff around contaminated areas.

The alternative to the prevention concept of compliance is the interception of contaminated stormwater runoff, storage and disposal without discharge of pesticides to the air or

water. The large volume of runoff water is the principal deterrent to general use of the method, particularly in locations where long-term net precipitation far exceeds the rate of evaporation. Also major storm events impose hydraulic conditions which require design of the system to allow for available, dry storage capability to intercept runoff from these storms. In addition, the large volumes of water must be disposed of by spray or other systems that require equipment, operation and significant power and/or fuel.

SELECTION OF OPERATION MODELS FOR COST ESTIMATION

Dismissed from consideration is the treatment and direct disposal of runoff because of the cost of treating large volumes of water to acceptable levels of pesticides.

Incineration is also dismissed because of cost considerations in managing contaminated stormwater runoff without direct discharge. Large volumes are involved in storage, pretreatment and final thermal destruction. Incineration may be useful and practical for disposal of accumulated aqueous spill cleanups and other contaminated wastewater in some instances, especially where this method will be used to dispose of spent solvents, dry spill cleanup, contaminated packages and unrecoverable off-quality product.

Incineration may be the method selected by commercial contract disposal firms for off-site disposal of these wastes.

Costs of two major options for managing stormwater runoff are considered here: (a) holding and evaporation; and (b) roofing/cover.

Holding and Evaporation

The following tabulation shows the estimated cost of a stormwater runoff holding-evaporation system. A study (Appendix A), made on a "worst case" basis, selected a location where net annual rainfall was 11 inches and storage allowance was made for a major storm event of 9 inches. The system would consist of a plastic film-lined, roofed earthen holding pond, and a spray-evaporation system. Costs for various watershed areas are indicated below:

Area	Installed Capital Equipment	Total Annual Operation
1/2 Acre	$60,000	$11,700
1/4 "	39,600	7,720
1/8 "	26,100	5,090
1/16 "	17,200	3,360

Roofing/Cover

The roofing/cover option appears to be a favorable one which can be effected at least cost to formulators. This option also will serve here to estimate cost of compliance based upon model plants devised for that purpose.

The roofing/cover option requires that all formulation activities including receiving, shipping, packaging and warehousing be conducted under cover and within curbed or walled spaces. This option also requires the complete control of the subject pesticides such that all active ingredients and products are eventually packaged for sale or recovered for proper disposal in order to achieve compliance. Ideally the operations would be completely housed and a mass balance of active ingredient input and output achieved consistent with worker safety and spillproof, safe storage of materials.

A model formulation plant as herein conceived would provide for an integrated, single roofed structure equipped with curbed concrete surfaces which would prevent stormwater runoff from loading and unloading areas, storage areas, formulating and packaging areas. Contaminated process water and water used for routine cleanup or cleanup of spills would be reduced to minimum quantities and collected for disposal of the pesticide without aqueous discharge, probably by evaporation.

The costs to control contamination resulting solely from fallout from air emissions will not be applicable to costs for compliance with standards proposed under Section 307. Other sections of PL 92-500 will be applied to gain control over soil and other surfaces that have been contaminated in the past. Any equipment outdoors such as cyclones and baghouses must be protected from runoff by roofing and curbing as necessary which will be applicable to costs included in the model. Also the cost of air pollution controls such as the scrubber systems is included in the model.

ESTIMATE OF MODEL PLANT COMPLIANCE COST IMPACTS

As stated earlier, technology is available and applicable by which discharges of process wastewaters and water for cleanup and cleanup of spills can be eliminated through preventive operational techniques and excellent housekeeping. Such costs will be considered to be applicable in compliance with Section 307 proposed regulations, but can be kept to inconsequential levels.

Costs incurred to control or correct the contamination (via air pollution fallout) of surface areas open to stormwater runoff will not be considered to be applicable to proposed standards under Section 307. Reference is made here only to fallout remaining in air emissions from exhaust and stack

systems after required air pollution controls have removed these pesticides by filters or scrubbers using water. It is expected that elimination of scrubbers using water would be of advantage to formulators in avoiding discharge of contaminated process wastewaters.

Because reliable plant-by-plant data are lacking, cost estimates herein are based upon small, medium and large "model" formulation plants and an approximation of roof areas required to avoid contamination of stormwater runoff. Roof areas are then used to calculate estimated costs in avoiding discharge to navigable waters. Costs developed are ultimately related to the added cost of production for each model.

No industry-wide data exist which indicate how many formulation operations are actually conducted outdoors, or conversely, how many operations are conducted under cover, or any combination of the two. Ferguson reported that formulation units, filling lines and storage areas located outdoors cannot be assumed to be free of pollutants. In a recent survey, Ferguson and Meiners (Appendix B) reported, upon inspection, that all liquid and dust formulation operations at a one million pound (technical ingredient) per year plant were accomplished indoors in a portion of a 40'x60' building.

No industry-wide data exist concerning the number of formulation units operated outdoors and without a concrete or other satisfactory working surface. It seems certain, however, that only a few such situations exist.

The cost estimates developed below do not apply to any one formulator. Three models have been selected as means of broadly visualizing the roof area that might be needed to protect a model plant from contamination of stormwater runoff by the subject pesticides. The selection of small, medium and large models was made by examining the smallest and largest rates of production among registered plants formulating endrin and toxaphene in 1975, and adding a medium level of production between the two extremes. The models visualized basic formulation operations common to liquid formulation and incremental areas were added for dust formulations to account for grinding, pulverizing and for added air pollution control facilities. The principal reckoning factors considered in the visualization are shown in Table 1. A small allowance for the cleanup of "spills" is included to account for accidents which occur despite all precautions taken. In summary, the model roof areas in square feet for the three models are shown below.

	250 gal/yr (A.1.)	85,000 gal/yr (A.1.)	100,000 gal/yr (A.
Liquid:	1175 sq. ft.	2050 sq. ft.	4550 sq. ft.
Dust:	1375 sq. ft.	2600 sq. ft.	5750 sq. ft.

The roof areas for the models were then used to estimate the cost of roof, concrete slab and curbing using 1975 costs. Sample calculations are based upon a steel roof supported by a light steel frame at a total cost of $1.00 per square foot. The costs shown on Table 2 were derived from the second edition of Plant Design and Economics for Chemical Engineers by M.S. Peters and K.D. Timmerhaus, (McGraw-Hill Book Co., N.Y. 1968).

The slab thickness selected is six inches of concrete with a six inch by six inch curbing around the perimeter of the slab. Cost of concrete is the delivered cost quoted at $77.55/cubic yards in late April 1976 in Northern Virginia. Labor cost is considered in these estimates to be equal to the cost of the concrete per cubic yard.

Table 3 shows the total annual operating costs.

REFERENCES

Blecker, H. G., and T. M. Nichols, "Capital and Operating Costs of Pollution Equipment Modules - Vol. II - Data Manual," EPA-R5-73-023b, July 1973.

Carlton, R., EPA, Washington, Telephone Communication will Gary Kelso, MRI, October 26, 1975.

Chemical Engineering, July 7, 1975.

Cohen, J. M., L. J. Kamphake, A. E. Lamke, C. Henderson, and R. L. Woodward, "Effect of Fish Poisons on Water Supplied, Part I, Removal of Toxic Materials," J. Amer. Water Works Assoc., 52:1551, December 1960.

Cornell, Howland, Hayes, and Merryfield, "Process Design Manual for Carbon Adsorption," EPA Technology Transfer, October 1972.

Danielson, J. A. (Editor), Air Pollution Engineering Manual, Publication No. 999-AP-40, U.S. Department of Health, Education and Welfare, Cincinnati, Ohio (1967).

David, D., Personal Communication with Thomas Ferguson, MRI, September 1975.

Edwards, C. A., Persistent Pesticides in the Environment, Chemical Rubber Company, Cleveland, Ohio (1970).

Engineering News Record, May 1, 1975.

Engineering News Record, December 19, 1974.

Environmental Protection Agency, "Pesticides and Pesticide Containers: Regulations for Acceptance and Recommended Procedures for Disposal and and Storage," Federal Register, 39(85:15236-15241, May 1, 1974.

Farm Chemicals Handbook 1975, Mesiter Publishing Company, Willoughby, Ohio (1975).

Ferguson, T. L., "Pollution Control Technology for Pesticide Formulators and Packagers," Final Report under EPA Grant No. R801577 for the National Environmental Research Center, Office of Research and Development, U.S. EPA, January 1975.

Goodrich, P. R., and E. J. Monke, "Insecticide Adsorption on Activated Carbon," Transactions of the American Society of Agricultural Engineers, 13(1):56-57, 60 (1970).

Guthrie, K. M., Process Plant Estimating Evaluation and Control, Craftsman Book Company of America, Solana Beach, California (1974).

Handbook of Aldrin, Dieldrin and Endrin Formulations, Shell Chemical Corporation, New York, New York, June 1959.

Hersey, J., "Choosing a Solvent for Insecticide Formulations," Farm Chemicals, 129(10):42-46, October 1966.

Hutchins, R. A., Development Associate with ICI United States, Inc., Wilmington, Delaware, in Written Communication with

Mr. Charles Mumma, Senior Chemical Engineer with MRI, October 24, 1975.

Jelen, F. C., Cost and Optimization Engineering, McGraw-Hill Book Company, New York (1970).

Lawless, E. W., T. L. Ferguson, and A. F. Meiners, "Guidelines for the Disposal of Small Quantities of Unused Pesticides," EPA-670/2-75-057, June 1975.

Lawless, E. W., R. von Rumker, and T. L. Ferguson, "The Pollution Potential in Pesticide Manufacture," EPA Technical Studies Report TS-00-7204, U.S. Government Printing Office, Washington, D.C., June 1972.

Monthly Labor Review, Vol. 98, No. 5, May 1975.

Monthly Labor Review, Vol. 98, No. 1, January 1975.

Mrak, E. M. (Chairman), Report to the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, U.S. Government Printing Office, Washington, D.C., December 1969.

Nicholson, H. P., A. R. Grzenda, and J. I. Teasley, "Water Pollution by Insecticides," J. Amer. Water Works Assoc., 32(1):21-27 (1968).

Pazar, C., Air and Gas Cleanup Equipment, 1970, Noyes Data Corporation, Park Ridge, New Jersey (1970).

Perry, R. H., and C. H. Chilton, Chemical Engineer's Handbook, 5th Ed., McGraw-Hill Book Company, New York (1957).

Raymond Division, Raymond Mills for Insecticides, Bulletin No. 84, Combustion Engineering, Inc. (1957).

Robeck, G. G., K. A. Dostal, J. M. Cohen, and J. F. Kreissl, "Effectiveness of Water Treatment Processes in Pesticides Removal," J. Amer. Water Works Assoc., 57(2):181, February 1965.

Shiroishi, K., EPA, Washington, Telephone Communication with Gary Kelso, MRI, October 21, 1975.

Weston, Roy F., Inc., "Development Document for Effluent Limitations Guidelines and Standards Performance -

Miscellaneous Chemicals Industry," Draft Report, EPA Contract No. 68-01-2932, February 1975.

Whitehouse, "A Study of the Removal of Pesticides from Water," University of Kentucky Water Resources Institute, Research Report No. 8, December 1967.

Winchester, J. M., and D. Yeo, "Future Developments in Pesticide Chemicals and Formulations," Chemistry and Industry, (4):106-108, January 27, 1968.

TABLE 1

Estimated Roof Area
Model Formulation Plant
Liquid and Dust Operations

	SMALL		MEDIUM		LARGE	
Liquid:	2000 gal/yr Product 250 gal/yr A.I.		550×10^3 lb/yr Product 68×10^3 lb/yr A.I. 85,000 gal/yr A.I.		6.5×10^6 lb/yr Product $.8 \times 10^3$ lb/yr A.I. 100,000 gal/yr A.I.	
Operations	Roof Area (sq. ft.)	Reckoning	Roof Area (sq. ft.)	Reckoning	Roof Area (sq. ft.)	Reckoning
Liquid:						
Receiving & Shipping	20x20 = 400	1 truck	20x40 = 800 15x15 = 225	2 trucks Tank car	20x80 = 1600 15x15 = 225	4 trucks RR Tank car
Storage (A.I.)	15x 5 = 75	(5) 55 gal. drum	----------		----------	
Mixing	10x10 = 100	1 mixer	15x15 = 225	1 mixer	15x15 = 225	1 mixer
Storage (product)	10x60 = 600 TOTAL: 1175	1 yr inv.	40x20 = 800 TOTAL: 2050	1 yr inv.	50x50 = 2500 TOTAL: 4550	1 yr inv.
Dust (increment):						
Grinding & pulverizing	10x10 = 100		20x20 = 400		50x20 = 1000	
Air Pollut. Control	10x10 = 100 TOTAL: 200		10x15 = 150 TOTAL: 550		10x20 = 200 TOTAL: 1200	
	GRAND TOTAL -- 1375		GRAND TOTAL -- 2600		GRAND TOTAL -- 5750	

TABLE 2

Estimated Installed Capital Equipment Costs
Model Formulation Plants
Roof, Slabs and Curbs

Liquid:	SMALL	MEDIUM	LARGE
Roof	$1,175	$2,050	$ 4,550
Slab	3,372	5,884	13,058
Curb	510	680	884
TOTALS:	$5,057	$8,414	$18,492

Dust:			
Roof	$1,375	$2,600	$ 5,750
Slab	3,946	7,462	16,503
Curb	612	833	1,224
TOTALS:	$5,933	$10,895	$23,477

$77.55/cu. yd. concrete
x2 labor & concrete
$155.10 formal finished concrete/yd.

Slab: sq. ft. x 0.5' deep x $\frac{1 \text{ cu. yd.}}{27 \text{ cu. ft.}}$ x $155.10 = sq. ft. x 2.87 = $

Curb: .5' x .5' x 1' = 0.25 cu. ft/linear ft. of curbing
.25 cu. ft. x linear ft. x $\frac{1 \text{ cu yd.}}{27 \text{ cu. ft.}}$ x $155.10 x (forms 1.20) =

$(\frac{.25}{27} \times 155 \times 1.20)$ linear ft. = cost = 1.7 x ft.

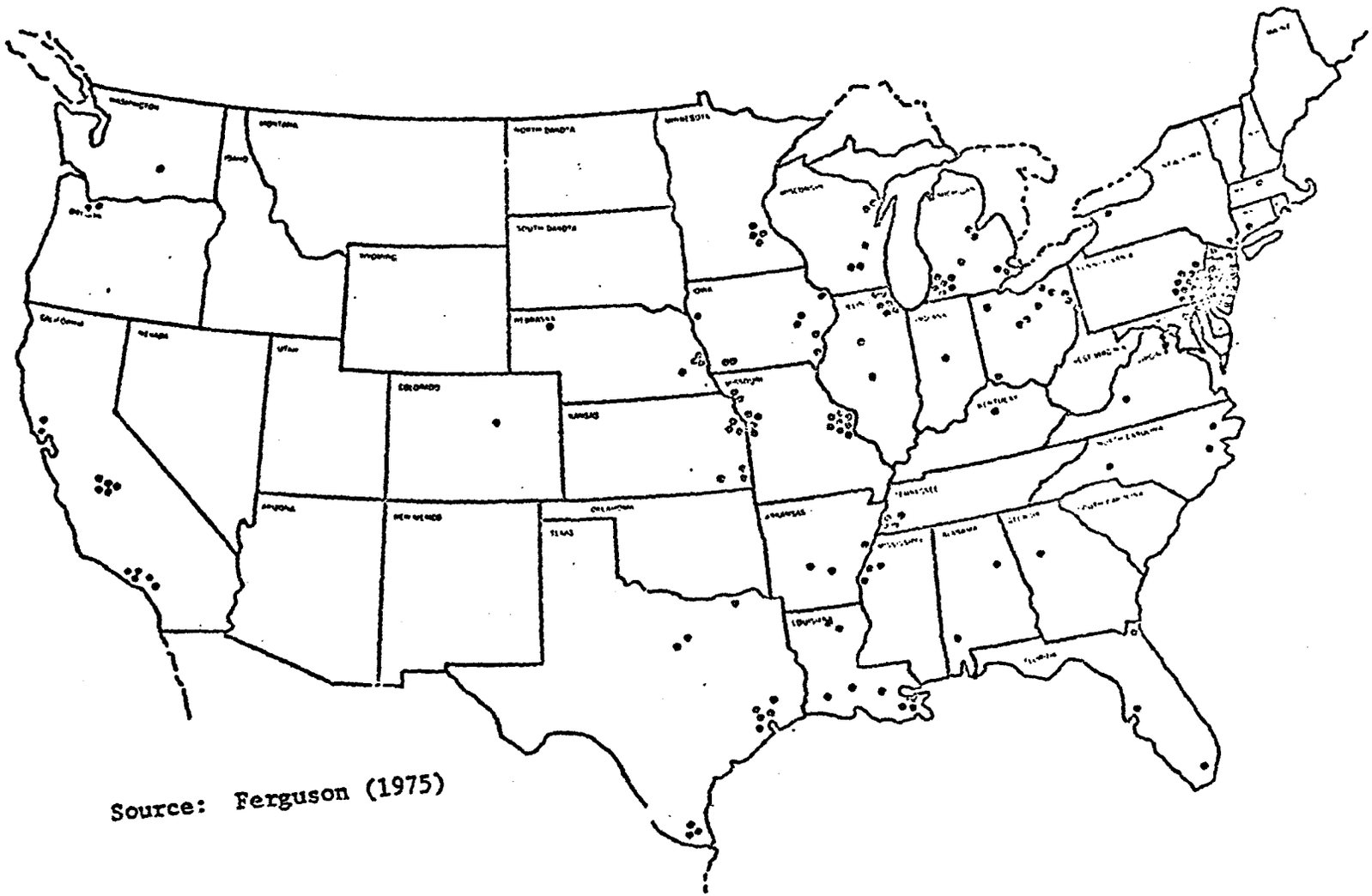
Roof: light steel frame and support @ $1.00/sq. ft.

TABLE 3

Estimated Total Annual Operating Costs
Model Formulation Plants
Roof, Slabs and Curbs

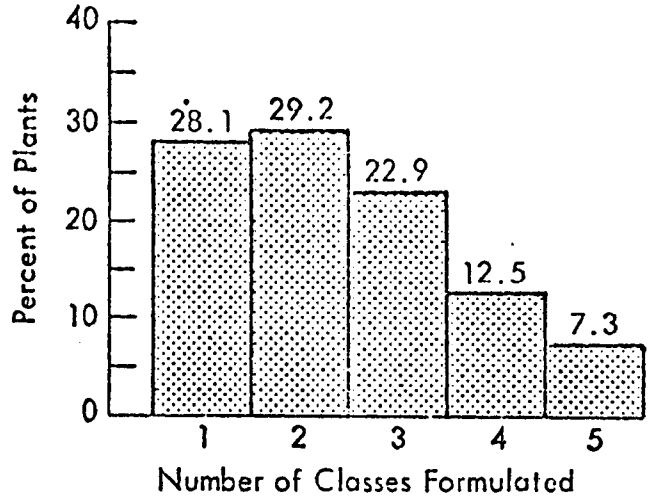
Liquid:	SMALL	MEDIUM	LARGE
Roof	$ 225	$ 410	$ 910
Slab	506	883	1,959
Curb	77	102	133
Spills	25	50	100
TOTAL:	$1,033	$1,445	$3,102
5% O&M Costs ---	52	72	155
GRAND TOTAL:	$1,085	$1,517	$3,257

Dust:			
Roof	$ 275	$ 520	$1,150
Slab	592	1,119	2,475
Curb	92	125	184
Spills	25	50	100
TOTAL:	$ 984	$1,814	$3,909
5% O&M Costs ---	49	91	195
GRAND TOTAL:	$1,033	$1,905	$4,104



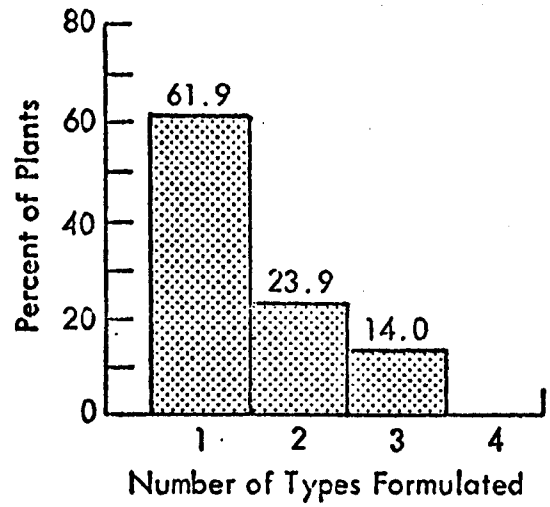
Source: Ferguson (1975)

Figure 1. Large formulation plant locations.



Classes: Organophosphate, inorganic, chlorinated hydrocarbon, nitrogen based, and all others

a) Distribution by chemical class of pesticide formulated

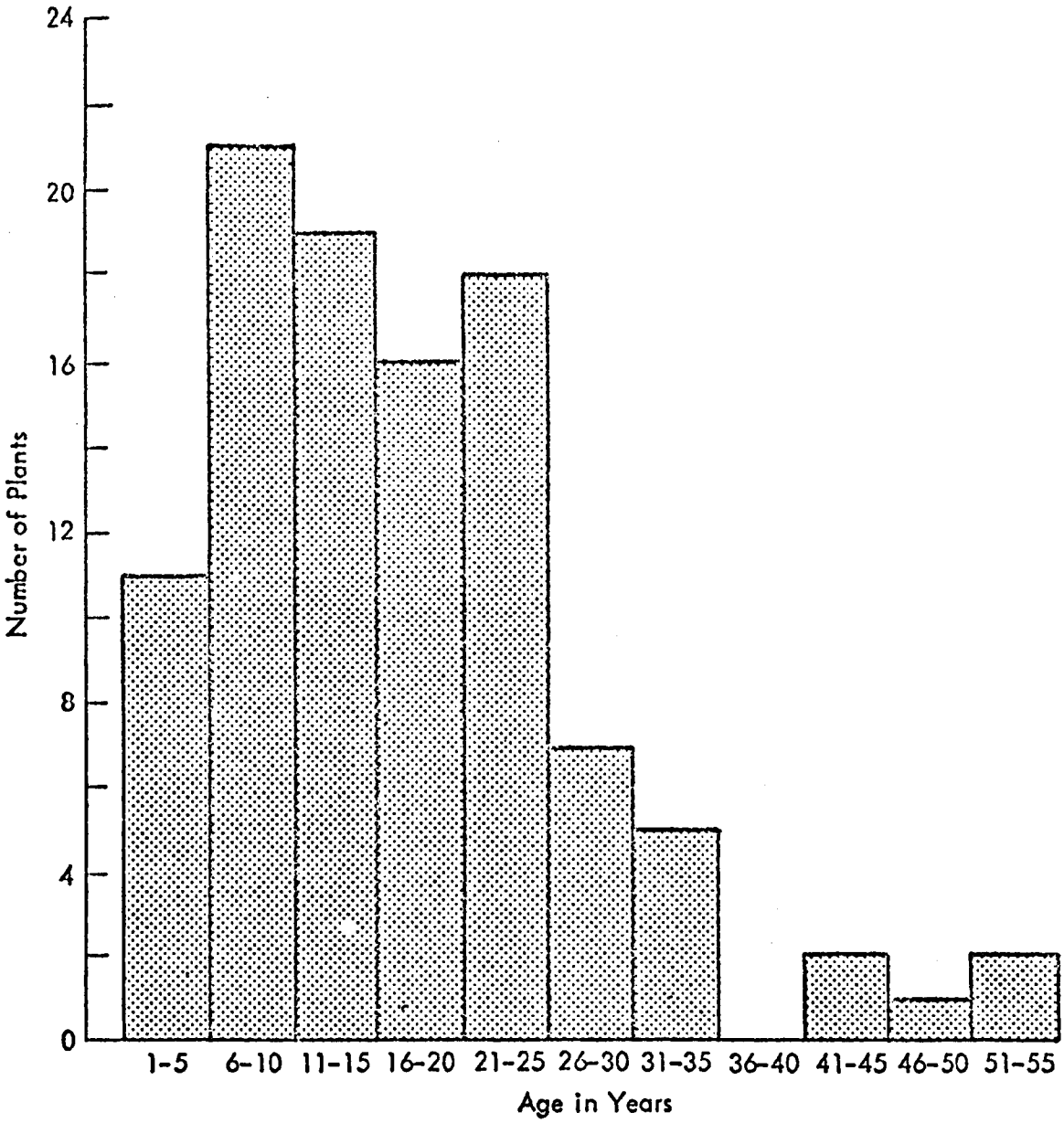


Types: Liquids, powders and dusts, granules, and all others (strips, baits, etc)

b) Distribution by type of formulation

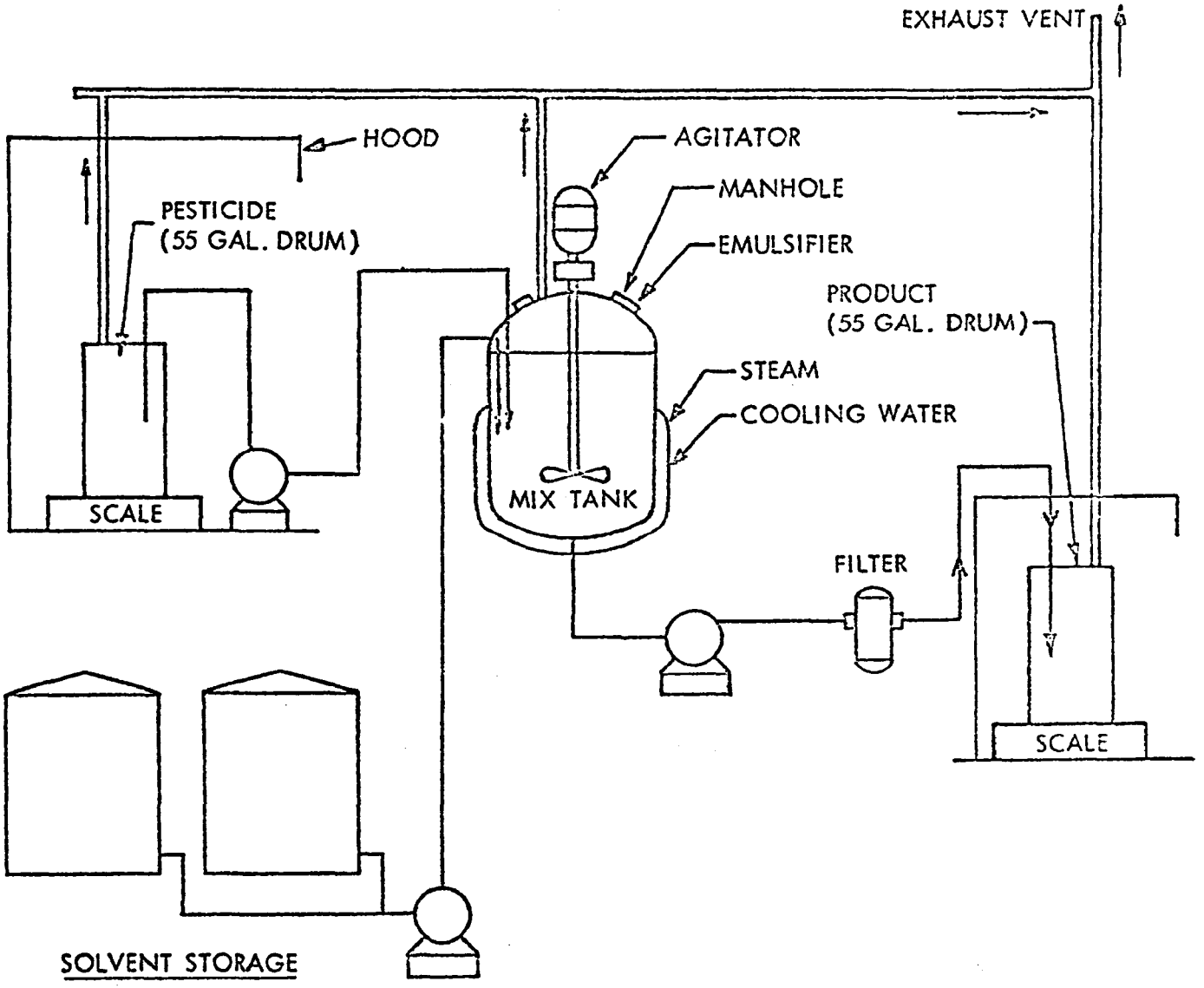
Source: Ferguson (1975)

Figure 2. Product distribution for large formulation plants.



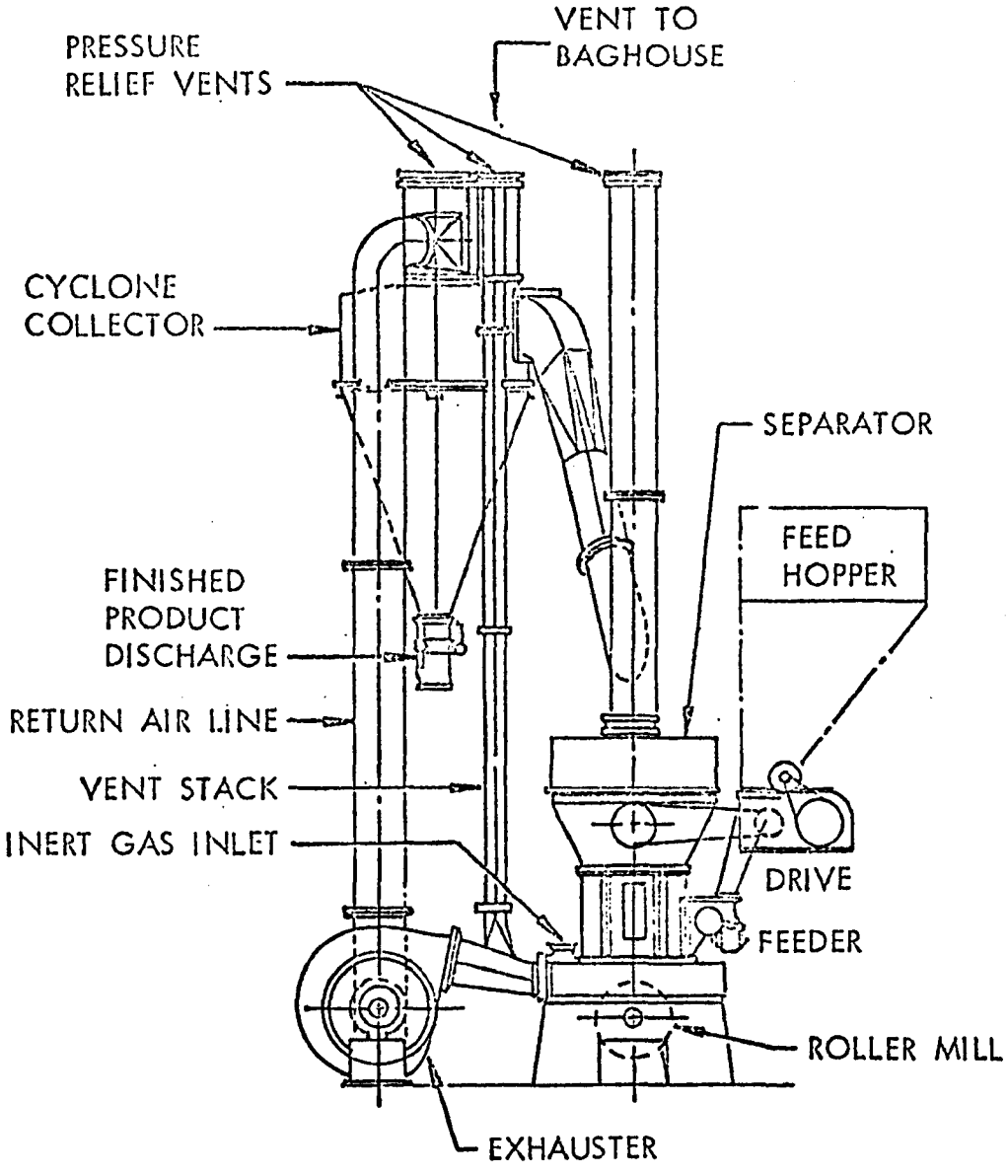
Source: Ferguson (1975)

Figure 3. Distribution of plants by age.



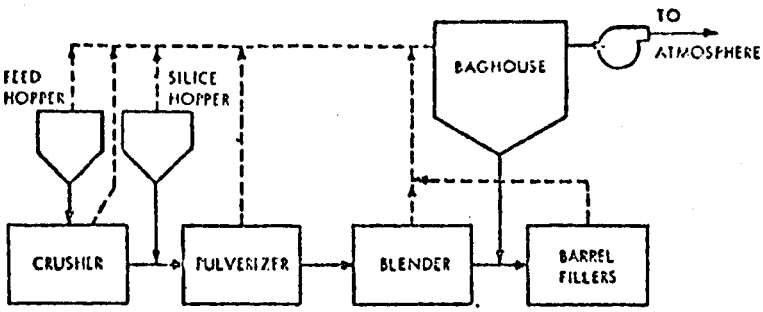
Adapted from: Handbook of Aldrin, Dieldrin, and Endrin Formulations (1959)

Figure 4. Liquid formulation unit.

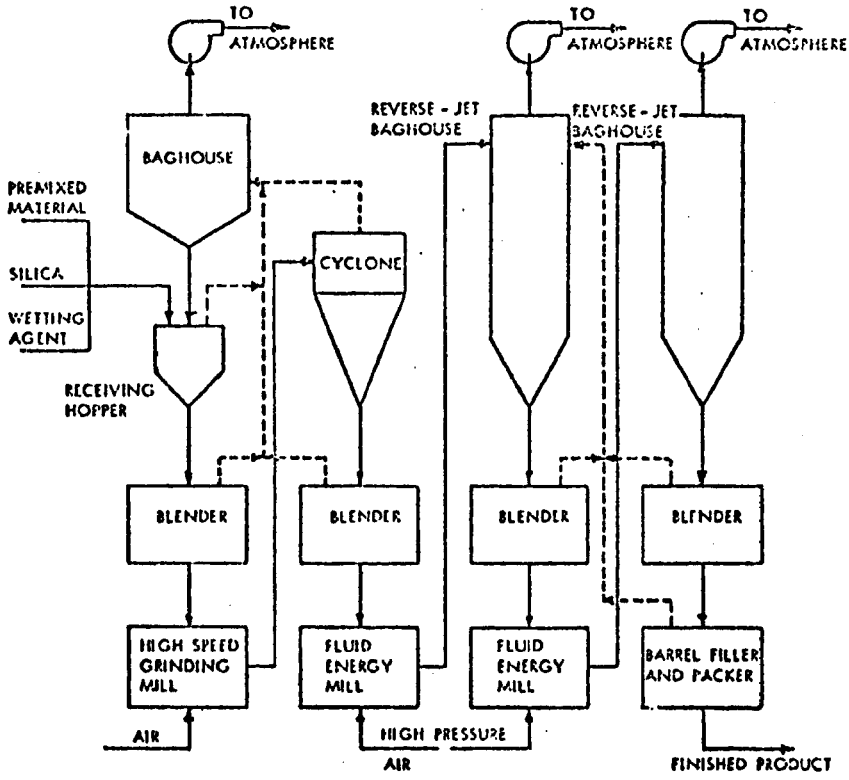


Source: Raymond Division (1957)

Figure 5. Typical sulfur grinding unit.



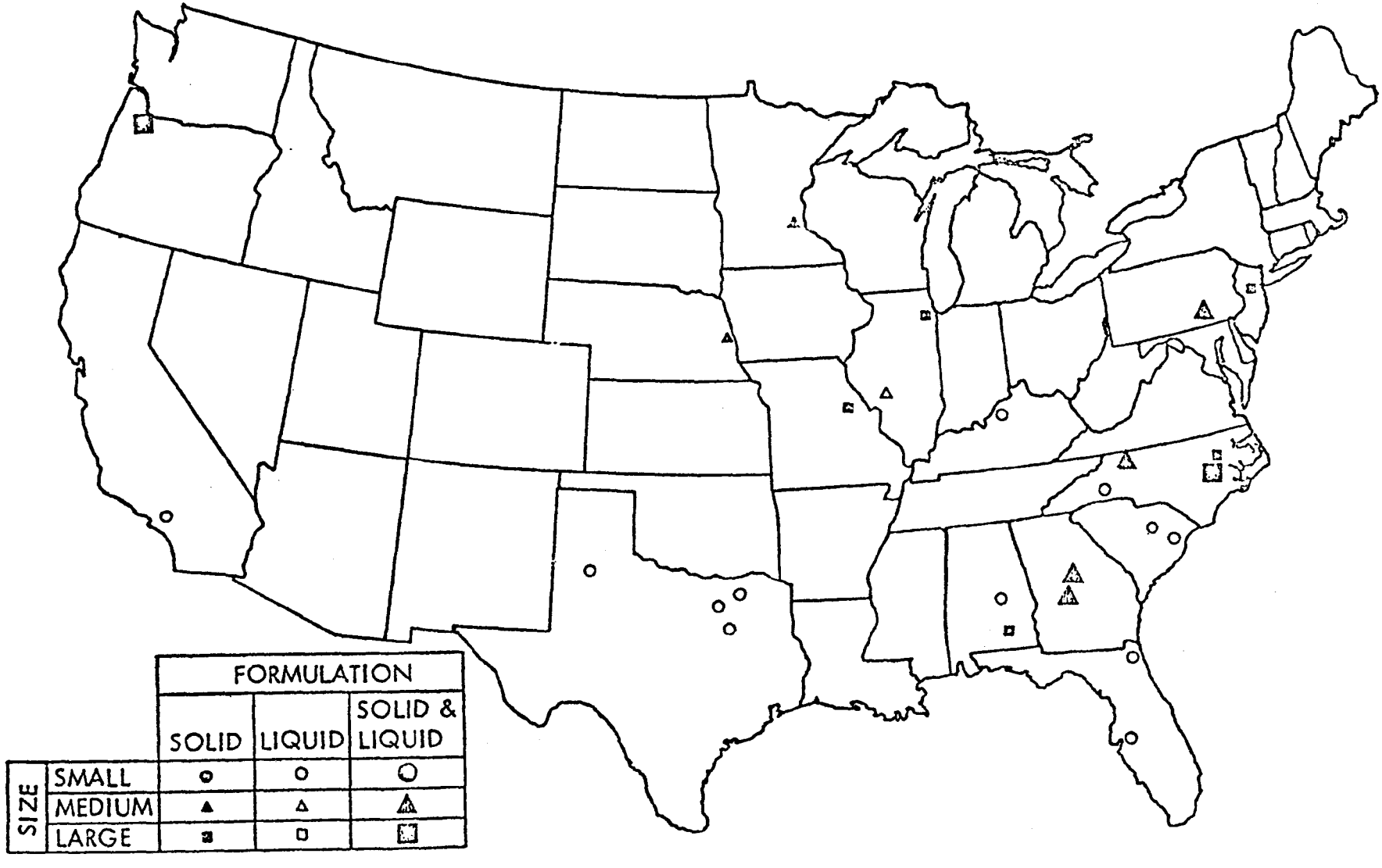
a) Premix Grinding



b) Final Grinding and Blending

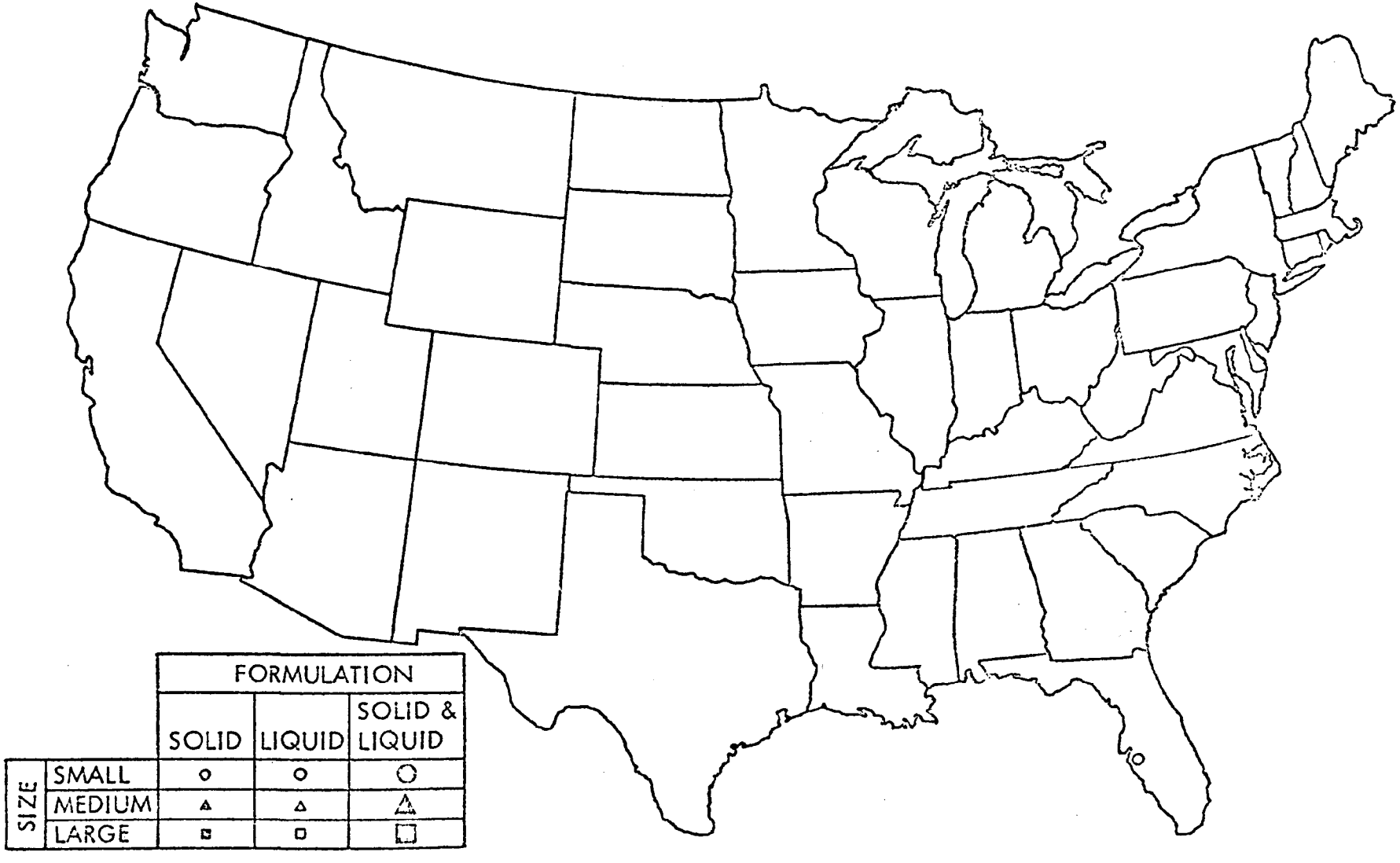
Adapted from: Danielson (1967)

Figure 6. Process for formulating dust.



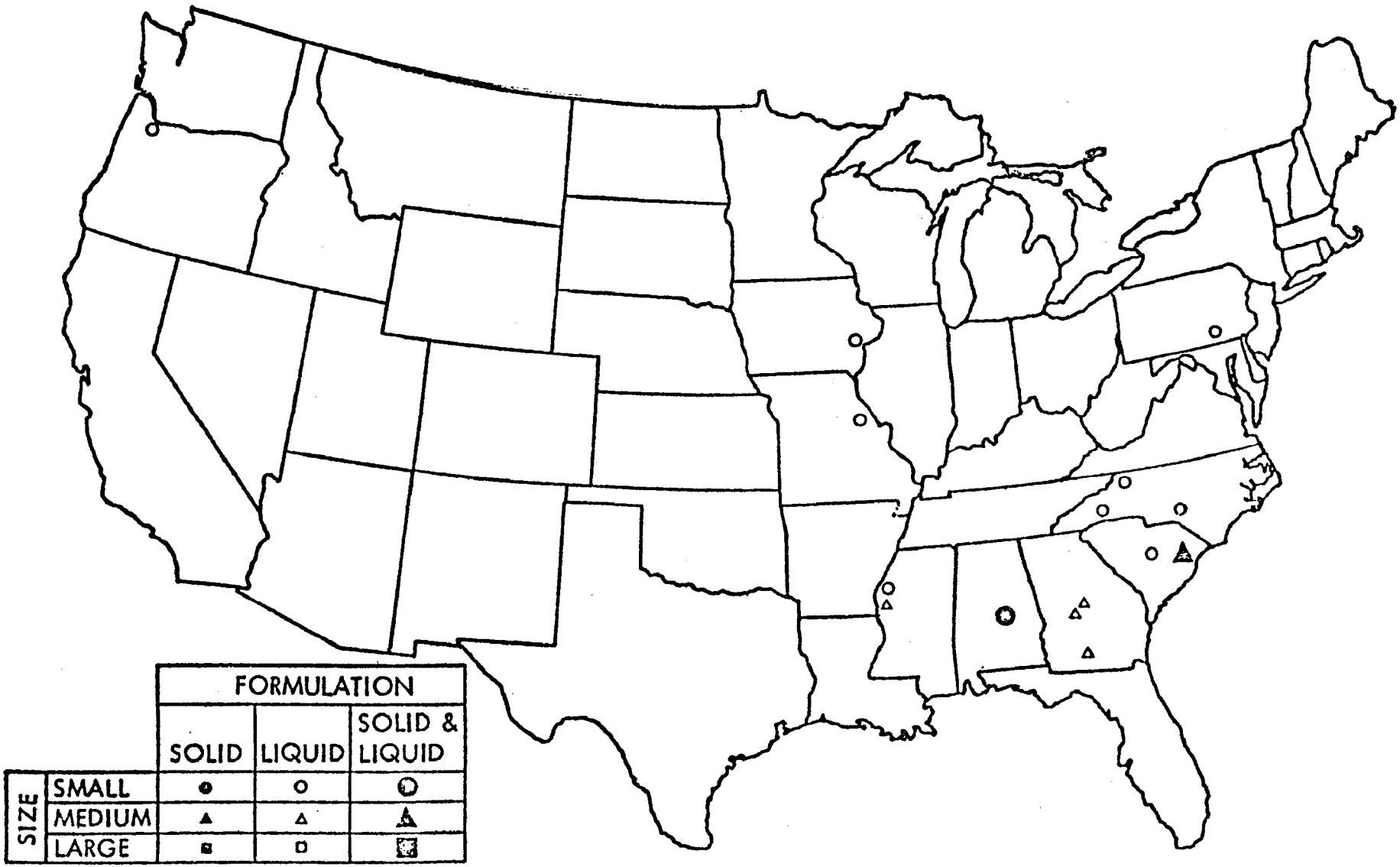
Source: Davis (1975)

Figure 7a Aldrin/dieldrin formulation plants (1973).



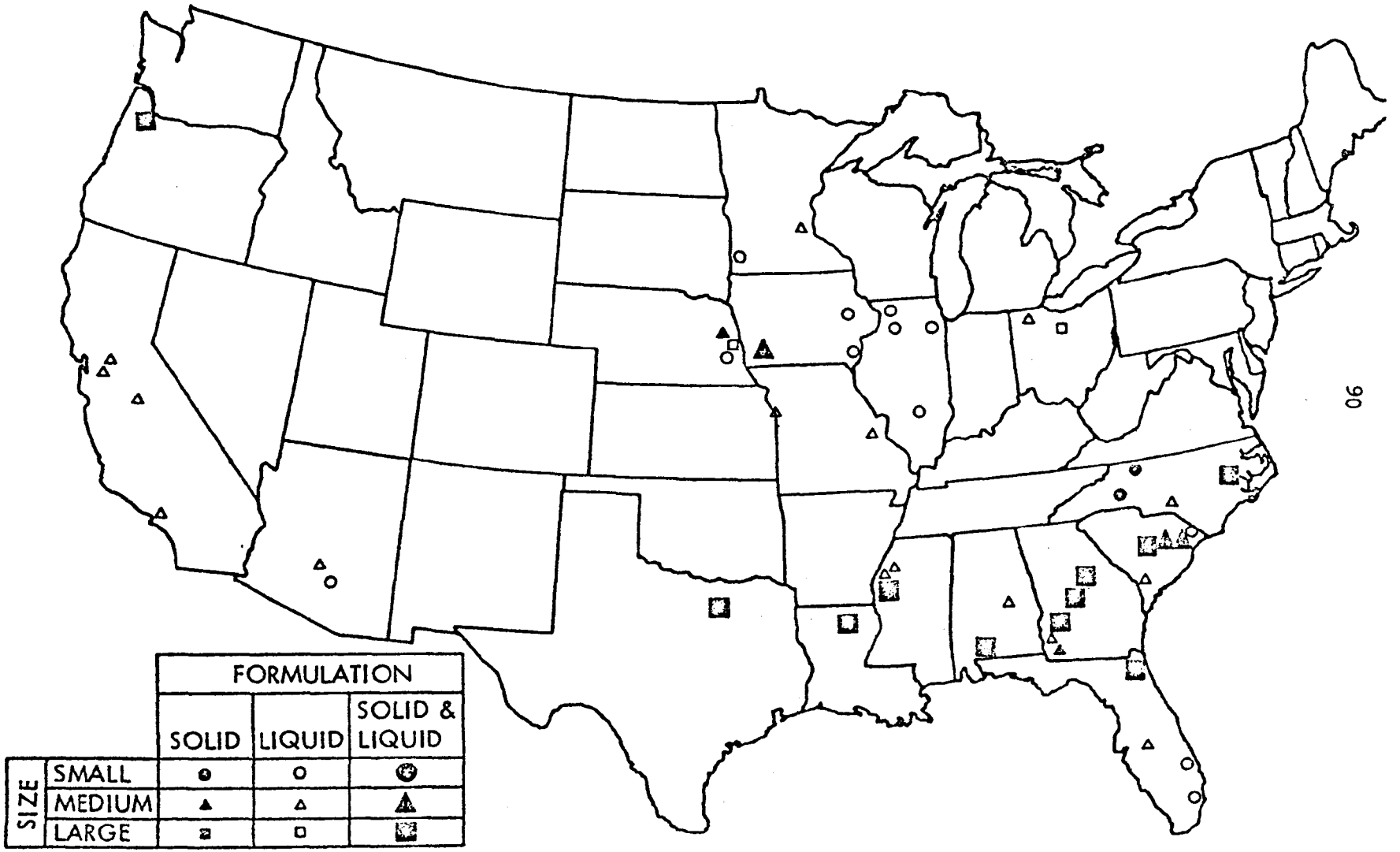
Source: Davis (1975)

Figure 7b DDT formulation plants (1973)



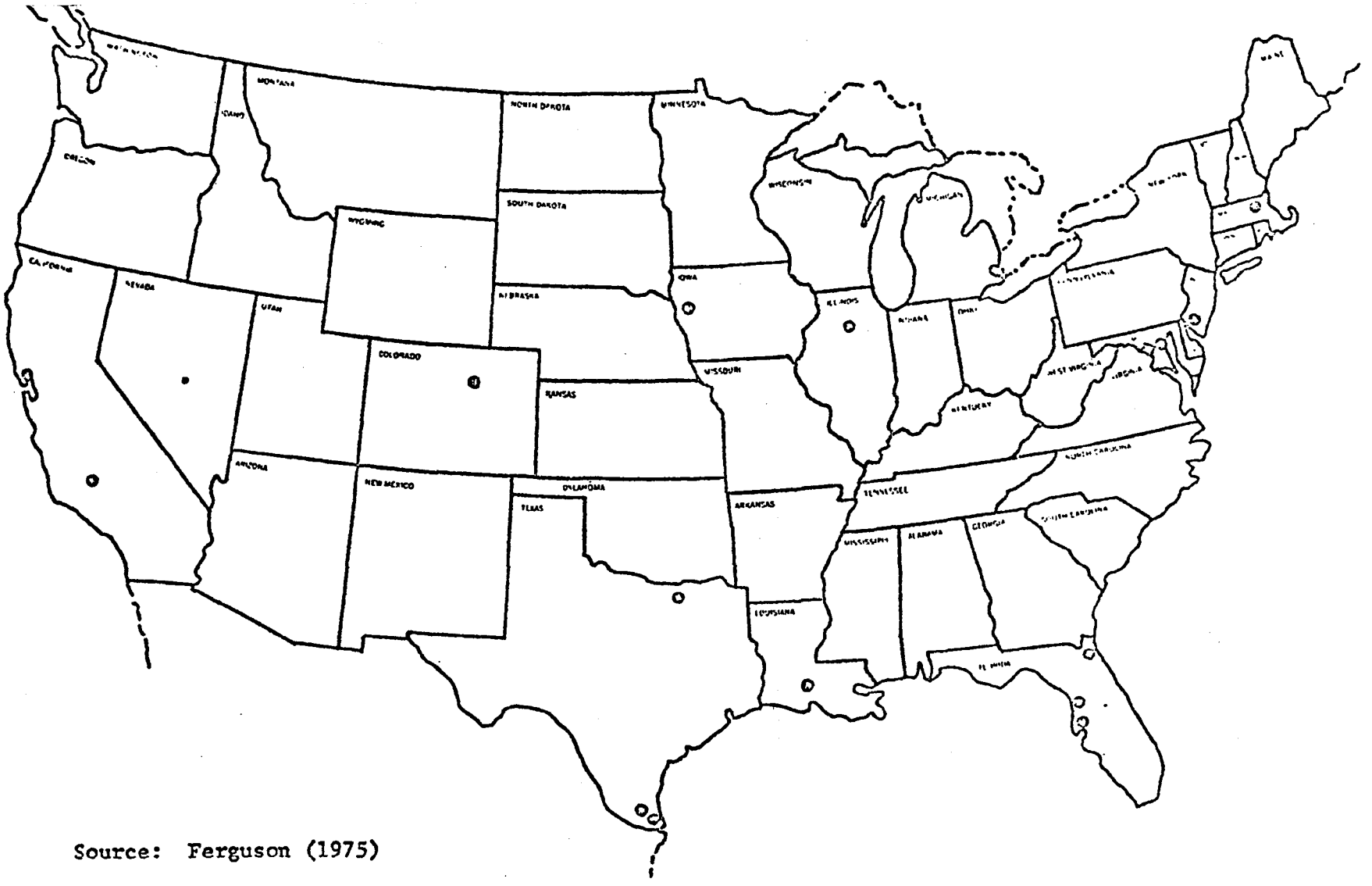
Source: Davis (1975)

Figure 7. Endrin formulation plants (1973).



Source: Davis (1975)

Figure 7.l Toxaphene formulation plants (1973)



Source: Ferguson (1975)

Figure 8. Formulation plants using evaporative treatment systems.

Appendix A

Holding - Evaporation System
Technology and Estimated Associated Costs
Worst Case Situation

Selected Location: Vicksburg, Miss.

Select 1/2 acre area:

		Inches	Storage Cu. ft.	Storage Gallons
Net annual precipitation	=	11	$20,000	$150,000
Design storm (24 hrs/10 yrs)	=	9	$16,300	$122,500
		20	$30,300	$272,500

Installed Equipment Costs:		Rounded Estimates
Pond excavation	:	$92,200
1333 yd 3 @ $5/yd		
Inlet structures @ 10%		
contingencies @ 10%		
Pond liner	:	$13,700
Hypolon, 30 mil 12,338 ft		
@ $0.70/ft Clay liner +		
surface dressing @ $.25 yd		
Ditching and Anchoring		
@ $.30 ft Installation		
12,338 @ $.30		
Evaporation System	:	$ 6,000
Pump, water, piping		
spray heads		
Roof		
Light/steel frame		
+ cover, $1/ft	:	$10,000
Land at $7500/acre		$ 3,800

		$42,700
Indirect Const.	at 10%	$ 4,270
Contingency	at 30%	$12,810
		$59,790
	Round to	$60,000

Annual Operating Costs

Direct:

Labor	$642
Supervision	$128
Payroll charges	$261
Maintenance	$1040
Utilities	$1000
	$3171
Round to	$3200

Indirect:

Depreciation	$2250
Property taxes	$1,200
Insurance	$ 600
Capital	$3,780
Plant overhead	$ 640
	$8,470
Round to	$8,500

Total Annual Operating Cost: $11,700

Adjust Costs to Lesser Watershed Areas:

Use Perry and Chilton's, Chemical Engineers Handbook, 5th Ed. McGraw-Hill (1970)

$$\text{New plant cost} = \left(\frac{\text{new capacity}}{\text{old capacity}}\right)^{0.6} \times \text{previous plant cost}$$

Area	Installed Capitol Equipment	Total Annual Operating Cost
1/2 acre	$60,000	$11,700
1/4 acre	$39,600	$ 7,720
1/8 acre	$26,100	$ 5,090
1/16 acre	$17,200	$ 3,360

Appendix B-1

SUMMARY OF CONTACTS WITH PESTICIDE FORMULATORS (JANUARY - FEBRUARY 1976)

Formulator	Location	Telephone contact	Plant visit	Plant tour	1975 Toxaphene production[a/]	1975 Endrin production[a/]	Currently formulating toxaphene	Generates aqueous process waste	Has NPDES permit	Discharges to public treatment works	Collects and treats runoff
Woolfolk Chemical Company	Fort Valley, Georgia	Yes	Yes	Yes[b/]	4	2	Yes	No	No	No	No
Triangle Chemical Company	Macon, Georgia	Yes	Yes	Yes	4	2	No	No	No	No	No
Helena Chemical Company	Cordele, Georgia	Yes	Yes	No[c/]	3	-	-	Yes	No	-	No
Paramore and Griffin Company	Valdosta, Georgia	Yes	Yes	Yes	4	-	Yes	No	No	Yes	No
Kerr McGee	Jacksonville, Florida	Yes	Yes	No[d/]	4	1	-	Yes		Yes	No
FMC, Inc.	Jacksonville, Florida	Yes	Yes	Yes	2	-	Yes	No	Yes	No	No
Asgrow Florida Company	Plant City, Florida	Yes	Yes	Yes	3	-	Yes	No	No	No	No
Helena Chemical Company	Tampa, Florida	Yes	Yes	Yes	(4)[e/]	some	Yes	Yes	No	No	No
PBI Gordon	Kansas City, Kansas	Yes	No	No	2	-	Yes	No	No[f/]	Yes	No
Patterson Green-up	Kansas City, Kansas	Yes	No	No	1	-	No	No	No	-	No
Southern Agricultural Chemicals, Inc.	Kingstree, South Carolina	Yes	No	No	2	1	-	Yes	-	-	No
FMC, Inc.	Los Fresnos, Texas	Yes	No	No	3	-	No	-	No	-	No
Texas Agricultural, Inc.	Mission, Texas	Yes	No	No	-	-	No	-	No	-	No
FMC, Inc.	Ennis, Texas	Yes	No	No	-	-	No	-	No	-	No
Nova Products	Kansas City, Kansas	Yes	No	No	1	-	No	No	No	-	No
Stauffer Chemical Company	Omaha, Nebraska	Yes	Yes	No	0	0	No	Yes	No	Yes	No

a/ 4 = over 100,000 gal.
3 = 50,000 to 100,000 gal.
2 = 10,000 to 50,000 gal.
1 = less than 10,000 gal.

b/ Only portions of plant were toured.

c/ Was unable to arrange to meet our schedule.

d/ Asked for later visit after they complete new construction..

e/ No EPA figures available, but toxaphene capacity was large.

f/ Formerly had NPDES Permit.

Appendix B2

Memoranda of Plant Site Visits

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

March 1, 1976

MEMORANDUM OF PLANT VISIT

BY: Thomas L. Ferguson

DATE OF VISIT: October 27, 1975

COMPANY: Stauffer Chemical Company
4111 11th Street
(P.O. Box 7222)
Omaha, Nebraska 68107
(402) 733-3200

Visit Arrangements

Our arrangements to visit this formulation plant were made by Mr. Frank Porter at the Stauffer Chemical Company headquarters in Westport, Connecticut 06880, (203) 226-1511.

After preliminary authorization had been obtained from Mr. Porter, I made final arrangements with Mr. Norm Lamb, the Omaha plant manager.

Plant Information

This plant was selected because (a) it had been identified in an earlier study of pesticide formulation as using the "best practicable control technology currently available" for formulation plant wastewater, and (b) it was identified by EPA as having formulated "medium" volumes of both dieldrin and toxaphene during calendar year 1973.

I also visited this plant site on July 2, 1973. Information obtained from that visit has been attached (Case No. 7 in EPA-660/2-74-094, dated January 1975).

Mr. Lamb indicated that this site no longer produces dieldrin (or toxaphene) formulations. Further, they do not analyze their effluent for any of the five pesticides of interest (aldrin, dieldrin, endrin, DDT, and toxaphene). The effluent from the treatment system is now normally greater than 5 gpm, and contains < 0.01 ppm thiocarbamates and organophosphate.

Although effluent from the treatment plant is discharged into the Omaha city sewer system as authorized by a city permit dated June 23, 1971 (Mr. Charles A. Geisler, City Sanitary Engineer; 733-5465), the City of Omaha does not monitor the effluent.

Unfortunately, the plant had no additional data on the performance of the wastewater treatment system pertinent to our current study beyond that already reported in the attached case study. Comprehensive analyses of the effluent have not been conducted since 1971. No "material balance" data have been developed.

This formulation plant was also visited by Roy F. Weston, Inc., during their study of effluent limitations guidelines (EPA Contract 68-01-2932). Samples of the effluent were taken, but apparently were not analyzed for active ingredient content.

CASE STUDY NO. 7

General Information

This plant is operated by a large agricultural chemical manufacturer to formulate products for sale under the company's own label. The plant is located in the West North-Central United States, and has been in operation since 1955. This facility operates year round, and produces about 40,000,000 lb of formulated products each year. Active ingredients used include a number of thiocarbamate herbicides and organophosphate insecticides. No inorganics or metal-containing pesticides are formulated. Production is about evenly split between liquid and granule products.

Wastewater Characterization

The primary source of process wastewater is equipment washout. Dye is used for one of the major solid formulations, and is one of the main reasons for water-washing. All water from inside the dikes that surround technical material storage tanks also goes to the wastewater treatment system.

Effluent from the plant's wastewater treatment system has been analyzed by the local municipality into whose sewer system the water is discharged, and the quality of this water has been found to be acceptable. These analyses, however, were not available.

Where possible, solvent is used to clean out formulation equipment in order to minimize the volume of wastewater generated.

Wastewater Treatment System

The wastewater treatment in use at this plant site is depicted in Figure A-5. The system is still considered to be in the pilot plant phase, however, and for that reason complete design and operational data were not available. A general description of the system is given below.

Wastewater from the production units is collected in a sump and is pumped into a settling tank. Here, flocculating and deemulsifying agents are added. The wastewater is then continuously pumped to a vacuum filter unit. Sludge from the filter is disposed of with the other solid wastes. From the filter, the water is pumped to an aeration tank for secondary treatment. If necessary, water from the aeration tank can be recycled to the settling tank.

In the next step, the aerator effluent is passed through an activated carbon column and then into a 100-ft long x 6-ft wide "fish pond." The system effluent can be discharged to a garden plot, the city sewer, or to a recycling system.

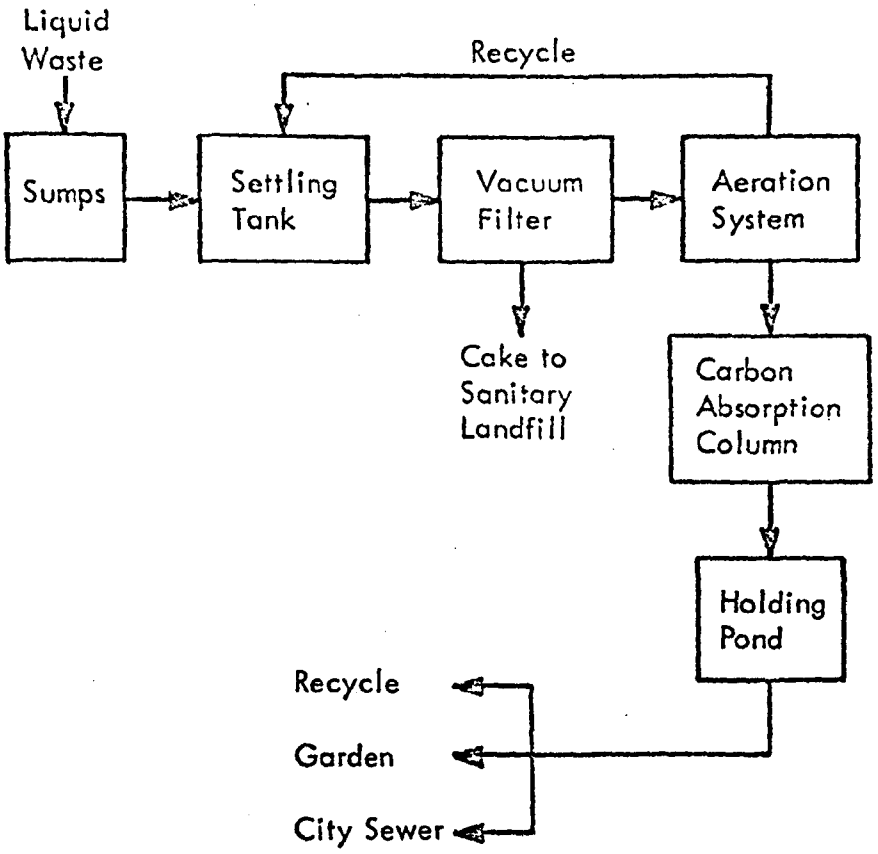


Figure A-5 - Pilot Absorption System

The design retention time for the system is about 30 days. The carbon column has been used up to 6 months between rechargings (about 540 lb of carbon). At the reported continuous flow rate of 2 to 5 gpm, a carbon capacity of 500 gal. per lb is indicated. This system has reportedly operated for short periods at a rate of 15 gpm.

Specific data on the quality of influent and effluent water for this system were not made available. However, data indicate that typical operation yields a reduction in total toxicants from an initial concentration of 140 ppm to an effluent containing < 0.1 ppm.

The actual capital cost of this plant is not significant because of its developmental status. Operational costs, however, are meaningful. This system requires the full-time attention of two people to operate the equipment and provide analytical services.

Miscellaneous Information

Solid waste is disposed of by shipping it to an approved landfill at a cost of about $1.25 per cubic foot (including freight). The disposal of drums and bags is not a problem as most technical materials are received in tank cars or tote tanks.

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

March 4, 1976

MEMO OF PLANT VISIT

BY: Alfred F. Meiners

DATE OF VISIT: February 11, 1976

COMPANY: Triangle Chemical Company
206 Lower Elm Street
Macon, Georgia
Mr. Richard M. Maddux, President
912-743-1548

Telephone Contact

Mr. Maddux said that they do not generate any liquid waste nor do they have any runoff. They simply mix their formulations in a kettle, and mix the solvents back next time they generate in that kettle. Evidently he has dedicated equipment.

He said that he no longer manufactures very many products. They do not discharge to the City of Macon Sewage Treatment System. He believes that they are on a septic tank. They have no evaporation system to handle wastes, nor do they discharge to a navigable waterway (for this reason they do not need a NPDES permit). He said they have very few labels for cotton pesticides anymore. They make them in kettles, and do not have waste liquids.

Formerly their business was large in formulated dusts, and they still make a few granular products. But this business, the dusts and granules, has decreased 75 to 85%. Most of their business now is in the distribution of other products.

Plant Visit

I met Mr. Richard M. Maddux, President of the company. Mr. Maddux was very much more cordial than he was over the phone. He indicated that he was very suspicious of persons who call by telephone. He is much more ready to speak to them when they visit him in person.

Mr. Maddux said that their formulation facilities consist of two large kettles, which sometimes are used to formulate the same product for months at a time. When they switch from one product to another, the kettles are washed out, and the wash either goes into the next product or is placed in a drum and is stored until that product is formulated again.

The major products sold by Triangle include a product called 6-2-1, which contains toxaphene, ethyl parathion, and methyl parathion; 6-3, which is methyl parathion and toxaphene; and a third formulation which consists of EPN and methyl parathion.

Mr. Maddux says that they do have a contamination problem, and a very small amount of washwater is needed. They are not on city sewers but they have septic tanks which receives their sanitary discharges. They do not have a discharge to any stream. They formerly discharged their boiler blowdowns, but this is now recycled.

Mr. Maddux said that water is very inefficient in cleaning up spills (therefore, I presume that they use organic solvents to clean up their spills). He indicated that they use granules (specified for the particular pesticide formulation) to absorb the spill. These are placed in containers, usually paper bags, and these are taken to the city dump. Mr. Maddux indicated that his plant has no more spillage than would occur by the proper use of the pesticide by three or four farmers.

They have in the past formulated endrin, but they will probably not formulate it this year. He indicated that they can buy it cheaper in the formulated form from Vesicol, even though they have labels of their own for endrin and an endrin/methyl parathion formulation. He indicated that they have only formulated 200 or 300 gal. of this product in the last few years. Triangle currently has no endrin in the plant.

The company formulates an aldrin product used for termite control, although they do not formulate any dieldrin product. (They have a label for a dieldrin formulation.) He indicated that some aldrin might be imported at the present time, even though it is not presently manufactured by Shell. Aldrin was never a big dollar volume for Triangle.

He indicated that toxaphene was not useful for termite control; it had little more termite preventive control than fuel oil itself.

Triangle is currently not formulating any toxaphene. As indicated previously, they do not use any water in the manufacturer of these formulations, even for the cleaning up of their kettles.

I gave Mr. Maddux a blank copy of the EPA formulators report that Roy Clark had given me.

Triangle receives toxaphene (from Hercules) in tankcars and this is transferred to their storage tanks. They receive methyl and ethyl parathion and EPN in drums. They put their finished products in the same drums. He indicated that a major problem was disposal of the drums by the farmer. He indicated that Triangle has no drums to dispose of themselves.

Triangle makes no toxaphene dusts, although they do make a Sevin® dust. He indicated that no one is using a dust type of toxaphene formulation at the current time. (According to our visit to Woolfolk, there is a demand for a toxaphene dust, apparently for home and garden products. Our subsequent visit to Parramore and Griffin confirmed the present demand for toxaphene dusts.) He indicated that liquid toxaphene is sprayed into the dust when the formulation is prepared. He indicated that Hercules makes their own dust formulation. Triangle could purchase the dust as a concentrate, which could be diluted with additional dusting material. However, they apparently purchase the dust formulation at the concentration they wished.

The only reason that they make a dust formulation from Sevin® is that Sevin® is difficult to formulate as a liquid.

During the tour of this plant, Mr. Maddux showed me his entire facility. Most of his buildings (about three) were warehouses filled with already formulated pesticides, as he had indicated. The growing season is about to begin and these warehouses looked very well filled with a wide variety of formulated pesticide products.

He showed me the kettles which are used to formulate liquid copper napthenate and the toxaphene formulations. There were two kettles, approximately 10 ft in diameter and 15 ft high. These were located inside a building. If there were any spills or liquid washes from this building they would be conducted through a drain to a small continuously moving stream which is located just outside this building. This stream is generated by a concrete block manufacturing facility located upstream (next door). The stream leads to a large swamp area.

Outside this formulation building were two large tanks, about 8 ft in diameter and 20 ft high. Mr. Maddux said they were owned by Hercules. I mentioned that it may become necessary for him to have these tanks diked; this comment touched a nerve. He said that no government authority or even his own insurance company could provide him with adequate specifications for such a dike. He would earnestly like to build a dike for these tanks, and for the four xylene tanks (8 ft diameter by 18 ft long, stored outside), but he does not want to build these dikes and then have some government authority say that they are inadequate.

Mr. Maddux showed me his dust manufacturing facility and again indicated that most of his dust products were purchased already formulated.

I took a picture (1-5) of the Triangle Chemical Company which shows the toxaphene storage tanks and the building (to the left of the tanks) in which the liquid formulation processes take place.

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

March 4, 1976

MEMO OF PLANT VISIT

BY: Alfred F. Meiners

DATE OF VISIT: February 11, 1976

COMPANY: The Helena Chemical Corporation
Cordele, Georgia
912-273-1379

I called Mr. Tom Mock, Plant Manager, on Wednesday morning, February 11. He stated that his plant was very modernistic and up-to-date and would probably meet any EPA specifications. They produce toxaphene dust and concentrates (50,000 to 100,000 gal/year). He said we were welcome to visit the plant. However, he indicated that visits to this plant must be cleared through his supervisor, Harold Speer, Columbia, South Carolina 803-796-4830. We had already received permission from Mr. Speers' boss, Mr. Bobbie Pace, in Atlanta.

I told Mr. Mock I would be in Cordele Thursday, but he was unavailable that day.

Because of my fairly tight schedule, I was unable to schedule a visit to this plant. However, driving from Macon to Valdosta, I stopped by the Cordele plant and took a few pictures (1-6, 1-7, 1-8, and 2-1). The plant is located out in the country and does look like a very neat modernistic plant.

Mr. Mock said that their facility in Cordele was very similar to the facility in Tampa, which we will visit Friday (see below). I told Mr. Mock that we might telephone for some additional details after we had visited his Tampa plant. Mr. Mock seemed to be very cooperative.

During our visit to Helena in Tampa, Mr. David Lawhon stated that the evaporative system at Cordele was similar, but larger than the Tampa system. (Photographs of the system are available; see MRI report on Helena, Tampa, visit February 13, 1976.)

The Cordele system operates entirely by gravity flow from the floor of the formulating area to the evaporation system. About one-fourth

of the Cordele tank is used for sedimentation to remove most of the suspended solids before the evaporation step. The Cordele system operates in the same manner as the Tampa system; circulation and some aeration is provided by a pump which discharges through a manifold system consisting of nozzles directed straight down toward the water surface.

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

March 4, 1976

MEMO OF PLANT VISIT

BY: Alfred F. Meiners

DATE OF VISIT: February 11, 1976

COMPANY: Parramore and Griffin Company
(Pee Gee Chemicals)
Valdosta, Georgia
(The plant is located off Interstate 75 on 84 Exist, about 1/4 mile east of the junction)
912-242-8635

I visited Mr. R. A. (Rusty) Griffin, who is the owner of the plant and its president. Mr. McCloud is the plant sales manager.

The company no longer prepares the dust product called "sulphene" or a "sulphene with copper." These were toxaphene formulations; the copper formulation containing copper oxide and was used on peanuts.

The company's major toxaphene formulations are a 6-E and 8-E formulation. The company also formulates ethyl and methyl parathion; they are also equipped to formulate chlordane.

Like most of the formulators visited to date, this company does not generate any wastewater. The kettles in which the toxaphene formulations are prepared are rinsed with xylene and the xylene solvent is stored until the next time that toxaphene is formulated.

The companies formulating facilities are all enclosed in a building; therefore, their runoff problems are minimized. Mr. Griffin said that spills are a problem, but he did not elaborate on how they handled spills.

The company has waste pesticide bags to dispose of, and they take these bags to the city dump for burial in an approved landfill. Mr. Griffin was concerned with the problem of container disposal by the farmer.

The company takes no procedures to prevent runoff. The company area consists of about four modernistic buildings located near a major highway interchange.

Mr. Griffin said that the EPA has not been very cooperative to date. They have been more "Gestapo-like" with an attitude that they will "burn you or not burn you." They appear to be looking for violations. He said that the EPA representatives apparently do not realize that formulators are also good Americans interested in protecting the environment. Mr. Griffin said that he has requested informal visits to this plant by EPA representatives in order to determine what things were wrong, but has never received a visit of this kind. He would appreciate the opportunity to be informed of any procedures that are objectionable and have the opportunity of responding to EPA concerning his company's solution to these objections.

The company carries its own trash to the dump. This trash consists of many things, predominantly things that are not involved with pesticides. It would be very hard to segregate the company's trash from pesticide waste. The trash includes pesticide bags, broken pallets, and other debris.

I agreed to send Mr. Griffin a copy of the report we will send to EPA concerning his company. I also agreed to send him a copy of Ferguson's formulators report.

The company has just recently attached to the city sewer. They formerly used a septic tank. There is no plant drainage to the sewer, other than sanitary waste, and there is no way for this waste to get into the sewer. Mr. Griffin mentioned that the health department of Valdosta has been interested in the same problem and has satisfied themselves that there is no pesticide discharge to the sewer.

The company receives toxaphene by tankcar and by tanktruck and it is stored in two large containers which are outside the plant. These containers are made of aluminum and are approximately 10 ft wide and 20 ft high. There are two of these storage bins. There are also four tanks which contain xylene storage. These tanks are not diked, but Mr. Griffin would like to have them diked in order to prevent loss of valuable material, plus a very bad pesticide spill. He would like someone at EPA to tell him what kind of diking would be acceptable.

Mr. Griffin took me on a tour of his plant. The warehouses and formulation areas were in the same building. The building was quite modern. All preparation of dust formulations and liquid formulations is performed in this building. Mr. Griffin mentioned that completely formulated pesticides are becoming a larger proportion of his business.

Mr. Griffin said that they use xylene exclusively, because other solvents such as kerosene are not as clean or as convenient to use.

The toxaphene liquid formulation equipment consists of a mixing tank about 8 ft wide and 6 ft high. This tank is equipped with mixing facilities and is located in a pit which is about 6 ft deep. Completely mixed formulation is pumped from this equipment to a reservoir which is about three times the size of this equipment. This reservoir is equipped with three or four spigots from which 1 and 5 gal. containers can be filled.

The company has some large modernistic new equipment for the preparation of dusts. In this equipment, 90% toxaphene is sprayed into the dust in a large cylindrical piece of equipment which has a 5-ton capacity. The company formerly purchased 40% concentrated toxaphene dust from Hercules, but Mr. Griffin says that Hercules does not offer this dust concentrate anymore. This equipment is fairly standard, but Mr. Griffin would not like to have competitors obtain pictures of this equipment because of some new "wrinkles" that they have added.

The formulated dusts from the large mixer are transferred to a reservoir and are conducted to an automatic dust weighing device. This equipment is very modernistic and provides a relatively high degree of worker safety.

ADDENDUM TO PARRAMORE AND GRIFFIN REPORT

I took two photographs (2-2 and 2-3) of this plant which show the large modern buildings in which pesticides are formulated and warehoused.

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

March 1, 1976

MEMORANDUM OF PLANT VISIT

BY: Alfred F. Meiners and Thomas L. Ferguson

DATE OF VISIT: February 12, 1976

COMPANY: FMC Corporation
Agricultural Chemicals Division
1200 Talleyrand Avenue
(P.O. Box 1709)
Jacksonville, Florida 32201
(904) 353-9041

Visit Arrangements

Our arrangements to visit this plant were made by Mr. Edward E. (Gene) Hodges, Production Manager, Agricultural Chemicals Division, Southern Department, 6065 Roswell Road, N.E., Suite 737, Atlanta, Georgia 30328, (404) 256-9333.

After we made preliminary arrangements for this visit, we received a call from Mr. Neil C. Elphick of the FMC Chemical Group Headquarters, 2000 Market Street, Philadelphia, Pennsylvania 19103, (215) 299-6000. Mr. Elphick said that it would be necessary for us to write a letter of intent stating our purpose for visiting the plant, what we wish to see, and who was going to make the visit. We sent this letter of intent to Mr. Elphick by Special Delivery Service in order to obtain his decision in time to conform with our travel schedules.

Mr. Elphick called on Monday, February 9, and said that it would be acceptable for us to visit the plant as planned on February 12, but that we would need to sign a plant visit agreement for nongovernmental compliance officials. We agreed to sign this letter of intent and visited the plant on Thursday morning, February 12, 1976. Mr. Tom Ferguson and Dr. Alfred Meiners visited with Mr. Hodges, Mr. James D. Green, Plant Manager, and Mr. Frank Snowden, Assistant Plant Manager, and toured the complete plant site (~ 9.8 acres in size) which has been actively formulating pesticides for about 30 years.

Toxaphene and Cotton Production

We first discussed our reason for selecting this FMC site as a plant to visit. We told him we were looking for companies who are actually formulating toxaphene and therefore had chosen the Florida area and the Texas area. In regard to the Texas area, it was our understanding that less toxaphene was now being formulated there because of a recent switch by the farmers from primarily a cotton crop to primarily a milo crop. Mr. Hodges noted that FMC has a plant in Los Fresnos, Texas, in the Rio Grande Valley and corrected our impression by stating that the production of cotton had decreased from approximately 300,000 acres in 1974 to 70,000 acres in 1975. However, in 1976 he expected the cotton acreage to again reach 300,000 acres.

Mr. Hodges said that if we were interested in the cotton planting industry of the United States, we should be interested in an area comprising a 90 mile circle around Greenville, Mississippi. He said that this area would also include a representative portion of toxaphene formulators--from those that are very large to those that are very small. He also indicated that we could probably see all of them within a short time.

Mr. Hodges indicated that, in his opinion, DDT had been a very important pesticide for the cotton industry. DDT apparently gave considerable extension to the insect-killing lifetime of methyl parathion. Mr. Hodges did not speculate whether the extended insect-killing capability was due to the longer killing action of DDT or whether there was indeed a synergistic action. He considered toxaphene a less efficient insecticide than DDT, but in combination with methyl parathion it can replace some of the uses of DDT on cotton.

Mr. Hodges mentioned that toxaphene is the backbone of some company's operations and that if stringent discharge regulations concerning toxaphene were placed into effect, a company of this kind might be able to spend the money required to meet the toxaphene discharge standard. However, Mr. Hodges believes that most companies to whom toxaphene represents only a small part of their business would not spend this money, but would cease toxaphene formulation.

Production at the FMC, Jacksonville Plant

Mr. Green said that production of toxaphene at this site was formerly about 1 million pounds per year of the technical ingredient. This has leveled off to at present 120,000 lb/year and represents about 2 to 4% of their total volume. Their major toxaphene product, which constitutes 90 to 99% of the toxaphene they sell, is an 8 lb/gal emulsifiable concentrate. This site only produces about 10,000 lb of dust per year.

Mr. Hodges mentioned that it is tricky to manufacture toxaphene to WHO specifications. A few years ago, FMC and a number of other formulators in this area had very large contracts under which large amounts of toxaphene were shipped to Egypt.

We asked about the apparent discrepancy in that this site's major toxaphene product consists of toxaphene alone, but that the material actually applied to crops contains toxaphene along with parathion or methyl parathion. Evidently, these active ingredients are mixed together in tank-mix operations prior to application to crops. A major advantage of toxaphene, according to Mr. Hodges, is that it extends the insect-killing capacity of parathion. Parathion alone might provide insect protection for as much as 1 day, but with added toxaphene this protection can be extended up to about 4 days.

Mr. Hodges said that the total number of FMC products, i.e., labels, has decreased from 1,700 to approximately 47 at the present time.

Mr. Hodges indicated that the only formulations of toxaphene prepared at this plant are the dusts and the emulsifiable concentrate. This plant does not formulate any aldrin, dieldrin, endrin, or DDT, nor do they produce any treated seed.

Mr. Hodges indicated that the "bread and butter" of this site's operations is the sale of their own proprietary products. Losing the toxaphene business would not constitute an economic disaster to this company and is not of major concern to them. He indicated that products produced at this plant other than FMC's own proprietary products are "me too" products and the profit margins are not large for these products.

He said that there was a general trend away from secrecy among formulators. Basically they are all now selling the same formulation and the equipment is basically the same also. However, although the equipment is standard, each formulator modifies the equipment to meet his specific needs.

Mr. Hodges observed that all new pesticide products that have been placed on the market within the last few years had been put out in finished, formulated, packaged form.

Plant Tour

Mr. Hodges took us on a tour of his entire plant and we were joined during this tour by Mr. Frank Snowden, Assistant Manager. He showed us the Munson mixers where dusts are formulated at FMC. He indicated that FMC once made a 40% toxaphene dust for Hercules. He indicated that some 40% dust formulations were still made.

Mr. Hodges said that the plant is equipped with a septic tank and only sanitary wastes are disposed to this tank.

The dust formulation unit at this site is located in the same building as the warehouse. While we toured this building, they were blending captan with talc using a ribbon blender followed by an attrition mill; the formulated product was loaded into 50-lb bags. Dusts escaping from the dust unit were picked up by a vacuum system which went into a central collecting system.

Dusts are formulated at this site in 1,000-lb batches. The equipment includes a Raymond roller mill and a ribbon blender.

FMC had a fugitive dust collection piping system which carried dusts from all potential emission points within the dust unit to a central cyclone collection system. The cyclone was located outside the building. The collected dust is periodically removed from the bottom of the cyclone. Mr. Hodges said that this dust, along with other trash, is disposed of in a city dump; they have specific permission to dispose of this material in the dump. Under this agreement, however, they can dispose of no Class B poisons. The waste material is transported to the dump in their own trucks. The amount of waste dust averages 200 to 300 lb/day.

Mr. Hodges stated that the fugitive dust collected from the formulation of Class B poisons, such as parathion, is handled separately in a special collection system, and decontaminated before disposal.

Toxaphene is received by this company as the 90-10 technical material primarily by tanktrucks. It is stored in two large toxaphene tanks which contain approximately 10,000 gal. each. These tanks are surrounded by a soil dike.

Aluminum is the accepted material of construction for toxaphene storage tanks because of the corrosive properties of toxaphene.

Evaporative Waste Treatment System

The area of the plant where the liquid formulation takes place is a large roofed (but open) building approximately 40 x 60 ft. It has a concrete floor. Toxaphene is pumped to the mixing tanks by means of a dedicated pumping system. The equipment for pumping parathion is also dedicated. Spills in this area are decontaminated with caustic, lime or hypochlorite and are then washed with water to a drain which leads to a sump. Liquid from this sump is pumped to an evaporator constructed of an old converted boiler tank which has a capacity of about 4,000 gal. The tank is made of three-quarter inch steel. The tank has an opening at the

top (about 6 x 10 ft) and is covered with a semitransparent roof. The purpose of the roof is to keep out most of the rain water. The tank is equipped with a steam coil to accelerate the evaporation rate. Mr. Hodges indicated that this site has excess steam capacity, and therefore the operating cost is negligible.

Mr. Hodges indicated that the contents of this tank were acidic. He indicated that when toxaphene decomposes, hydrochloric acid is generated, accounting for the acidity.

Mr. Hodges indicated that he had not sampled the contents of this tank nor was there any easy way for it to be sampled. The water in this tank was approximately 1 to 2 ft deep. We took pictures of this piece of equipment (Photos 3-4 and 3-5).

Mr. Hodges indicated that in some of the other FMC plants, burlap wicks are used to accelerate the evaporation of the water in tanks of this kind. Mr. Hodges indicated that the type of system used at the Jacksonville, Florida, plant was the type most commonly used at other FMC formulation plants.

Plant Runoff and NPDES Permit

In regard to water pollution, Mr. Hodges indicated that 15 years ago formulators had very considerable water pollution problems. However, approximately 8 years ago, most formulators did away with the use of water in their processing. Many formulators formerly used a fire hose to clean an area and washed wastes into a nearby stream.

During the plant tour we passed over a ditch through which a small quantity of water was running. Mr. Green indicated that all of this water was generated on site, e.g., a stream was not flowing through the plant site. He also said that FMC has monitored the flow of this stream and has been required to send data to Atlanta. It was then determined that these data had been submitted in support of an NPDES permit (No. FL0025615), dated September 4, 1973. The most recent data were submitted on October 9, 1975, but consisted only of the time of monitoring, the pH of the water, and its temperature. The report was submitted to Mr. Thomas Rouzie, Engineer, Northeast Region, State of Florida, Department of Pollution Control, 3426 Bills Road, Jacksonville, Florida. Mr. Green said that the water that goes into this ditch includes tap water and cooling water. The major portion of the surface runoff from the plant also goes into this ditch. The NPDES permit indicated the flow rate of this stream to be 5 gal/min. However, Mr. Green stated that for a week or two at a time there would be no flow in this ditch at all. However, there would be considerable runoff in the event of a rain.

Mr. Green says that FMC has sampled the soil and the water in and around the ditch. He indicated that they have found toxaphene on their property, but did not find toxaphene outside their property. He indicated that the sensitivity of the method used for toxaphene was 100 ppm.

Mr. Hodges said that they occasionally check their runoff water but have not found any toxaphene in it.

The site has "clean" and "dirty" shower facilities for workers. The contaminated water from these showers and lavatories (and from the control laboratory) is sent to a separate septic tank and is not discharged to any sewer.

Postscript

We told Mr. Hodges that we would get a copy of our report to EPA to them so that they could review it and suggest clarifications or additions. Copies of the agreements that Tom Ferguson and Dr. Meiners signed are attached to this report.

i

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA-440/9-76-015	2.	3. Recipient's Accession No.

4. Title and Subtitle Wastewater Treatment Technology Documentation, Formulation of Aldrin/Dieldrin, DDT, Endrin, Toxaphene	5. Report Date Pub. June 1976 6.
7. Author(s) A. F. Meiners, C. E. Mumma , T. L. Ferguson and G. L. Kelso	8. Performing Organization Rept. No. 4127-C
9. Performing Organization Name and Address Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110	10. Project/Task/Work Unit No. 11. Contract/Grant No. 68-01-3524
12. Sponsoring Organization Name and Address Office of Water Planning and Standards U. S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460	13. Type of Report & Period Covered Interim Report, Edited 14.

15. Supplementary Notes
Some editing was performed by EPA

16. Abstracts

This report was prepared to provide technologic supporting information for toxic pollutant effluent standards proposed by EPA under §307(a) of the Federal Water Pollution Control Act Amendments of 1972. The report identifies potential technologics, assesses implementation feasibility, estimates final effluent characteristics and estimates installation and operation costs for Aldrin/Dieldrin, DDT, Endrin, Toxaphene formulation.

17. Key Words and Document Analysis. 17a. Descriptors

Waste water
Waste Treatment
Cost Analysis
Cost Comparison
Pesticides
Formulation

17b. Identifiers/Open-Ended Terms

Toxic pollutant effluent standards
Federal Water Pollution Control Act

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Releasedunlimited	UNCLASSIFIED	130
	20. Security Class (This Page) UNCLASSIFIED	22. Price $6.00

INSTRUCTIONS FOR COMPLETING FORM NTIS-35 (Bibliographic Data Sheet based on COSATI Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government, PB-180 600).

1. **Report Number.** Each individually bound report shall carry a unique alphanumeric designation selected by the performing organization or provided by the sponsoring organization. Use uppercase letters and Arabic numerals only. Examples FASEB-NS-73-87 and FAA-RD-73-09.

2. Leave blank.

3. **Recipient's Accession Number.** Reserved for use by each report recipient.

4. **Title and Subtitle.** Title should indicate clearly and briefly the subject coverage of the report, subordinate subtitle to the main title. When a report is prepared in more than one volume, repeat the primary title, add volume number and include subtitle for the specific volume.

5. **Report Date.** Each report shall carry a date indicating at least month and year. Indicate the basis on which it was selected (e.g., date of issue, date of approval, date of preparation, date published).

6. **Performing Organization Code.** Leave blank.

7. **Author(s).** Give name(s) in conventional order (e.g., John R. Doe, or J.Robert Doe). List author's affiliation if it differs from the performing organization.

8. **Performing Organization Report Number.** Insert if performing organization wishes to assign this number.

9. **Performing Organization Name and Mailing Address.** Give name, street, city, state, and zip code. List no more than two levels of an organizational hierarchy. Display the name of the organization exactly as it should appear in Government indexes such as Government Reports Index (GRI).

10. **Project/Task/Work Unit Number.** Use the project, task and work unit numbers under which the report was prepared.

11. **Contract/Grant Number.** Insert contract or grant number under which report was prepared.

12. **Sponsoring Agency Name and Mailing Address.** Include zip code. Cite main sponsors.

13. **Type of Report and Period Covered.** State interim, final, etc., and, if applicable, inclusive dates.

14. **Sponsoring Agency Code.** Leave blank.

15. **Supplementary Notes.** Enter information not included elsewhere but useful, such as: Prepared in cooperation with . . . Translation of . . . Presented at conference of . . . To be published in . . . Supersedes . . . Supplements . . . Cite availability of related parts, volumes, phases, etc. with report number.

16. **Abstract.** Include a brief (200 words or less) factual summary of the most significant information contained in the report. If the report contains a significant bibliography or literature survey, mention it here.

17. **Key Words and Document Analysis. (a). Descriptors.** Select from the Thesaurus of Engineering and Scientific Terms the proper authorized terms that identify the major concept of the research and are sufficiently specific and precise to be used as index entries for cataloging.
(b). Identifiers and Open-Ended Terms. Use identifiers for project names, code names, equipment designators, etc. Use open-ended terms written in descriptor form for those subjects for which no descriptor exists.
(c). COSATI Field/Group. Field and Group assignments are to be taken from the 1964 COSATI Subject Category List. Since the majority of documents are multidisciplinary in nature, the primary Field/Group assignment(s) will be the specific discipline, area of human endeavor, or type of physical object. The application(s) will be cross-referenced with secondary Field/Group assignments that will follow the primary posting(s).

18. **Distribution Statement.** Denote public releasability, for example "Release unlimited", or limitation for reasons other than security. Cite any availability to the public, other than NTIS, with address, order number and price, if known.

19 & 20. **Security Classification.** Do not submit classified reports to the National Technical Information Service.

21. **Number of Pages.** Insert the total number of pages, including introductory pages, but excluding distribution list, if any.

22. **NTIS Price.** Leave blank.