Pesticide Applicator Core Training Manual

Certification, Recertification and Registered Technician Training

Part A

Required reading for:

- **Private pesticide applicators**
- **Commercial pesticide applicators**
- **Registered technicians**

Part A and Part B

Required reading for:

- **Private pesticide applicators**

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Julie Stachecki Johanningsmeier, editor
2002 revisions by Carolyn J. Randall

Contributors

This manual, "Pesticide Applicator Core Training Manual: Certification, Recertification and Registered Technician Training, Parts A and B" was produced by Michigan State University, Pesticide Education Program in conjunction with the Michigan Department of Agriculture with Dr. Larry Olsen providing overall support and leadership. The following team members generously gave their time and contributed their expertise by reviewing various segments of this manual. Their input guided the creation and direction of this training material. We would like to give them distinct recognition and thanks for their commitment to assisting the Pesticide Education Program staff with this project.

Manuscript Reviewers:

Jan Castanza, Urban Pest Management, DowElanco, Bowling Green, OH

Elaine Chittenden, collections manager, Grounds Maintenance, Michigan State University, East Lansing, MI

Gina Davis, pesticide certification manager, Michigan Department of Agriculture, Lansing, MI

Tim Doppel, Atwood LawnCare, Inc. Sterling Heights, MI

Doug Foytek, Aquatrol, Inc., Clarkston, MI

Lynnae Jess, extension associate, Pesticide Education Program, Michigan State University, East Lansing, MI

Dan Rajzer, Cass county agriculture and natural resource agent, Michigan State University Extension, Cassopolis, MI

Bob Mansfield, Citizens Elevator, Vermontville, MI

George McManus III, Benton Harbor, MI

Carol Osborne, East Michigan Environmental Action Council, Grosse Pointe, MI

Greg Patchan, Oakland county agriculture and natural resource agent, Michigan State University Extension, Pontiac, MI

Natalie Rector, Calhoun county agriculture and natural resource agent, Michigan State University Extension, Marshall, MI

Paul Wylie, Allegan county agriculture and natural resource agent, Michigan State University Extension, Allegan, MI

Chapter Reviewers:

Bradley L. Aaron, academic specialist, Environmental Toxicology, Michigan State University, East Lansing, MI

Steve Allen, Countrymark Cooperative, Inc., Indianapolis, IN

Ned Birkey, Monroe county agriculture and natural resources agent, Michigan State University Extension, Monroe, MI

Ben Darling, environmental engineer, site response manager, Michigan Department of Agriculture, Lansing, MI

Mike Kamrin, professor, Environmental Toxicology, Michigan State University, East Lansing, MI

Dale Mutch, district crop integrated pest management agent, Michigan State University Extension, Hickory Corners, MI

Sandy Perry, extension associate, Pesticide Education Program, Michigan State University Extension, East Lansing, MI

Jeffrey Rohlena, Raven Industries, Sioux Falls, SD

Robin Rosenbaum, pesticide registration manager, Michigan Department of Agriculture, Lansing, MI

Brian Rowe, pesticide enforcement coordinator, Michigan Department of Agriculture, Lansing, MI

Mark Swartz, groundwater manager, Michigan Department of Agriculture, Lansing, MI

Bob Wilkinson, agricultural engineer, Agricultural Engineering, Michigan State University, East Lansing, MI.

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We would like to express our thanks to the following people for assisting in the production of this manual: Larry G. Olsen, pesticide education coordinator, Michigan State University Extension; Leslie Johnson, MSU Extension Outreach Communications; Dave Roberts, MSU Department of Botany and Plant Pathology; Gary Van Ee, MSU Department of Agricultural Engineering; Karen Renner, MSU Crop and Soil Science Department; Phil Korson, Cherry Marketing Institute; Tom Weise, Michigan Department of Natural Resources; Gary Thornton and Jim Bardenhagen, Michigan State University Extension; and Ken Dettmer, Graphicom, East Lansing, MI.

Table of Contents

STOP! Read this important information!

How to use this manual and become a certified applicator or registered technician.

This manual, *"Pesticide Applicator Core Training Manual Certification, Recertification and Registered Technician Training, Parts A and B"* is intended to prepare pesticide applicators for certification, recertification or registered technician status under Act 451, Part 83, Pesticide Control. It also satisfies the applicator training requirements of the Federal Insecticide, Fungicide, and Rodenticide Act.

Many people representing commercial and private applicators, pesticide dealers and distributors and many departments at Michigan State University (MSU), the Michigan Department of Agriculture (MDA), Extension field staff and specialists were involved with the development of this document. The format of this manual has changed to better serve all pesticide applicators. The previous versions, while giving much basic information, were slanted toward agricultural pesticide use. Recognizing that more and more applicants for certification come from areas other than agriculture, Part A of this version has taken a broad approach. The core of information it contains is, in general, necessary and applicable to the entire range of categories in which certification is granted. Part B then satisfies the information needed by private applicators to perform pesticide-related tasks safely and effectively. Commercial applicators receive category-specific pest management information in the appropriate category manuals and registered technicians receive task-specific training.

This manual is divided into two sections of study material: Part A and Part B. Information in the appendices is **not** required for the MDA certification examinations.

Part A is required reading for:

- Private pesticide applicators.
- Commercial pesticide applicators.
- Registered technicians.

Part A and Part B are required reading for:

- Private pesticide applicators.

This edition of the core manual addresses the common needs of all pesticide applicator groups (Part A) and then supplements that information for private applicators with the information in Part B.

Part A should be read by all persons preparing to take the core pesticide applicator state certification, recertification or registered technician exam.

Part B serves as supplemental information pertinent to pesticide-related tasks performed by private applicators and should be read in addition to Part A by people certifying or recertifying as private pesticide applicators.

Initial Certification Exams

There will be different versions of the core exam based on this manual. To become initially certified, *commercial applicator candidates* are required to pass an examination that reflects information in Part A of this manual. Commercial applicators also must pass an exam on the category(ies) information specific to their pest management and pesticide application tasks. Category information is presented in separate study manuals. See table on page 8.

Registered technician candidates in any category must pass an examination that tests their knowledge on the information found in Part A of this manual. Next, registered technician candidates must undergo MDA-approved category-specific training by an MDA-approved trainer.

Private applicator candidates must pass an initial core exam that will reflect information in both Part A and Part B of this manual.

Recertification Exams

This manual is used for recertification purposes, also. If recertifying by exam, commercial applicators can take a recertification exam that reflects information in Part A of this manual. They must also pass recertification exams in the categories in which they want to recertify.

Registered technicians, if recertifying by exam, can take a recertification exam that reflects information in Part A of this manual. They must also go through a refresher, MDA-approved category-specific training by an MDA-approved trainer.

Private applicators can recertify by passing a recertification core exam that reflects information in Parts A and B of this manual.

Applicators have the option of recertifying by training meeting attendance. See below.

PLEASE continue reading for more complete details on certification and recertification procedures and definitions.

Who must have certification or registered technician credentials?

Act 451, Part 83, Pesticide Control, requires any person who applies a pesticide product for a commercial purpose, or applies any pesticide in the course of his or her employment or other business activity for any purpose other than a private agricultural purpose, to be either a commercially certified applicator or a registered technician.

Pesticide applicators not required to be licensed by the act, and who use only general-use, ready-to-use pesticide products, are exempt from the certification and registered technician requirements. For example, a person who works at a hospital, school, factory, golf course, or apartment complex who uses only a general-use, ready-to-use product for controlling a pest would not be required to be a certified applicator or a registered technician. (See pp. 18 and 19 for definitions of general-use and ready-to-use pesticides.)

What is the difference between a commercial and a private applicator?

Two classes of applicators are defined under Michigan law: private and commercial. Within each class, applicators may be certified applicators or registered technicians.

1. Private applicators. Persons using or supervising the use of restricted-use pesticides in the production of an agricultural commodity on their own or their employer's land, or on lands rented by them, are private applicators. "Production of an agricultural commodity" means production for sale into commerce and includes crops, livestock, ornamentals, forest products and other products regarded as agricultural commodities.

2. Commercial applicators. A commercial applicator is any person other than private applicators applying pesticides.

Subclass A - Any person (including homeowners) who uses or supervises the use of restricted-use pesticides (RUPs) for a non-agricultural purpose.

Subclass B - Any person who either:

(i) Applies pesticides other than ready-to-use pesticides in the course of his or her employment.

(ii) Or, applies a pesticide for a commercial purpose (for hire).

Applicators included in subclass A must be certified as commercial applicators. Those in subclass B have the option of becoming certified commercial applicators or registered technicians (applicators). Because pesticides are used in a wide variety of operations, commercial applicators are certified or registered in special commodity or site-specific categories.

What is a registered technician?

The 1988 amendments to the Michigan Pesticide Control Act established a subclass of applicators called registered technicians. This classification includes people who are authorized to apply pesticides for a commercial purpose or apply general-use pesticides as a scheduled and required work assignment.

A registered technician working for a licensed pesticide applicator firm may apply general use pesticides under supervision of a certified applicator and restricted -use pesticide (RUPs) while under direct supervision. (See definitions for supervise [supervision] and direct supervision on pp. 18 and 19).

Where can I obtain pesticide applicator certification application forms?

Application forms can be obtained from the MDA or from MSU Extension offices. (See Appendix E.)

Where do I get the pesticide applicator study manuals?

Persons should obtain the training manual(s) from the Extension bulletin system. Some local Extension offices carry an inventory of select manuals. Otherwise, they will assist you in ordering what you need. Allow two weeks.

Where are the pesticide applicator exams given?

Call the regional MDA office to request a list of current test sites and dates in your area and to schedule a time to take your examination. Take your completed application form and certification fee to the exam site.

How do I recertify by training meeting attendance?

During the three-year certification period, pesticide applicators may obtain credits toward recertification by attending preapproved pesticide applicator training meetings. At the end of the certification period, if the applicator has earned the proper number of credits, he/she can be recertified without taking a recertification examination(s).

When the applicator receives a MDA renewal packet toward the end of his/her certification period, the applicator sends a check for the recertification fee and a record of the seminars and credits earned to the MDA Lansing office. After verifying the information, the MDA will mail the new credentials to the applicator.

Continued on next page ☞

Category	Training manual bulletin #	# of core credits for recertification	Category credits
Private applicators	E-2195, Part A and B	12	n / a
Registered technicians	E-2195, Part A	8 plus appropriate category credits	see below
Commercial applicators	E-2195, Part A	8 plus appropriate category credits	see below
1A Field crop	E-2034		4
1B Vegetable	E-2160		4
1C Fruit	E-2037		4
1D Livestock	E-2601		4
2 Forest	E-2045		4
2A Wood preservation	E-2046		4
3A Turfgrass	E-2327		4
3B Ornamental	E-2291		4
4 Seed treatment	E-2035		4
5 Aquatic	E-2437		4
5A Swimming pool	E-2621		4
5B Microbial	E-2435		4
5C Sewer line root control	E-2609		4
6 Right-of-way	E-2043		4
7A General	E-2048		4
7B Wood-destroying	E-2047		4
7C Contractual public health	E-2049		4
7D Vertebrate	E-2050		4
7E Interiorscape	E-2308		4
7F Mosquito	E-2180		4
7G Small animal	E-2492*		4
8 Public health	E-2049		4
9 Regulatory	E-2055		4
10 Demonstration & research	none	n / a	n / a
Aerial standard	E-2019	2	Must *also* attend one Operation Safe Fly-in *with* aircraft
Fumigation	E-2579		2

NOTE:
* This manual currently contains core information and does not require the purchase of the core manual if certifying in that category only.

Pesticide Applicator Core Training Manual

Certification, Recertification and Registered Technician Training

Part A

Required reading for:

- Private pesticide applicators
- Commercial pesticide applicators
- Registered technicians

CHAPTER PART A 1

PRINCIPLES OF PEST MANAGEMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Understand "integrated pest management" and list several management tactics that may be used in an IPM strategy.
- Explain "monitoring" as it relates to pest management and explain why it is important to pest management strategy.
- Explain why identification of the pest is an important step in developing an effective pest control strategy.
- Determine pest management goals as they relate to prevention, suppression and eradication of pests.
- Describe "thresholds" and why they are an important consideration in developing a pest management strategy.
- Avoid factors that can cause pesticide applications to fail to control pests.
- Help prevent pest resistance to pesticides.

TERMS TO KNOW

Host – A plant or animal on or in which a pest lives or feeds.

IPM – Integrated pest management.

Juvenile hormones – Natural insect chemicals that keep the earlier stages of an insect from changing into normal adult form.

Labeling – The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

Mycoplasmas – The smallest known living organisms that can reproduce and exist apart from other living organisms.

Nematodes – Small, usually microscopic, eel-like roundworms.

Nontarget organism – All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Parasite – An organism living on, in or with another living organism for the purpose of obtaining food.

Pathogen – An organism that causes disease in other organisms.

Pest – An unwanted organism (animal, plant, bacteria, fungus, etc.).

Pesticide – A substance or mixture of substances used to prevent, destroy, repel or control undesirable organisms.

Pheromones – Chemicals emitted by an organism to influence the behavior of other organisms of the same species.

Predator – An organism that attacks, kills and feeds on other organisms.

Scouting – Regular monitoring of a crop or site in a prescribed manner to determine pest population levels and the extent of pest damage.

WHAT IS A PEST?

A pest is any organism that:

- Competes with humans, domestic animals or desirable plants for food or water.
- Injures humans, animals, desirable plants, structures or possessions.
- Spreads disease to humans, domestic animals, wildlife or desirable plants.
- Annoys humans or animals.

Types of Pests

Types of pests include:

- Insects, such as roaches, termites, mosquitoes, aphids, beetles, fleas and caterpillars.
- Insectlike organisms, such as mites, ticks and spiders.
- Microbial organisms, such as bacteria, fungi, nematodes, viruses and mycoplasmas.
- Weeds, which are any plants growing where they are not wanted.
- Mollusks, such as snails, slugs and shipworms.
- Vertebrates, such as rats, mice, other rodents, birds, bats, fish and snakes.

Most organisms are not pests. A species may be a pest in some situations and not in others. An organism should not be considered a pest until it is proven to be one.

PEST MANAGEMENT STRATEGIES

Any time you are considering whether pest management is necessary, remember:

- Control a pest only when it is causing or is expected to cause more harm than is reasonable to accept.
- Use a tactic or combination of tactics that will reduce pest numbers to an acceptable level.
- Cause as little harm as possible to everything except the pest.

Even though a pest is present, it may not do very much harm. It could cost more to manage the pest than would be lost because of the pest's damage.

Pest Management Goals

Whenever you manage a pest, you will want to achieve one or a combination of these three goals:

- Prevention — keeping a pest from becoming a problem.
- Suppression — reducing pest numbers or damage to an acceptable level.
- Eradication — destroying an entire pest population.

Prevention may be a goal when the pest's presence or abundance can be predicted in advance. For example, some plant diseases occur only under certain environmental conditions. If such conditions are present, steps can be taken to prevent the plant disease organisms from harming desirable plants.

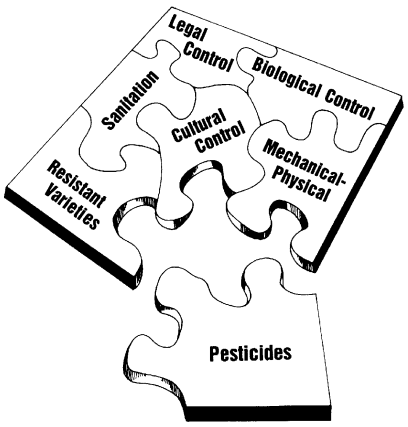
Suppression is a common goal in many pest situations. The intent is to reduce the number of pests to a level where the harm they are causing is acceptable. Once a pest's presence is detected and the decision is made that control is necessary, suppression and prevention often are joint goals. The right combination of management measures can often suppress the pests already present and prevent them from building up again to a level where they cause unacceptable harm.

Eradication is rarely a goal in outdoor pest situations because it is difficult to achieve. Usually the goal is prevention and/or suppression. Eradication is occasionally attempted when a foreign pest has been accidentally introduced but is not yet established in an area. Such eradication strategies often are supported by the government. Mediterranean fruit fly, gypsy moth and fire ant control programs are examples.

In indoor areas, eradication is a more common but still difficult goal to achieve for some pests. Enclosed environments usually are smaller, less complex and more easily controlled than outdoor areas. In many enclosed areas (dwellings, schools, office buildings, water heating and cooling systems, and health care, food processing and food preparation facilities), certain pests cannot or will not be tolerated.

INTEGRATED PEST MANAGEMENT (IPM)

Integrated pest management is the use of all appropriate and economical strategies to manage pests and their damage to acceptable levels with the least disruption to the environment. Using many different tactics to manage a pest problem tends to cause the least disruption to non-target organisms and the surroundings at the application site. Relying only on pesticides for pest control can cause pests to develop resistance to pesticides and may cause outbreaks of other pests. IPM provides the applicator with a diverse pest management program that avoids sole reliance on one technique and its potential shortcomings.



IPM involves monitoring, identifying pests, determining threshold levels, selecting management tactics evaluating the results, and keeping records.

To solve pest problems, pest managers must:

- Determine pest management goal(s).
- Detect and identify the pest(s) and determine whether control is warranted.
- Know what management strategies are available.
- Evaluate the benefits and risks of each tactic or combination of tactics.
- Choose a strategy that will be most effective and will cause the least harm to people, nontarget organisms and the environment.
- Use each tactic in the strategy correctly.
- Observe local, state and federal regulations that apply to the situation.
- Evaluate the strategy and make adjustments as necessary.
- Keep records of activities and results.

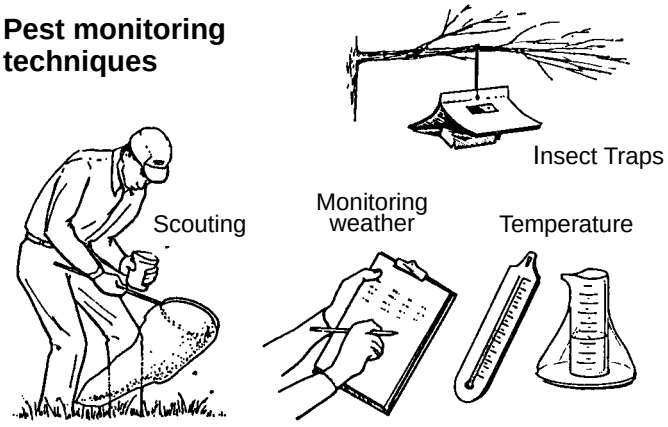
Pest Monitoring

In most pest management situations, the area to be protected should be monitored (visually inspected or scouted) often. Regular monitoring can answer several important questions:

- What kinds of pests are present?
- Are the numbers great enough to do damage and to warrant control?
- Are natural controls present and working?
- When is the right time to begin control?
- Have management efforts successfully reduced the number of pests?

Monitoring of insect, insectlike, mollusk and vertebrate pests usually is done by trapping or by scouting; weeds, by visual inspection (scouting); and microbial pest detection by looking for the injury or damage they cause or lab analysis.

Pest monitoring techniques



Environmental conditions should also be monitored in the area being managed. Temperature and moisture levels, especially humidity, are often important clues in predicting when a pest outbreak will occur or hit threshold levels.

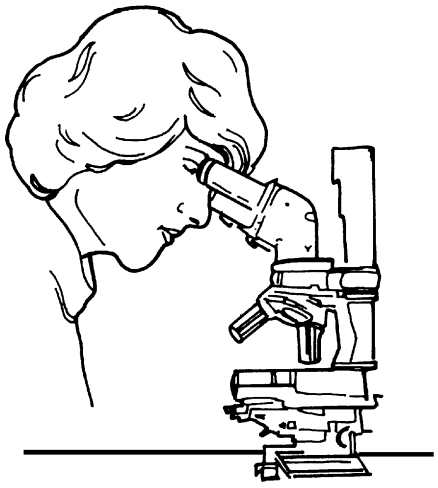
Pest Identification

Accurate identification is necessary for an effective pest management program. Never attempt a pest control program until the pest has been correctly identified. The more you know about the pest and the factors that influence its development and spread, the easier, more cost-effective and more successful your pest management will be. Correct identification of a pest allows you to determine basic information about it, including its life cycle, what stage is most destructive and when it is most susceptible to being controlled.

As a certified applicator, you need to be familiar with the pests you are likely to encounter in your line of work. To be able to identify and manage pests, you need to know:

- The physical features of the pests.
- Characteristics of the damage they cause.
- Their development and biology.
- What the pest management goal is.

An organism should not be classified or treated as a pest until it is proven to be one. A species may be a pest in some situations and not in others. If you need help identifying a pest, contact commodity or industry organizations, an Extension agent or Michigan State University.



Threshold Levels

Thresholds are the levels of pest populations at which pest management action should be taken to prevent the pests from causing unacceptable damage. These levels, which are known as "action thresholds," have been identified for many pests. Thresholds may be based on aesthetic, health or economic considerations.

A threshold often is set at the level where the economic losses caused by pest damage would be greater than the cost of controlling the pests. These types of thresholds sometimes are called *"economic thresholds."*

In some pest management situations, the threshold level is zero: even a single pest in such a situation is unreasonably harmful. For example, the presence of any rodents in food processing facilities forces action. In homes, people generally take action to control some pests, such as rodents or roaches, even if only one or a few have been seen.

In contrast, some pest species in low numbers may cause limited injury and the threshold level for taking pest management action is likely to be much higher. As the pest manager, you and your customer or client may establish the threshold that requires action.

Thresholds can vary depending on the vigor of the host, potential of injury based on environmental conditions, or the time of year.

TECHNIQUES USED IN PEST MANAGEMENT

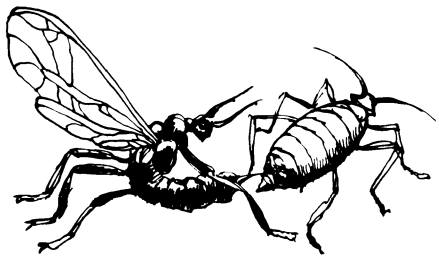
Natural and applied techniques are used to manage pests. Proper identification and knowledge of the pest's life cycle, the pest's density, and its relationship to the plant's or animal's stage of development allow applicators to choose the right tactic or combination of tactics to manage the pest in the most economical and least disruptive manner.

Natural Controls

Some natural forces act on all organisms, causing their populations to rise and fall. These natural forces act independently of humans and may either help or hinder pest control. Natural forces that affect pest populations include climate, natural enemies, natural barriers, availability of shelter, food and water supplies.

Climate — Weather conditions – especially temperature, day length and humidity – affect pests' development, activity and rate of reproduction. Pests may be killed or suppressed by rain, freezing temperatures, drought or other adverse weather.

Natural enemies — Birds, reptiles, amphibians, fish and mammals feed on some pests and help control their numbers. These are sometimes called beneficial organisms. Many predatory and parasitic insect and insect-like species feed on other organisms, some of which are pests. Pathogens often suppress pest populations.



Wasp parasitizing an aphid

It is important to identify these beneficial organisms when scouting the site. These natural enemies may already be hard at work reducing a pest outbreak, reducing or eliminating the need for intervention.

Geographic barriers — Features such as large bodies of water and mountains restrict the spread of many pests. Other features of the landscape can have similar effects.

Food and water supply — Pest populations can thrive only as long as their food and water supply lasts. Once the food source — plant or animal — is exhausted, the pests die or become inactive. The life cycle of many pests depends on the availability of water.

Shelter — The availability of shelter from predators or for overwintering can affect some pest populations.

Applied Controls

Unfortunately, natural controls often do not control pests quickly or completely enough to prevent unacceptable injury or damage. Then other management measures must be used. Those available include:

- Host resistance.
- Biological control.
- Cultural control.
- Mechanical control.
- Habitat modification and sanitation.
- Chemical control.

Host resistance — Some plants, animals and structures resist pests better than others. Use of resistant types, when available, helps keep pest populations below harmful levels by making conditions less favorable for the pests.

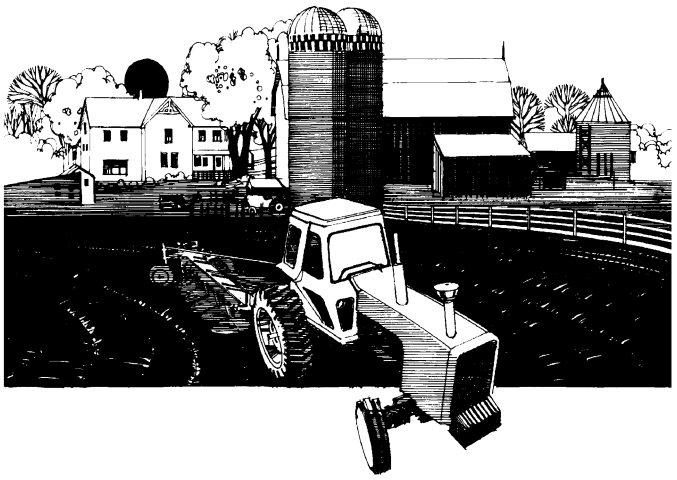
Host resistance works in three main ways:

- Chemicals in the host repel the pest or prevent the pest from completing its life cycle (some crops have this ability).
- The host is more vigorous or tolerant than other varieties and thus less likely to be seriously damaged by pest attacks (this may be true for plants and animals).
- The host has physical characteristics that make it more difficult to attack (certain buildings are designed to be less attractive or prone to insect invasions).

Biological control — Biological control involves the use of natural enemies — parasites, predators and pathogens. There is a time lag between pest population increase and the corresponding increase in natural controls. You can supplement this natural control by releasing more of a pest's enemies into the target area or by introducing new enemies that were not in the area before. The degree of control fluctuates, but, under proper conditions, sufficient control can be achieved over time.

Biological control also includes methods by which the pest is biologically altered, as in the production and release of large numbers of sterile males, and the use of pheromones or juvenile hormones.

Pheromones are chemicals emitted by an organism to influence the behavior of other organisms of the same species. Pheromones can be useful in monitoring pest populations. When placed in a trap, they can attract the insects in a sample area so that pest numbers can be estimated. Pheromones also can be a control tool. A manufactured copy of the pheromone that a female insect uses to attract males can be used to attract and trap or confuse males and so prevent mating, resulting in lower numbers of pests. Applying juvenile hormones to an area can reduce pest numbers by keeping some immature pests from becoming reproducing adults.



Cultural control — Cultural practices are used to reduce the numbers of pests that attack cultivated plants. These practices alter the environment, the condition of the host plant or the behavior of the pest to prevent or suppress an infestation. They disrupt the normal relationship between the pest and the host plant and make the pest less likely to survive, grow or reproduce. Common cultural practices include rotating crops, cultivating the soil, varying time of planting or harvesting, planting trap crops, adjusting row width, pruning, thinning, irrigating and fertilizing cultivated plants.

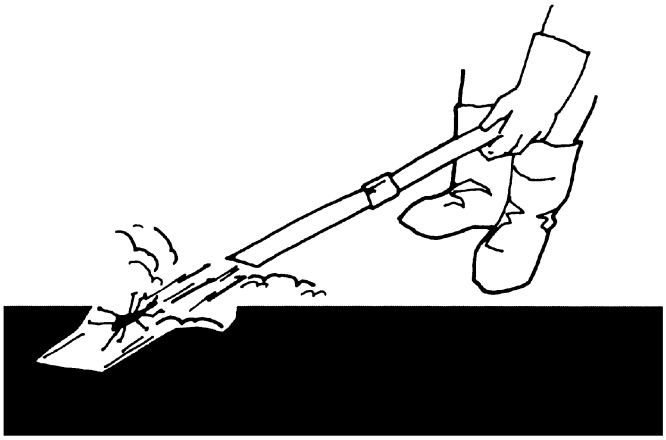
Mechanical (physical) control — Devices, machines and other physical methods used to control pests or alter their environment are called mechanical or physical controls. Traps, screens, barriers, fences, nets, radiation and electricity sometimes can be used to prevent the spread of pests into an area or to remove pests from an area.

Lights, heat and refrigeration can alter the environment enough to suppress or eradicate some pest populations. Altering the amount of water, including humidity, can control some pests, especially insects and diseases.

Habitat modification and sanitation — Sanitation practices help to prevent and suppress some pests by removing the pests themselves or their sources of food and shelter. Urban and industrial pests can be reduced by improving cleanliness, eliminating pest hiding places and increasing the frequency of garbage pickup. Management of pests attacking domestic animals is enhanced by good manure management and other sanitation practices. Carryover of agricultural pests from one planting to the next can be reduced by crop residue management or crop rotation. Modifying a structure by repairing water leaks and rotting wood can often eliminate structural pest problems.

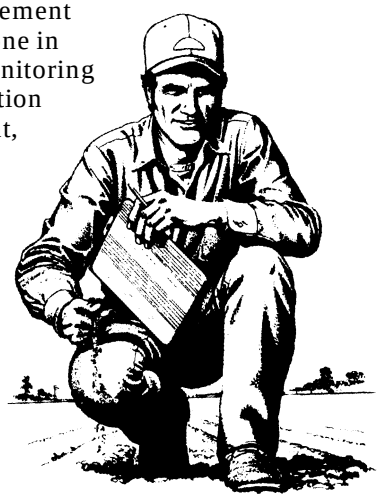
Other forms of sanitation that help prevent pest spread include using pest-free seeds or transplants and decontaminating equipment, animals and other possible carriers before allowing them to enter a pest-free area or leave an infested area. The proper design of food-handling areas can reduce access and shelter for many pests.

Chemical control — Chemical controls use naturally derived or synthetic chemicals called pesticides that kill, repel, attract, sterilize or otherwise interfere with the normal behavior of pests. In many instances, pesticides are the only control tactic available. Examples of chemical control include pentachlorophenol to protect telephone poles from wood-damaging pests, chlorine in drinking water to control bacteria, mothballs to repel clothes moths, sex pheromones of gypsy moth to reduce mating incidence, herbicides to kill weeds, insecticides to manage insects, and fungicides to manage fungal diseases.



Evaluation and Recordkeeping

It is extremely important to evaluate the results of pest management programs. This can be done in several ways, such as monitoring pest populations or infection before and after treatment, comparative damage ratings, etc. Take note of the conditions during your pest management activities such as timing, pest numbers, temperature and any other factor that may influence the outcome of your efforts. Record the results from the evaluation for future reference.



Evaluate your pest management procedures and keep records of the results.

PEST CONTROL FAILURES

Sometimes, even though you applied a pesticide or pest control method, the pest was not controlled. You should review the situation to determine what went wrong. There are several possible reasons for pest control failure.

Pest Resistance

A pesticide may fail to manage some pests because the pests have developed resistance to the product. Consider this when planning pest management programs that rely on the use of pesticides. Rarely does a pesticide application kill all the target pests. Each time a pesticide is used, it selectively kills the most susceptible pests. Some pests avoid the pesticide by escaping from the application site. Others withstand its effects. Pests that are not destroyed may pass along to their offspring the trait that allowed them to survive.

When one pesticide is used repeatedly in the same place against the same pest, the surviving pest population may be more resistant to the pesticide than the original population was. The opportunity for resistance increases when a pesticide is used over a wide geographic area or when a pesticide is applied repeatedly to a rather small area where pest populations are isolated. Rotating the pesticides used by selecting from different chemical families may help reduce the development of pest resistance. Use of controls other than pesticides helps to minimize pest control failures due to pest resistance.

Other Reasons for Failure

Make sure that the correct pesticide and the correct dosage have been used and that the pesticide was applied according to the label directions. Improper mixing of chemicals and poorly calibrated application equipment cause pest control failures. Occasionally, pesticide failure is caused by pest resistance. More commonly a pesticide application fails to manage a pest because the pest was not identified correctly and the wrong pesticide was chosen. Other applications fail because the pesticide was not applied at an appropriate time — the pest may not have been in the area during the application or it may have been in a life cycle stage that was not susceptible to the pesticide. Weather conditions (too dry, wet, hot or cold) can also cause failure. Pesticide applicators must be able to recognize when a pesticide treatment is fitting as well as when the situation is not suitable for an effective application. Misplacing a pesticide and not getting complete coverage can cause an application to fail, e.g., spraying the top of branches and leaves of a plant when the pest is on the underside.

Avoiding Harmful Effects

Pest management involves more than simply identifying a pest and using a control strategy. The treatment site, whether an outdoor area or inside a structure, usually contains other living organisms (such as people, animals and plants) and nonliving surroundings (such as air, water, structures, objects and surfaces). Most treatment sites are disrupted to some degree by pest management strategies. The actions of every type of organism or component sharing the site usually affect the actions and well-being of many others. When the balance is disrupted, certain organisms may be destroyed or reduced in number, and others — sometimes the pests — may dominate. Unless you consider the possible effects on the entire system where the pest exists, your pest management effort could cause harm or lead to continued or new pest problems. Use good judgment and, when pesticides are part of the strategy, follow the pesticide labeling for safe and effective use.

CHAPTER 1 PART A

Review Questions

Principles of Pest Management

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. What is the first thing you should do when you detect the presence of a pest?
   a. Select a control tactic.
   b. Notify the Department of Agriculture.
   c. Identify the organism and gain information about its biology.
   d. Determine the economic threshold for control.

2. How can pest identification help you develop a good pest control strategy?

3. Suppression of a pest is:
   a. Keeping a pest from becoming a problem.
   b. Reducing pest numbers or damage to an acceptable level.
   c. Destroying an entire pest population.
   d. None of the above.

4. What is a threshold as it relates to IPM?
   a. The level of pesticide required to control a pest.
   b. The levels of pest populations at which you must take pest control action to prevent unacceptable damage or injury.
   c. A type of structure designed to be more resistant to pest invasion.
   d. The levels of heat and moisture required for a pest to survive.

5. Why should you consider thresholds when you develop a pest control strategy?

6. What is pest monitoring ?
   a. Watching your pesticide application kill the pest.
   b. Recordkeeping of the pesticide used.
   c. Checking or scouting for pests in an area to determine what pests are present, how many and how much damage they are causing.
   d. Identifying the pest's predators.

7. Why is pest monitoring so important to pest management?

8. Define integrated pest management (IPM).

9. List several possible control tactics that may be used in an IPM strategy.

10. A pesticide was applied, but it did not control the pest. Name four reasons why the pesticide application might have failed to control the pest.

11. What can you do to keep the pests you are trying to control from becoming resistant to the pesticides you use?

CHAPTER PART A

2

LAWS & REGULATIONS

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Understand the laws and regulations that affect pesticide applicators.
- Evaluate your pesticide use practices and avoid uses that are inconsistent with the pesticide labeling.
- Understand the difference between restricted use pesticides and general use pesticides and who can purchase and use them.
- Know what agencies administer and enforce the laws and regulations that affect pesticide applicators.
- Understand the difference between a certified pesticide applicator and a registered technician.
- Understand the importance of having up-to-date knowledge about how to comply with all laws and regulations.

TERMS TO KNOW

Certified commercial applicator – Any person (other than private applicators) who is certified or registered to use or supervise the use of a restricted use pesticide and who is in the business of applying pesticides for others.

CZMA – Coastal Zone Management Act.

Direct supervision – When a certified applicator is supervising the application of a pesticide and is physically present at the time and the place the pesticide is being applied.

DOT – U.S. Department of Transportation.

EPA – U.S. Environmental Protection Agency.

Endangered species – A plant or animal that is in danger of becoming extinct.

FAA – Federal Aviation Administration.

FIFRA – Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

General use pesticide – A pesticide that is not classified as a restricted use pesticide.

MDA – Michigan Department of Agriculture.

MDNR – Michigan Department of Natural Resources.

MIOSHA – Michigan Occupational Safety and Health Administration.

NOAA – National Oceanic and Atmospheric Administration.

OSHA – Occupational Safety and Health Administration, part of the U.S. Department of Labor.

Private applicators – Persons using or supervising the use of restricted use pesticides to produce an agricultural commodity on their own or their employer's land, or on rented lands.

RCRA – Resource Conservation and Recovery Act — the federal law regulating the transport, storage, treatment and disposal of hazardous wastes.

Ready-to-use pesticide – A pesticide that is applied directly from its original container consistent with label directions, such as an aerosol insecticide or rodent bait box, which does not require mixing or loading prior to application.

Reciprocity – An agreement between states to allow certified applicators in one state to obtain certification credentials in the other state.

Registered technician – A classification of applicators in Michigan who are authorized to apply general use pesticides for a commercial or private purpose as a scheduled and required work assignment.

Restricted use pesticide (RUP) – Pesticides designated by the EPA for restricted use because, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to humans, could occur. A restricted use pesticide may be used only by or under the direct supervision of a certified applicator.

SARA – Superfund Amendments and Reauthorization Act — amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

State Management Plan – A written plan that establishes guidelines for activities that will protect groundwater from pesticide contamination. Required by the EPA so that states may register pesticides that pose a threat to groundwater quality.

Supervise – The act or process of a certified applicator in directing the application of a pesticide by a competent person under his or her instruction and control and for whose actions the certified applicator is responsible, even though the certified applicator is not physically present at the time and the place the pesticide applied.

USDA – U.S. Department of Agriculture.

WPS – Worker Protection Standard for agricultural pesticides

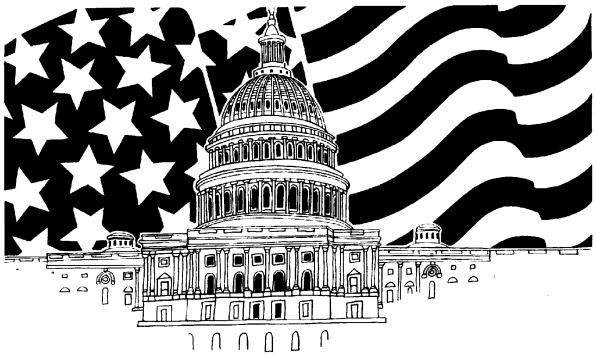
Many federal and state laws and regulations have been adopted to help protect the public, the environment, pesticide handlers and agricultural workers from possible adverse effects caused by pesticide use. In this chapter, you will learn about the state and federal laws that regulate pesticide applicators.

Keep up to date with legal requirements at all governmental levels—laws and regulations are constantly evolving as pesticide application becomes more complex and more is learned about potential hazards. Ignorance of the law is never an accepted excuse for a violation.

FEDERAL LAWS

Several federal laws regulate and set standards for pesticide use. Both state and federal agencies enforce these laws. The following sections describe requirements of pesticide laws and tell which agencies enforce them.

The U.S. Congress established the **Environmental Protection Agency (EPA)** in 1970 and has mandated that the agency regulate pesticides. Through its Office of Pesticide Programs (OPP), the EPA uses the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to carry out its mandate.



FIFRA

The basic federal law administered by the EPA in regulating pesticides is the F**ederal Insecticide, Fungicide and Rodenticide Act (FIFRA)**, enacted in 1947. This law has been amended several times since then. The Michigan Department of Agriculture (MDA) has a cooperative agreement with the EPA to enforce some provisions of FIFRA in Michigan. The major provisions of FIFRA are:

- The EPA has authority to develop rules establishing national standards for safe use, storage, transportation and disposal of pesticides.
- States may establish standards governing pesticides that exceed federal minimum standards.
- The EPA must register all pesticides before they can be sold or used.
- Pesticides must be classified as either “general use” or “restricted use”.
- Anyone who uses a restricted use pesticide must be certified in an applicable pest control category or be directly supervised by a person with such certification.
- States have the authority to certify applicators, register selected pesticides for use in those states and initiate programs designed to meet local needs.
- State Management Plans (SMP) are required for pesticides that may pose a threat to groundwater.
- Persons who misuse pesticides (in a way that is “inconsistent with the pesticide labeling”) are subject to penalties.
- Applicators who violate the provisions of FIFRA can incur a civil or a criminal penalty.

Civil penalties – A private applicator who violates FIFRA after a written warning or other citation for a prior violation may be fined up to $1,000 for each offense. A commercial applicator may be fined up to $5,000 for each offense.

Criminal penalties – An applicator who knowingly violates FIFRA is guilty of a misdemeanor. A commercial applicator may be fined up to $25,000 and imprisoned for up to one year. A private applicator may be fined up to $1,000 and imprisoned up to 30 days.

FIFRA defines the term "misuse" as "to use any pesticide in a manner inconsistent with its labeling". For more information on pesticide labels and labeling, see chapter 4, Pesticide Labeling and Registration. However, the law specifies that the following activities do not constitute misuse:

- Using a pesticide for a pest not noted on the label if the application is made to the site, system, plant or animal specified on the label (e.g., applying an insecticide labeled for use on roses to roses to control aphids, though aphids are not listed on the label).
- Any method of application unless expressly forbidden by the label.
- Using a pesticide at dosages (rates) less (but not more) than the labeled dosage (rate) or frequency.

These exemptions apply only if the pesticide is otherwise used according to the label. Do not use these exemptions unless you are certain of their results. The exempted uses may not be covered by the pesticide manufacturer's warranty.

Federal Pesticide Recordkeeping

The 1990 Farm Bill (officially called the Food, Agriculture, Conservation, and Trade [FACT] Act of 1990) mandated keeping records of RUP applications. Congress included these requirements in the Farm Bill as a response to public concerns about food and environmental safety, and as a way to acquire data to aid policymaking and the pesticide registration process. The federal pesticide recordkeeping requirements primarily affect private applicators because commercial applicators are already required to keep records by Michigan's Regulation 636 (see page 24). However, these regulations add the stipulation that commercial pesticide applicators must now provide a copy of their RUP pesticide application records to the client within 30 days. There is no required record form. Private applicators should read Part B: Laws and Regulations of this manual for more information.

SARA Title III

Title III of the federal **Superfund Amendments and Reauthorization Act of 1986 (SARA)** is also called the Emergency Planning and Community Right-to-Know act. This legislation provides a means to protect people from chemical emergencies by requiring state and local agencies to gather information about the quantities and locations of hazardous chemicals in their community. Pesticide users – including farmers, dealers and pesticide application businesses – are some of the groups that must comply with this law. The law is divided into numerous sections.

Section 302 (facility notification) requires that anyone who stores a specified quantity of an EPA-designated "extremely hazardous substance" must notify proper authorities and provide the name of the person responsible for the storage facility.

Section 304 (emergency release notification) requires that applicators or businesses report any release (spills, leaks, etc.) of an extremely hazardous substance above specific reportable quantities.

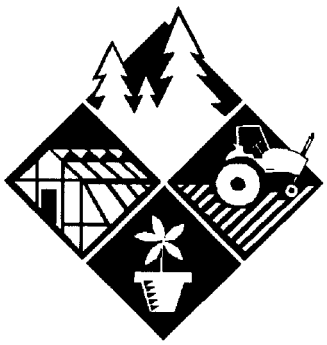
Section 311 requires that businesses that sell and store large quantities of pesticides (dealers) need to supply material safety data sheets (MSDS) or a list of the chemicals stored with specific information to the appropriate committees and the local fire department.

Section 312 requires that dealers provide an annual Tier 1 or Tier 2 inventory report form to the appropriate committees and the local fire department.

For more information on SARA Title III and the EPA-designated extremely hazardous substance (EHS) list, call the Michigan Department of Environmental Quality (MDEQ) SARA Title III office, (517) 373-8481. MSU Extension bulletin E-2575 explains SARA Title III, how to comply with its requirements and the EHS list.

Worker Protection Standards (WPS)

The **Worker Protection Standard (WPS)** is a federal regulation issued by the U.S. EPA. It covers pesticides that are used in the production of agricultural plants on farms, and in forests, nurseries and greenhouses. The WPS requires that you take steps to reduce the risk of pesticide-related illness and injury if you use such pesticides, or employ workers or pesticide handlers who are exposed to such pesticides.



WPS were revised in 1992. Some of the basic requirements the WPS establishes for employers include:

- Displaying information about pesticide safety, emergency information and recent pesticide applications on an agricultural establishment.
- Training workers and handlers about pesticide safety.
- Setting up decontamination sites.
- Compliance with restricted-entry intervals – the time immediately after a pesticide application when workers may not enter the treated area.

- Notifying workers (through posted and/or oral warnings) about areas where applications are taking place and areas where restricted-entry intervals are in effect.
- Providing personal protective equipment for pesticide handlers and for workers who enter pesticide-treated areas before expiration of the restricted-entry interval (in a few limited circumstances permitted by the WPS).

These rules apply only to persons involved with the production of agricultural plants on farms, and in forests, nurseries and greenhouses.

Agricultural custom (for hire) applicators must supply information related to pesticide applications to the agricultural customer. The owner/operator will then use this information to protect his/her workers and others. (See the chart below for a list of the information that must be provided.) In turn, the agricultural operator must supply the custom applicator with information about treated areas on the agricultural establishment, such as restricted entry intervals (REI).

WPS-required information to be provided to agricultural establishment owners and operators by custom applicators.

Location and description of area to be treated
Product name
EPA registration number
Active ingredient: common or chemical name
Application – month/day/time
Restricted entry interval: Entry restricted until – month/day/time
Whether both posting and oral notification are required
Personal protection equipment (PPE) required for handlers
Early entry PPE required for workers
Other label-specific requirements to protect workers and others

Adapted from *"The Worker Protection Standard for Agricultural Pesticides —How To Comply Manual,"* p.115.

For complete Worker Protection Standard compliance requirements, refer to the manual, **"The Worker Protection Standard for Agricultural Pesticides — How to Comply."** This manual is available for free from the EPA. It can also be ordered from Gempler's Inc. (800-382-8473).

Occupational Safety and Health Act (OSHA)

The federal **Occupational Safety and Health Administration (OSHA)** is in the Department of Labor (DOL). OSHA recordkeeping and reporting requirements apply to employers with 10 or more workers. The records must include all work-related deaths, injuries and illnesses. Minor injuries needing only first aid treatment need not be recorded. A record must be made if the injury involves any of the following:

- Medical treatment.
- Loss of consciousness.
- Restriction of work or motion.
- Transfer to another job.

Regardless of the number of employees you have, if a work-related death occurs or if five or more employees are hospitalized, OSHA must be notified within 48 hours. (Also, see Michigan Occupational Safety and Health Act in this chapter.)

Endangered Species Act

The federal **Endangered Species Act** requires the U.S. EPA to ensure that endangered species are protected from pesticides. An endangered species is a plant or animal that is in danger of becoming extinct. There are two classifications of plants and animals in jeopardy — "endangered species" and "threatened species". The term "endangered species" is used here to refer to the two classifications collectively.

The Act requires *each pesticide label* to limit its use in areas where endangered species could be harmed. These limitations usually will apply only in currently occupied habitats of the species at risk. The label may direct you to another source for detailed information about what the applicator must do. County bulletins that define habitat areas will be available from pesticide dealers or county Extension offices. For further information on endangered species, contact the U.S. Fish and Wildlife Service, Department of the Interior, at (517) 351-2555.

The Michigan Department of Natural Resources (MDNR) Land and Water Management Division administers the Michigan Endangered Species Act (Act 451, Part 365) and maintains the federal and state endangered species lists in the state. Michigan applicators who want to be sure they are complying with the act must

take the initiative and consult with the MDNR and the FWS to be sure there are no endangered species in their area. The Nature Conservancy, a private land and habitat conservation organization, is working with the MDNR and the FWS and is conducting a landowner contact program to notify and work with landowners who own property important for endangered species protection.

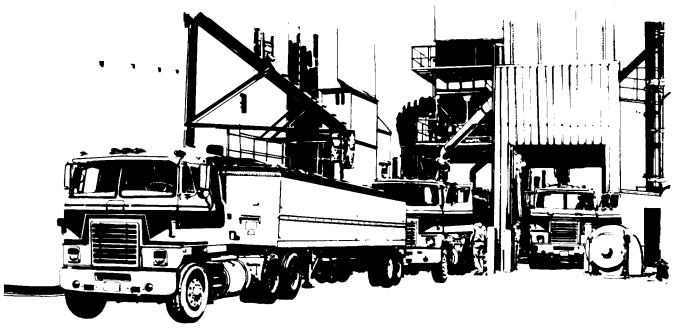
Coastal Zone Management Act (CZMA)

The EPA and the National Oceanic and Atmospheric Administration (NOAA) have identified urban runoff, agriculture, forestry and marinas as leading contributors to non-point source water pollution. (See Chapter 5: Pesticides and the Environment, p. 55, for the definitions of point and non-point source pollution.) As a result, Congress amended the Coastal Zone Management Act in 1990 by enacting Section 6217, "Protecting Coastal Waters." This provision requires Michigan and other states to develop and implement Coastal Non-point Pollution Control Programs to improve and protect water quality. These programs must be jointly approved by the EPA and the NOAA.

The pesticide management measures should minimize water quality problems by reducing pesticide use, improving timing and efficiency of application, preventing backflow of pesticides into water supplies and improving calibration of equipment. A key component of this measure is the use of integrated pest management. The penalty for states that do not comply with the program is a progressive reduction in federal funds for both the Clean Water Act and Section 306 of the Coastal Zone Management Act. For more information, contact the MDA at (517) 373-1087.

Transportation Regulations

Shipment of pesticides and other dangerous substances across state lines is regulated by the federal **Department of Transportation (DOT).** The DOT issues the rules for hauling these materials. DOT standards tell you which pesticides may create a health hazard during transportation.



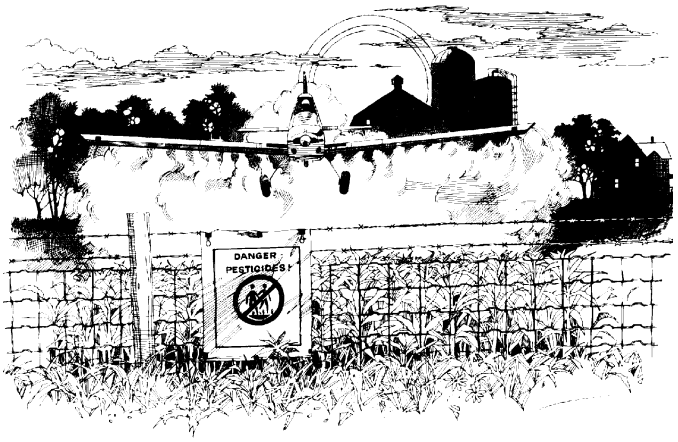
If you haul pesticides between states, you should know that:

- They must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a DOT-approved sign. Manufacturers must put the correct warning signs on each package.
- Pesticides may not be hauled in the same vehicle with food products.
- You must contact DOT immediately after an accident if:
  - Someone is killed.
  - Someone is injured badly enough to go to a hospital.
  - Damage is more than $50,000.
- You must tell DOT about all spills during shipment.

Contact a local DOT office for information on which pesticides are listed as hazardous substances and what rules apply to them during transportation. Local laws may require that additional precautions be taken.

Aerial Pesticide Applications

Application of pesticides from aircraft requires a pilot's license issued by the Federal Aviation Administration (FAA) and MDA pesticide certification including the aerial standard. Pesticide applications made from aircraft are regulated by the FAA, the MDA and the Michigan Aeronautics Commission. An aerial applicator must attend one or more annual program(s) called Operation S.A.F.E. Fly-In to recertify by seminar attendance. This program provides pilots the opportunity to fly a flight line that assists in analyzing their equipment's calibration accuracy and spray deposition. They must bring their aircraft to this program at least once during the three-year certification period and have them inspected and calibrated and must also attend a separate educational component that is held later in the year. For more information, contact the MDA at (517) 373-1087.



MICHIGAN LAWS

Michigan's environmental laws were recodified in March 1995. Two of these laws and their regulations are pertinent to pesticide use and are discussed below. The Pesticide Control Act of 1976 (Act 171, as Amended) and the Groundwater and Freshwater Protection Act (Act 247) have been incorporated as parts of Act 451, Natural Resources and Environmental Protection Act.

Natural Resources and Environmental Protection Act, Act No. 451, Part 83, Pesticide Control, Sections 8301 to 8336

The Michigan Legislature passed the Pesticide Control Act of 1976 to assure that pesticides are properly registered and applied. The Act was amended in 1988 and 1993 and recodified into Act 451, Natural Resources and Environmental Protection, Part 83 in 1995. This legislation gives the director of the MDA authority to register or certify private and commercial applicators and to prescribe standards for certification and registration. The MDA also registers, suspends and cancels pesticide registrations used in Michigan; investigates the use and misuse of pesticides; enacts rules; licenses restricted use pesticide dealers and firms performing pesticide applications for hire; and issues oral and written orders. The 1993 amendments provided the MDA the ability to develop an EPA-acceptable **State Management Plan (SMP)** for pesticides that may pose a threat to groundwater quality.

Two classes of applicators are defined under the law: private and commercial. Within each class, applicators may be certified applicators or registered technicians.

1. Private applicators. Persons using or supervising the use of restricted use pesticides in the production of an agricultural commodity on their own or their employer's land, or on lands rented by them, are private applicators. "Production of an agricultural commodity" means production for sale into commerce and includes crops, livestock, ornamentals, forest products and other products regarded as agricultural commodities.

To become a certified private applicator, an individual must complete an application form, pay a certification fee and pass a written multiple-choice/true-false examination relating to the information found in Part A and Part B of this manual.

Private applicators are required to keep pesticide application records. See the "Laws and Regulations" chapter in Part B of this manual.

2. Commercial applicators. A commercial applicator is any person other than private applicators applying pesticides.

Subclass A - Any person (including homeowners) who uses or supervises the use of restricted use pesticides (RUPs) for a non-agricultural purpose.

Subclass B - Any person who either:

(i) Applies pesticides other than ready-to-use pesticides in the course of his or her employment.

(ii) Or, applies a pesticide for a commercial purpose (for hire).

Applicators included in subclass A must be certified as commercial applicators. Those in subclass B have the option of becoming certified commercial applicators or registered technicians (applicators). Because pesticides are used in a wide variety of operations, commercial applicators are certified or registered in special commodity or site-specific categories (a list is provided in the introduction of this manual).

To become a certified commercial applicator in any category, an individual must complete an application form, pay a fee and pass a written multiple-choice/true-false examination relating to the information found in Part A of this core manual and an exam on information found in the appropriate commercial category training manual(s). Application forms can be obtained from the MDA or from MSU Extension offices. (See Appendix E.) Persons should obtain the training manual(s) from the Extension bulletin system. When you feel you understand the contents of the manual(s), call the regional MDA office and schedule a time to take the examination on this material or to receive a list of current test sites and dates. Take your completed application form and certification fee to the exam site.

Commercial applicators who purchase or apply pesticides must keep records. (See "State Law: Regulation 636" in this chapter.)

Commercial registered technicians. This classification includes people who are authorized to apply general use pesticides for a commercial purpose or apply general use pesticides as a scheduled and required work assignment. A registered technician working for a licensed pesticide applicator firm may apply general use pesticides under **supervision** of a certified applicator and restricted use pesticide (RUPs) while under **direct supervision.** (See "Terms to Know" for definitions of supervision and direct supervision). The intent of this portion of the Act is to establish minimum competency standards for all commercial applicators.

To become a registered technician in any category, you must pass an examination that tests your knowledge on the information found in Part A of this manual. Next, you must undergo category-specific training by an MDA-approved trainer.

All employees of businesses such as veterinary clinics, golf courses, outdoor and indoor pest control operations, industrial sites, hospitals, schools, municipalities, nurseries, licensed pesticide application businesses, etc., who *apply pesticides other than general use, ready-to-use pesticides* must either be certified applicators or registered technicians.

Reciprocity. Each state has its own certification regulations. An agreement between states to allow certified applicators who are residents in one state to obtain certification credentials to use pesticides without taking exams in the other state is called reciprocity. Currently, Michigan has reciprocal agreements with Indiana, Ohio and Wisconsin.

Commercial pesticide application *business* license. Any business established to apply pesticides for hire must obtain an annual **commercial pesticide applicator license** by sending an application and fee to the MDA. Such businesses must employ at least one certified commercial applicator before the license can be issued. Note that the *business* is licensed, and the applicator is certified. The business must also provide proof of insurance as required by Regulation 636 (R 285.636.14, Financial responsibility).

An applicator may not obtain a **commercial pesticide applicator license** for a business without first meeting the necessary experience requirements. Businesses applying for a license must have one person with at least two years of pesticide application experience or the equivalent, or one year of application experience and a four-year college degree in a related discipline.

Restricted use pesticide dealer's license. Any person or business wishing to sell or distribute RUPs must obtain an **RUP dealer's license** from the MDA. The licensed dealer must keep records on the sale of any RUP and submit those records each month to the MDA. It is illegal to sell or distribute RUPs to anyone who is not a certified applicator.

Penalties. Significant criminal **penalties exist for violators** of the Pesticide Control Act:

- Private and commercial applicators are subject to administrative fines of up to $1,000 per violation of any provision of the act.
- Commercial applicators who knowingly violate this act can be fined up to $5,000. If the violation is with malicious intent, the applicator can be fined up to $25,000.

The MDA is responsible for investigating pesticide misuse and failures of pesticides to perform when used in accordance with label instructions. If you have a complaint involving a pesticide or suspect pesticide misuse or failure, notify the nearest MDA office as soon as possible. Delays greatly reduce the chances of a satisfactory investigation.

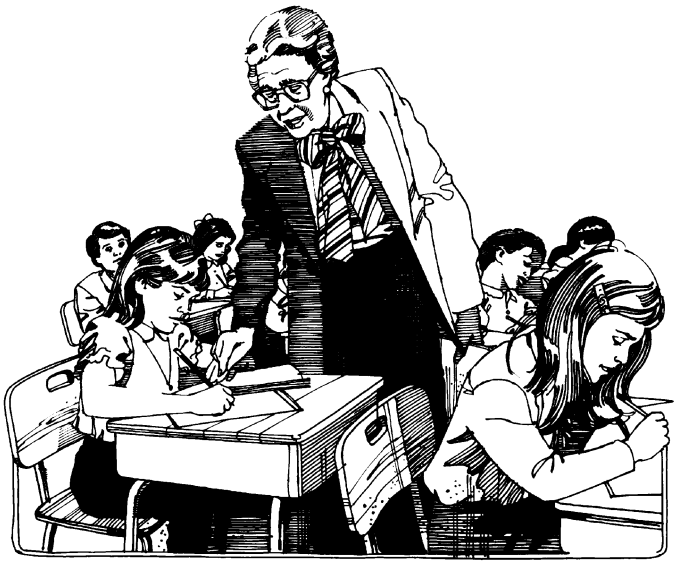
General use pesticide means a pesticide that is not classified as a restricted use pesticide.

Ready-to-use pesticide means a pesticide that is applied directly from its original container consistent with label directions, such as an aerosol insecticide or rodent bait box, which does not require mixing or loading prior to application.

According to the definitions of private or commercially certified applicators and registered technicians, persons who use only general use, ready-to-use pesticides and who are not required to be licensed as a pesticide business (a non-licensed, commercial purpose) are exempt from certification or registration requirements (e.g., hospital or school employees). Aerosols, pump sprays, strips, ready-to-use baits, etc., are included in the "ready-to-use" group. This exemption applies only to applicators who are not operating on a for-hire basis (licensed).

Preemption and local ordinances. It is illegal for a local unit of government to enact, maintain or enforce an ordinance, regulation or resolution that duplicates or conflicts with Act 451. A local government may enact an ordinance in certain situations. The Agriculture Commission must approve the local ordinance.

Pesticide use at schools. At the beginning of each school year, school administrators must notify parents and guardians of children attending that school (including day care centers) of the right to be informed prior to any application of a pesticide at that school.



Regulation 636 – Pesticide Applicators

Regulation 636 establishes the two types of certified applicators as discussed above—private and commercial. The regulation also sets the criteria for *registered* applicator standards. It states that persons who do not work for a licensed pesticide applicator and who use general use, ready-to-use pesticides are exempt from the certification or registration requirements. All other persons and businesses that apply pesticides for hire, such as using flea shampoos on animals or treating pests in agricultural

fields, homes, lawns, schools or industrial systems for pay, must satisfy the regulation's requirements. The following are some of the primary components of Regulation 636 and are not intended to represent the regulation in its entirety. Check the actual regulation for details.

Regulation 636 expanded the pesticide **recordkeeping** requirements (see Appendix C). All commercial applicators shall maintain records of pesticide use for a time period not less than the following:

General-use pesticides. One year following application.

Restricted-use pesticides. Three years following the application.

All records shall contain the following:

A. The name and concentration of the pesticide applied and the EPA registration number.

B. The amount of pesticide applied.

C. The target pest or purpose.

D. The date the pesticide was applied.

E. The address or location of pesticide application.

F. Where applicable, the method and rate of application.

The records must be made available to the MDA upon request.

Regulation 636 also enacted the **registered technician** classification for pesticide applicators as a minimum competency standard. Part of Regulation 636 and the registered technician program involves **approved trainers.**

Approved trainers are certified applicators who have two years' experience in the category they intend to train in and who have participated in a designated seminar to earn credentials making them eligible to train registered technicians.

Regulation 636 also provides an exemption from some provisions of the Act for **incidental uses.** An individual or firm may make a written request to the MDA for an exemption to the registered technician or certified applicator requirement if they meet the following conditions:

- A general use pesticide is used.
- The person is not regularly engaged in the application of pesticides for hire.
- The pesticide application is an integral part of another operation.

Regulation 637 – Pesticide Use

Regulation 637 sets standards for pesticide use. It requires that pesticides be used in a manner consistent with their labels, that applications be made in a manner that prevents off-target discharges of pesticides, and that pesticide application equipment be properly calibrated and in sound mechanical condition. Rules 4, 8, 9 and 10 apply to both private and commercial applicators. The following rules are found in Regulation 637.

RULE -

1-3. Establish definitions and terms.

4. Requires specific conduct of all pesticide applicators to protect people and the environment.

5. Establishes a registry of persons who must be notified before ornamental or turf pesticide applications occur on adjacent properties.

6-7. Require the use of containment structures for certain mixing/loading and washing/rinsing operations of commercial applicators.

8. Defines acceptable means for disposing of pesticides and pesticide-containing materials by all applicators.

9. Requires all applicators to use the personal protective equipment (PPE) required by the label and establishes minimum PPE requirements for commercial applications.

10. Addresses avoidance of off-target drift and use of Drift Management Plans by all applicators.

11. Calls for the posting of certain areas treated commercially with pesticides and notification of the public prior to right-of-way and community pesticide applications.

12. Requires commercial service agreements that include application and risk/benefit information to be supplied to the customer.

13. Prohibits false claims regarding pesticide safety.

14. Requires commercial applicator training in integrated pest management and use of IPM programs in certain areas.

15. Describes manners of commercial pesticide use in and around schools and includes requirements for providing written notification to parents (see page 24).

16. Establishes a registry of certified organic farms.

Obtain a copy of Regulation 637 to understand the components of each rule and how your pest management practices must comply. Regulation 637 became effective in 1992.

Regulation 640 – Commercial Pesticide Bulk Storage

Commercial applicators, dealers, wholesalers, and/or service-type operations that store pesticides in bulk quantities fall under the regulatory requirements of Regulation 640. If **BOTH** of the following conditions apply to your facility or operation, it must be registered annually with the MDA.

1. *Stores* pesticides in individual quantities *greater than* 55 gallons (liquid) or 100 pounds (dry).
2. Distributes these bulk pesticides as a direct sale or as part of a service you perform.

Regulation 640 sets rules for commercial pesticide storage (refer to the actual regulation for details) regarding:

- Registration.
- Siting of the storage facility.
- Primary (tanks and plumbing) and secondary containment (diking).
- Liquid level gauging.
- Venting.
- Security.
- Operational area containment (pad).
- Containment area management.
- Abandoned containers and site closure.
- Bulk dry pesticide storage.
- Discharge response plan.
- Inspection, maintenance, recordkeeping.
- Remediation.
- Advisory information (other agency regulations).

For more information, contact your local MDA office or call (517) 373-6544.

Michigan Groundwater and Freshwater Protection, Act 451, Part 87, Sections 8701 to 8717

The Groundwater and Freshwater Protection Act was enacted in 1993 and recodified into Act 451, Natural Resources and Environmental Protection Act in 1995. This Act allows the MDA to satisfy the EPA requirements for State Management Plans (SMP). The SMPs outline the actions that will be taken to prevent pesticides, particularly those that may pose a threat to groundwater, from causing environmental harm. Without the SMP, the MDA would not be able to register certain pesticides (those that may pose a threat to groundwater) for use in Michigan. Those pesticides that currently require an SMP to be in place include alachlor, atrazine, bromacil, carbofuran, cyanazine, metolachlor, metribuzin and simazine.

The Groundwater and Freshwater Protection Act allows the MDA to promote pesticide education, technical assistance and cost-share programs for persons interested in joining a groundwater stewardship program. A key component of this program is the development of groundwater stewardship practices designed to protect groundwater and be technically and economically feasible to implement. To minimize duplication, the stewardship practices will incorporate standards proposed by other state and federal laws whenever possible. Interagency groundwater stewardship "teams" ensure that standards being proposed by one agency are consistent with all others. All of these activities support the overall State Management Plan.

Information, demonstration and technical assistance programs are provided for persons interested in implementing the groundwater stewardship practices. For more information, contact the MDA Environmental Stewardship Division.

The Safe Drinking Water Act maximum contaminant levels (MCL) -1994.

Primary contaminants	Maximum contaminant level (MCL)
Organic chemicals – pesticides and PCBs	
Endrin	0.002 mg/l
Lindane	0.0002 mg/l
Methoxychlor	0.04 mg/l
PCBs	0.0005 mg/l
Toxaphene	0.003 mg/l
Silvex 2,4,5-TP	0.05 mg/l
2,4-D	0.07 mg/l
Alachlor	0.002 mg/l
Atrazine	0.003 mg/l
Chlordane	0.002 mg/l
Dalapon	0.2 mg/l
Dinoseb	0.007 mg/l
Heptachlor	0.0004 mg/l
Heptachlor Epoxide	0.0002 mg/l
Hexachlorobenzene	0.001 mg/l
Hexachloro-cyclopentadiene	0.05 mg/l
Picloram	0.5 mg/l
Simazine	0.004 mg/l

Hazardous Waste Management Regulations

The Michigan Department of Environmental Quality (MDEQ) Waste Management Division administers both the federal Resource Conservation Recovery Act (RCRA) and the Michigan Hazardous Waste Management Act (Public Act 451, Part 111 of 1994, as amended). Waste pesticides and pesticide containers are subject to regulation as hazardous waste **unless** they are disposed of properly. When waste is classified as a hazardous waste, strict disposal and handling requirements must be followed.

Empty pesticide containers that have been triple-rinsed or power-rinsed (with a high-pressure nozzle) can be recycled at an MDA pesticide container recycling program. Pesticide containers need to be triple- or power-rinsed and punctured before disposal in a regular licensed Type II sanitary landfill. Any rinsing operation should be treated as a pesticide use and done in conjunction with a pesticide application.

Remember that no free liquids can be placed in any landfill in the state. Rinsate must be disposed of properly. This is most commonly done by applying rinsate at or below label rates for an application permitted by the pesticide label. To minimize the amount of excess pesticides and avoid disposal problems, applicators are encouraged to purchase and/or mix only those pesticides and quantities they are certain to need. Properly calibrated application equipment will also help avoid having leftover material. Questions about hazardous waste requirements should be directed to the MDEQ Waste Management Division. Any spills or discharges of any polluting material (pesticides included) that will potentially reach any surface or groundwater must be controlled. Spills or discharges of pesticides should be reported to the Pollution Emergency Alerting System (PEAS) at 1-(800) 292-4706.

Michigan Occupational Safety and Health Act

The Michigan Department of Public Health (MDPH) and the Michigan Department of Labor (MDL) jointly enforce the **Michigan Occupational Safety and Health Act (MIOSHA)**, Act 154, which was amended in 1986 to include what is commonly known as the Michigan Right-to-Know Act. This act incorporated the Federal Hazard Communication Standard into the MIOSHA Right-to-Know Act.

The MIOSHA Right-to-Know Act requires employers to:

- Obtain and retain material safety data sheets (MSDS) on all hazardous chemicals (including pesticides) for employee review.
- Develop and implement a written employee training program.
- Ensure that all containers of hazardous materials are properly labeled.

Employers engaged in agricultural operations are not required to comply with the act for any hazardous chemicals regulated under FIFRA or the Michigan Pesticide Control Act. In essence, this means pesticides are not covered under the Right-to-Know law if they are used for agricultural purposes.

The law covers other hazardous chemicals used on farms, such as some petroleum products, some fertilizers and other non-pesticide chemicals. If you have concerns or complaints concerning MIOSHA Right-to-Know provisions, contact either the MDPH Division of Occupational Health at (517) 335-8250, or MDL Division of Safety Standards at (517) 322-1831.

CHAPTER 2 PART A

Review Questions

Pesticide Laws & Regulations

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. The basic federal law regulating pesticides is referred to as:
   a. FFDCA
   b. FIFRA
   c. MPCO
   d. USEPA

2. What federal government agency is mandated to regulate pesticides and pesticide use?
   a. DOT
   b. USDA
   c. MDA
   d. EPA

3. Restricted use pesticides can be sold only for use by or under the direct supervision of:
   a. Government agencies
   b. Private applicators
   c. Commercial applicators
   d. Certified applicators

4. Records of restricted use pesticide applications must be made and kept by all applicators. (True or False?)

5. Which of the following would be considered a "misuse" of a pesticide?
   a. Treating for a pest not noted on the label but the site is specified on the label.
   b. Using a pesticide at a less frequent interval than specified on the label.
   c. Using a pesticide at a dosage rate lower than recommended on the label.
   d. Using a pesticide at a lower dosage rate but more frequently than directed on the label.

6. Where can the EPA "extremely hazardous substance" list be obtained?

7. SARA Title III requires that _____ who store(s) a specified quantity of an EPA designated "extremely hazardous substance" must notify proper authorities.
   a. Commercial applicators
   b. Schools
   c. Farmers
   d. Anyone

8. OSHA requires that anyone with 10 or more employees keep records and make periodic reports of all work-related deaths, injuries and illnesses. What are the guidelines for whether an injury must be recorded to comply with OSHA regulations?

9. The Worker Protection Standard applies to pesticides that are used in the production of agricultural plants on farms, and in forests, nurseries or greenhouse. (True or False?)

10. If pesticides are hauled between states:
    a. They must be in their original containers.
    b. They cannot be hauled in the same vehicle with food products.
    c. And a spill occurs, you must report it to the DOT.
    d. All of the above.

11. For each pesticide product that has an effect on an endangered species, the Endangered Species Act required that the pesticide labeling include a list of states and counties where the product affects the endangered species and pesticide application is restricted. (True or False?)

12. The Coastal Zone Management Act:
    a. Is a state law that affects Michigan's rivers and streams.
    b. Requires states to develop and implement programs to prevent nonpoint source pollution.
    c. Has no penalties for non-compliance.
    d. Has nothing to do with integrated pest management.

13. Who administers the pesticide applicator certification program in Michigan?

14. In Michigan, there are three types of pesticide applicator credentials. What are they?

    1.

    2.

    3.

15. Any person (including homeowners) who uses or supervises the use of RUPs for a non-agricultural purpose is a:

    a. Private applicator

    b. Commercial applicator

16. Persons who apply pesticides for hire (license required) must be either certified or registered. (True or False?)

17. Commercial applicators are not required to keep records of RUP applications. (True or False?)

18. Which two of the following require posting of treated areas as a means of notification that a certain type of pesticide application has occurred?

    a. Hazardous waste regulations

    b. Regulation 640

    c. Regulation 637

    d. WPS

19. Any business established to apply pesticides for hire must obtain a Michigan commercial pesticide applicator license:

    a. Annually.

    b. At least once.

    c. Every three years.

    d. Every two years.

20. Commercial and private applicators may be fined for violation of Act 451, Natural Resources and Environmental Protection, Part 83, Pesticide Control.

    (True or False?)

21. Who investigates complaints about pesticide misuse and pesticide failures?

22. The _____administers both the federal (RCRA) and state (Act 64) hazardous waste regulations.

23. Plastic pesticide containers may be recycled only if they have been triple-rinsed or power-rinsed and there are no visible signs of residue. (True or False?)

24. Which state law requires employers to obtain and retain MSDS sheets on all hazardous chemicals on site?

25-30. Match the following laws and regulations with the appropriate description.

___ 25. FIFRA

___ 26. Regulation 640

___ 27. Michigan Groundwater and Freshwater Protection Act

___ 28. Endangered Species

___ 29. Natural Resources and Environmental Protection Act 451

___ 30. Regulation 636

a. To obtain the goal of this law will require some limitations on pesticide use in or near certain plant or animal habitats.

b. Federally defines the term “misuse” as “to use any pesticide in a manner inconsistent with its labeling.”

c. Defines and enacts the registered technician type of pesticide applicators and expanded the pesticide recordkeeping requirements for commercial applicators.

d. Considers quantities of pesticides greater than 55 gallons (liquid) or 100 pounds (dry) as bulk quantities.

e. Allows state groundwater protection plans to be developed to satisfy federal pesticide registration requirements.

f. Requires any business established to apply pesticides for hire to obtain an annual commercial pesticide applicator license.

CHAPTER PART A

3

PESTICIDES

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Explain a few ways that pesticides are classified.
- Be familiar with terms used to describe pesticides.
- Explain what organic and inorganic pesticides are and provide examples.
- Know some characteristics of microbial pesticides.
- Explain how using pesticides with different modes of action will help prevent pest resistance.
- Understand the difference between contact and systemic pesticides and how they control pests.
- Explain what a pesticide formulation is.
- Distinguish between active and inert ingredients.
- Identify the factors to consider when choosing a formulation.
- Use your knowledge of the characteristics, advantages and disadvantages of different types of pesticide formulations to select appropriate formulations for specific purposes.
- Explain how and when pesticides may be incompatible.
- Perform a test to determine whether two pesticides can be safely mixed together for application.
- Understand the purpose of adjuvants and list several types.

TERMS TO KNOW

Abrasive – Capable of wearing away or grinding down another object.

Acidic – Having a pH less than 7.

Agitation – The process of stirring or mixing.

Alkaline – Having a pH greater than 7.

Botanical pesticide – Organic pesticides derived or extracted directly from plants.

Broad-spectrum pesticide – A pesticide that is effective against a wide range of pests or species.

Carrier – The primary material used to allow a pesticide to be dispersed effectively; for example, the talc in a dust formulation, the water mixed with a wettable powder before a spray application, or the air that disperses a pesticides from an airblast sprayer.

Contact pesticide – A pesticide that kills pests simply by contacting them.

Dilute – To make less concentrated.

Emulsion – A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other.

Inorganic – Of mineral origin; does not contain carbon.

Insoluble – Does not dissolve in liquid.

Microbial pesticides – Bacteria, viruses and fungi used to cause disease in some pests.

Nonpersistent pesticide – A pesticide that breaks down quickly after it is applied.

Nonselective pesticide – A pesticide that is toxic to most plants, insects or animals.

Nontarget- Any site or organism other than the site or pest toward which the control measures are being directed.

Organic – Containing carbon.

Persistent pesticide – A pesticide that remains active for a period of time after application and gives continued protection against a pest.

Pesticide – Substances or mixtures of substances intended to prevent, destroy, repel or mitigate pests.

Pesticide handler – Person who directly works with pesticides, such as during mixing, loading, transporting, storing, disposing and applying, or working on pesticide equipment.

Petroleum-based – Made from petroleum products. Examples are: xylene, refined oil and kerosene.

Phytotoxicity – Injury to plants due to chemical exposure.

Protectant pesticide – Pesticide applied to a target site to prevent pest establishment.

Restricted-use pesticide (RUP) – Pesticides designated by the EPA or the State for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, could occur. A "restricted-use" pesticide may be used only by or under the direct supervision of a certified applicator.

Selective pesticides – A pesticide that is more toxic to some kinds of plants and animals than to others.

Soluble – Able to be dissolved in another substance, usually a liquid.

Solvent – A liquid, such as water, kerosene, xylene or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Sterilant – A pesticide that renders a pest incapable of reproduction.

Suspension – A substance that consists of undissolved particles mixed throughout a liquid.

Synthetic – Man-made.

Systemic pesticide – A pesticide that is taken into the blood of an animal or the sap of a plant.

Target pest – The pest toward which control measures are being directed.

Volatile – Evaporating rapidly; turning easily into a gas or vapor.

Pesticides are substances or mixtures of substances intended to prevent, destroy, repel or mitigate pests. Though the ending "cide" is derived from the Latin word cida, meaning "to kill," not all pesticides actually kill the target organism. For example, some fungicides may simply inhibit the growth of a fungus without killing it; attractants and repellents lure a pest to or divert it from a particular site. In addition, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) has extended the legal definition of "pesticide" to include compounds intended for use as plant growth regulators, defoliants or desiccants.

In this chapter, you will learn how pesticides are classified, the types of formulations, compatibility complications and some special concerns about pesticide use.

CLASSIFICATION

"Pesticide" is a broad term representing many types of chemicals used for pest control. Pesticides are classified according to a number of methods – function (e.g., growth regulator, defoliant); pests managed (e.g., insecticide, rodenticide); mode of action (e.g., sterilant, stomach poison); application technique (foliar or soil); and chemistry. Pesticides are also classified by the EPA and the state for registration purposes as "unclassified" or "general use" or as "restricted use" pesticides. Most commonly, pesticides are classified by the group of pests managed – insects, fungi, etc.

Types of Pests Managed

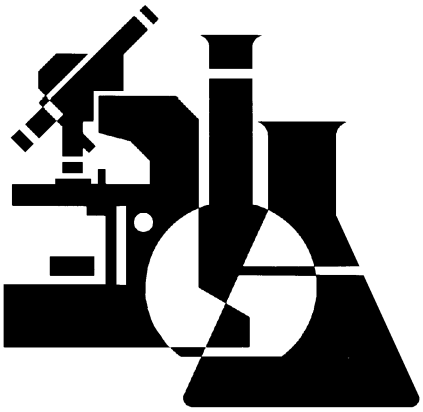
Pesticides commonly are classified according to the types of pests they control or the function they perform. For instance:

Pesticide classification	Pests managed
Algaecide	Algae
Biocide	Microbial organisms
Fungicide	Fungi
Insecticide	Insects & other related animals
Herbicide	Weeds
Miticide	Mites
Nematicides	Nematodes
Rodenticide	Rodents
Avicide	Birds
Piscicide	Fish
Molluscicide	Slugs & snails
Ovicide	Eggs of organisms
Predacide	Vertebrates

Other chemicals classified as pesticides not bearing the -cide suffix	Function
Growth regulator	Modifies plant or insect development
Defoliant	Removes plant foliage
Desiccant	Dries plant foliage
Repellent	Diverts a pest
Attractant	Lures a pest
Pheromone	May attract pests or disrupt behavior
Sterilant	Renders pest unable to reproduce

Pesticide Chemistry

Pesticides can be divided into chemical groups. The most basic chemical difference is whether a compound is organic or inorganic.



Inorganic pesticides are of mineral origin and therefore do not contain carbon. They commonly contain either arsenic, copper, boron, mercury, sulfur, tin or zinc. Examples are sulfur dust, Bordeaux mix and Paris green. Inorganic pesticides are used today primarily to manage plant diseases. They are not, however, very specific in their activity and may be toxic to a wide range of organisms (broad-spectrum), a characteristic that is often not desirable. They are generally less effective than many of the organic compounds. Some do offer the advantage of relatively low acute toxicity to humans, though compounds containing lead, mercury and arsenic have generated widespread health-related and environmental concerns and their uses have been banned or severely curtailed.

Organic pesticides contain carbon. Organic pesticides can have natural origins or can be man-made. They also contain hydrogen and often oxygen, nitrogen, phosphorus, sulfur or other elements. Most pesticides in use today are organic compounds. "Organic" does not necessarily mean "all natural," and use of these materials should not be represented in any way other than factually.

Botanical pesticides are organic and are either derived or extracted directly from plants (e.g., rotenone, nicotine, pyrethrins and strychnine).

Microbial pesticides are a distinct group of pest management compounds. These are simply bacteria, viruses and fungi that cause disease in given pest species. Though they may occur naturally in certain areas, they are mass produced and intentionally introduced by humans in sufficient quantities so that a relatively high level of control becomes possible. Their activity tends to be highly specific, and they are often harmless to nontarget species. There are, however, only a few microbial pesticides registered for use at this time. Perhaps the best known example is the bacterium *Bacillus thuringiensis* (Bt), which has been used effectively against some species of caterpillars, including the gypsy moth.

Pesticides can be categorized according to their chemical structure. Most pesticides used today are **synthetic** or man-made organic compounds. Since the 1940s, pesticide use has expanded because of the development of the synthetic organic compounds. The synthetic organic pesticides (i.e., man-made, carbon-containing chemicals) include the chemical groups chlorinated hydrocarbons, organophosphates, carbamates, pyrethroids, phenoxy herbicides and a number of other chemical classes. Groups with similar chemical structure tend to be similar in their mode of action, fate in the environment and pest control properties, but not necessarily in level of toxicity. Though pesticides may have different chemical structures, they can have similar modes of action. This is important to distinguish when switching between products to avoid pest resistance.

Pesticide Mode of Action and Other Pesticide Functions

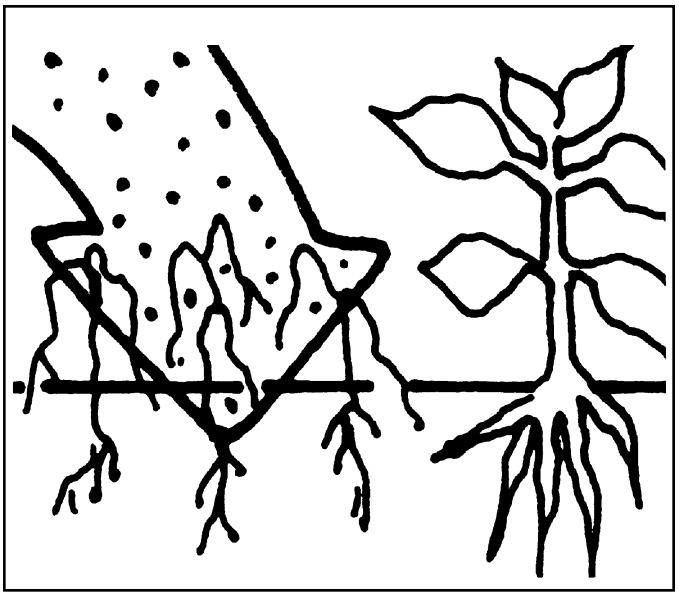
Several common terms describe how pesticides interact with the site, host plant or animal, target pest and environment. Certain terms listed below are more appropriate to a specific functional class of pesticide – such as insecticide, fungicide or herbicide – than to others.

A pesticide's **mode of action** is the method by which it kills or adversely affects the target pest. For instance, an insecticide may act as a stomach poison, a herbicide may prevent root development in seedlings or a biocide may disrupt cell membranes of microorganisms. Pesticides may be grouped or classified by their mode of action. Some examples of various modes of action are listed below.

Protectants – Pesticides applied to plants, animals, structures, mechanical systems and products to prevent pest establishment are considered protectants. These may include repellents. Many fungicides are used as protectants and are intended to be applied before or during infection of the host by the pathogen. Biocides are added to water treatment systems to prevent microbial buildup. Wood products may be protected with pesticides to prevent insect infestations and rots caused by fungi.

Sterilants – Pesticides that manage pests by rendering them incapable of normal reproduction are known as sterilants. "Sterilant" may also describe a pesticide that eliminates all pests from a given environment, such as a soil sterilant.

Selective – A pesticide is selective if it is effective against one type of organism and not another. For instance, microbial insecticides are usually specific to a given species but are not harmful to other insect species. Herbicides that control one plant without harming other plants close by demonstrate selective control. Selectivity can be accomplished through the pesticide's chemistry, timing and/or placement, environmental conditions and characteristics of the target pest.



Selective Herbicide.

Nonselective – When a pesticide kills or adversely affects many organisms in a target site, it is considered nonselective. Where no plant growth is wanted – such as in fencerows, ditch banks and greenhouse floors – a nonselective herbicide may be used.

Broad-spectrum – Pesticides that control a wide range of pests are considered broad-spectrum. They are sometimes labeled as multipurpose pesticides. A material capable of controlling scab and powdery mildew on apples, for example, is broad-spectrum. Many insecticides are broad-spectrum because they are effective against more than one type of insect. This category of pesticides is somewhat more general than the others – a broad-spectrum material may be a protectant, a contact pesticide or systemic in its action.

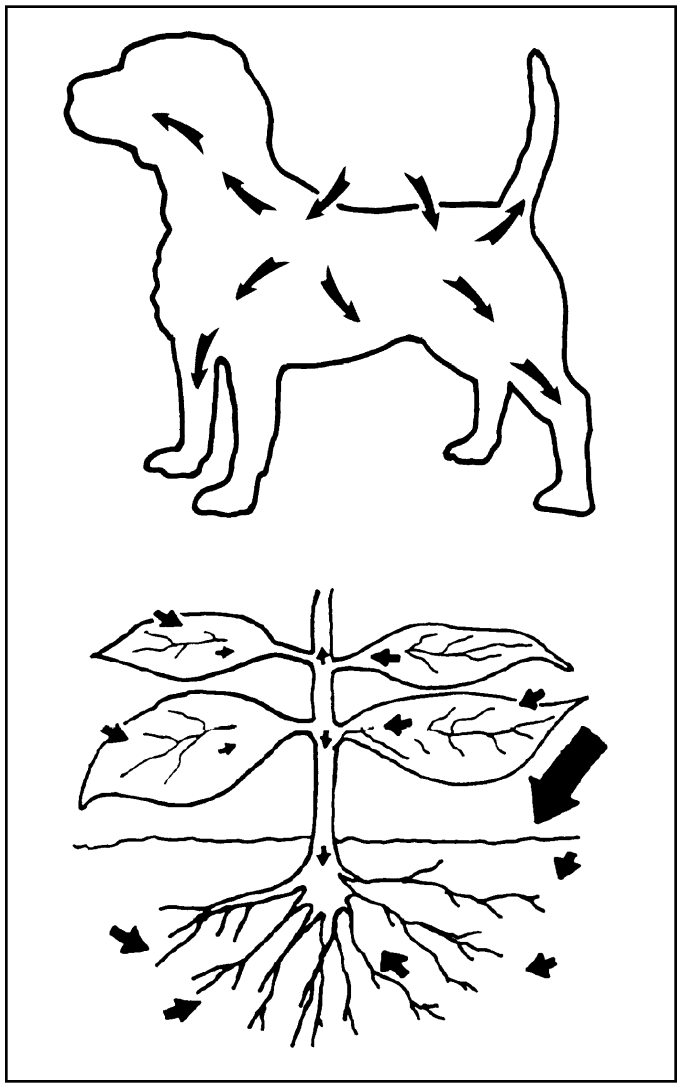
Contact – Pesticides that kill or adversely affect pests simply by contacting them are known as contact pesticides.

Systemic – Pesticides that are absorbed by one part of the animal or plant and distributed internally to other parts of the animal or plant are systemic pesticides. These can kill the pest without harming the host. Examples include heartworm control in dogs and insecticide treatments in trees for control of boring insects. Systemic herbicides are effective in controlling perennial weeds. They are absorbed and then translocated through the weed, including into the root system, distributing the chemical throughout, to kill all parts of the plant.

Persistent – Persistent pesticides remain active for a period of time after application and give continued protection against the pest. These may also be referred to as residual pesticides. Persistence may range from a few days, such as a fungicide on plant foliage, to a few years, such as a herbicide used under asphalt or along a fencerow.

Nonpersistent- Pesticides that control pests at the time of application and then break down quickly are nonpersistent.

Many synthetic organic pesticides work in one or more of the ways listed above. For example, a pesticide may be a nonselective, contact and persistent chemical. Another product may be persistent, a protectant and a sterilant. Read the pesticide label or ask the chemical manufacturer's representative to learn how a pesticide will act once it's applied.



Systemic pesticides are absorbed into the organism.

How Pesticides Work

Type of pesticide	Mode of action
Protectant	Prevents pests from becoming established.
Sterilant	Renders pests incapable of normal reproduction; or eliminates all pests from a given area (e.g., soil sterilant)
Selective	Effective against one type of organism and not another
Nonselective	Kills or adversely affects many organisms in a target site.
Broad-spectrum	Controls a wide range of pests: sometimes labeled as *multipurpose pesticides.*
Contact	Kills pests by coming into contact with them.
Systemic	Absorbed into and moves (translocates) throughout the host or target pest.
Persistent	Remains active for a period of time after application.
Nonpersistent	Controls pests at time of application and then breaks down rapidly.

Pest Resistance

When making repeated pesticide treatments to a system or area for the same pest, using pesticide products with *different* modes of action as well as other pest control methods (such as sanitation, crop rotation, etc.) is recommended. When one pesticide is used repeatedly in the same place against the same pest, surviving pest populations may be more resistant to the pesticide than the original population was. If chemicals with different modes of action are used, there is less chance for the pest population to develop resistant traits. Using other pest control methods can help reduce overall pest resistance.

Pest resistance is a problem now. Triggered by pesticide use patterns, certain turfgrass diseases show resistance to the fungicides that once provided control. Weeds resistant to herbicides can be found in field crops, and resistant insect populations occur in orchards and vegetable crops. Resistant microbial organisms in water treatment systems have developed after repeated use of products with one mode of action. Refer to labels, Extension bulletins, specialists or chemical sales representatives to determine the mode of action of the chemicals you use. Alternate among them, use the lowest effective rates, spot-treat when possible and combine pesticide treatments with non-chemical pest management strategies to reduce the development of pest resistance to pesticides.

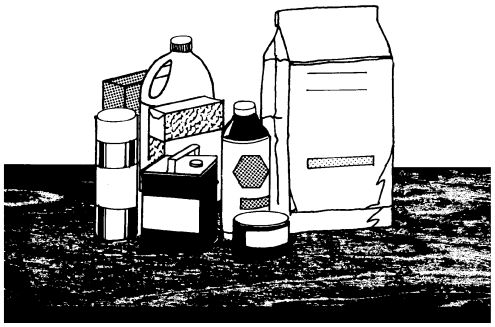
PESTICIDE FORMULATIONS

Pesticides may be referred to or classified based on their formulation. The component of a pesticide that controls the target pest is called the **active ingredient** (a.i.). During the manufacturing process, active ingredients are mixed with liquid or dry inert ingredients, which are non-pesticidal. Though inert ingredients do not kill the pest, they may be capable of adverse environmental and human health effects. Mixtures of active and inert ingredients are called **pesticide formulations.** Formulations may make an active ingredient safer to handle, more effective, easier to measure, mix and apply, and, in some cases, more attractive to the pest. A variety of formulations are described in the next section.

Formulations

A single active ingredient may be sold in several different kinds of formulations. It is important to choose the formulation that is best for your particular pest management situation. Before you make the choice, ask yourself several questions. For example:

- Do you have the necessary application equipment?
- Can the formulation be applied safely under the conditions in the application area?
- Will the formulation reach your target and stay in place long enough to control the pest?
- Is the formulation likely to harm the surface to which it will be applied?
- What is the most economical formulation you can use to achieve effective control with the least hazard?



To answer these questions, it is helpful to know the characteristics of different types of formulations and the general advantages and disadvantages of each type.

Liquid Formulations

Emulsifiable concentrates (EC or E)

An emulsifiable concentrate formulation usually contains a liquid active ingredient, one or more petroleum-based solvents and an agent that allows the formulation to be mixed with water to form an emulsion. An emulsion is one liquid dispersed, usually as very small drops, throughout another liquid. EC's mix with water to form a milky emulsion. Each gallon of EC usually contains 25 to 75 percent (2 to 8 pounds) active ingredient. EC's are among the most versatile formulations. They are used against agricultural, ornamental and turf, forestry, structural, food processing, livestock and public health pests. They are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers and low-volume aircraft sprayers.

Advantages:

- Relatively easy to handle, transport and store.
- Little agitation required — will not settle out or separate when equipment is running.
- Not abrasive.
- Do not plug screens or nozzles.
- Little visible residue on treated surfaces.

Disadvantages:

- High concentration makes it easy to overdose or underdose through mixing or calibration errors.
- May be phytotoxic (cause unwanted chemical damage) to plants.
- Easily absorbed through skin of humans or animals.
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate.
- May cause pitting or discoloration of painted finishes.
- Flammable — should be used and stored away from heat or open flame.
- May be corrosive.
- When EC's are combined with other products, particularly liquid fertilizers, compatibility can be a problem. Therefore, special mixing, agitation or compatibility agents may be needed to prevent separation. Compatibility and mixing pesticides of different formulations will be discussed later in this chapter. See Appendix D for information on mixing pesticides with liquid fertilizers.

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based solvent. When mixed with the solvent, they form a solution that will not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the solvent, and one or more other ingredients. Solutions may be used in any type of sprayer indoors or outdoors.

Ready-to-use (RTU) solution — Some solutions are products that contain the correct amount of solvent when purchased, requiring no further dilution before application. These formulations contain small amounts (often 1 percent or less) of active ingredient per gallon.

Concentrate solutions (C or LC) — Other solutions are sold as concentrates that must be further diluted with a liquid solvent before application. Occasionally the solvent is water, but more often the solvent is a specially refined oil or petroleum-based solvent.

Some uses of solutions are:

- Control of some household pests.
- Livestock and poultry pest control.
- Shade tree pest control.
- Mosquito control.

Advantages:

- No agitation necessary.

Disadvantages:

- Limited number of formulations of this type available.

Ultra-low-volume (ULV)

These concentrates may approach 100 percent active ingredient. They are designed to be used as is or to be diluted with only small quantities of specified solvents. These special purpose formulations are used mostly in outdoor applications, such as in agricultural, forestry, ornamental and mosquito control programs.

Advantages:

- Relatively easy to handle, transport and store.
- Little agitation required.
- Not abrasive to equipment.
- No plugging of screens and nozzles.
- Little visible residue on treated surfaces.

Disadvantages:

- Difficult to keep pesticide in the target site — high drift hazard.
- Specialized equipment required.
- Easily absorbed through skin of humans or animals.

Flowables (F or L)

Some active ingredients are insoluble solids. These may be formulated as flowables in which the finely ground active ingredients are mixed with a liquid, along with inert ingredients, to form a suspension. Flowables are mixed with water for application and are similar to EC formulations in ease of handling and types of pest control operations.

Advantages:

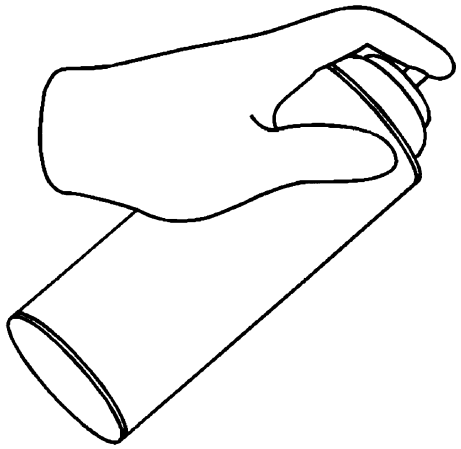
- Seldom clog nozzles.
- Easy to handle and apply.

Disadvantages:

- Require moderate agitation.
- May leave a visible residue.

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of aerosol formulations — the ready-to-use type, and those made for use in smoke or fog generators.



Ready-to-use aerosols — These aerosol formulations are usually small, self-contained units that release the pesticide when the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.

Advantages:

- Ready to use.
- Easily stored.
- Convenient way to buy small amount of a pesticide.
- Retain potency over fairly long time.

Disadvantages:

- Practical for very limited uses.
- Risk of inhalation injury.
- Hazardous if punctured, overheated or used near an open flame.
- Difficult to confine to target site or pest.

Formulations for smoke or fog generators — These aerosol formulations are not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly for insect control in structures such as greenhouses and warehouses and for mosquito and biting fly control outdoors.

Dry Formulations

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredient (usually 1/2 to 10 percent), plus a very fine, dry, inert carrier made from talc, chalk, clay, nut hulls or volcanic ash. The individual dust particles vary in size.

Dusts are always used dry, and they easily drift into nontarget sites. They sometimes are used for agricultural applications. In structures, dust formulations are used in cracks and crevices and for spot treatments. They are widely used in seed treatment. Dusts also are used to control lice, fleas and other parasites on pets and livestock.

Advantages:

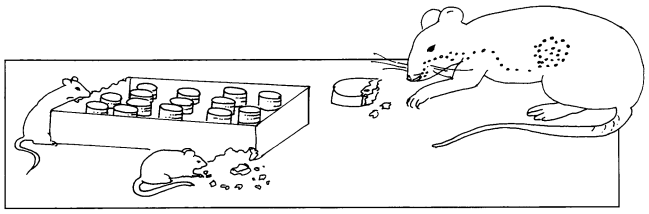
- Usually ready to use, with no mixing. (Note: if the dust is applied with equipment that requires "loading" prior to application, then it would not be an RTU; e.g., a bulb duster.)
- Effective where moisture from a spray might cause damage.
- Require simple equipment.
- Effective in hard-to-reach indoor areas.

Disadvantages:

- Easily drift off target during application.
- Residue easily moved off target by air movement or water.
- May irritate eyes, nose, throat and skin.
- Do not stick to surfaces as well as liquids.
- Difficult to get an even distribution of particles on surfaces.

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Pests are killed by eating the pesticide the bait contains. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent.



Baits are used inside buildings to control ants, roaches, flies and other insects, and rodents. Outdoors they sometimes are used to control snails, slugs and some insects, but their main use is for control of vertebrate pests such as rodents, other mammals and birds.

Advantages:

- Ready to use. (Note: if the bait is packaged in bulk amounts and then transferred or loaded into individual bait boxes, it is not an RTU.)

- Entire area need not be covered, because pest goes to bait.
- Control pests that move in and out of an area.

Disadvantages:

- Can be attractive to children and pets.
- Domestic animals and nontarget wildlife may encounter and be killed by baits more readily than other formulations outdoors.
- Pest may prefer the crop or other food to the bait.
- Dead pests may cause odor problem if not disposed of properly.
- Other animals may be poisoned as a result of feeding on the poisoned pests.
- If baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests.

Granules (G)

Granular formulations are similar to dust formulations except that granular particles are larger and heavier. The coarse particles are made from an absorptive material such as clay, corn cobs or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1 to 15 percent.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes and insects living in the soil. Granular formulations are sometimes used in airplane or helicopter applications to minimize drift or to penetrate dense vegetation.

Granular formulations also are used to control larval mosquitoes and other aquatic pests. Granules are used in agricultural, structural, ornamental, turf, aquatic, right-of-way and public health (biting insect) pest control operations.

Advantages:

- Ready to use – no mixing. (Note: if the product requires loading into application equipment, it is not an RTU, e.g., granular weed-and-feed turfgrass products.)
- Drift hazard is low, and particles settle quickly.
- Little hazard to applicator – no spray, little dust.
- Weight carries the formulation through foliage to soil or water target.
- Simple application equipment, such as seeders or fertilizer spreaders.
- May break down more slowly than WP's or EC's because of a slow-release coating.

Disadvantages:

- Do not stick to foliage or other non-level surfaces.
- May need to be incorporated into soil or planting medium.
- May need moisture to start pesticidal action.
- May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the grain- or seedlike granules.

Wettable powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts. Usually they must be mixed with water for application as a spray.Wettable powders contain 5 to 95 percent active ingredient, usually 50 percent or more. Wettable powder particles do not dissolve in water – they settle out quickly unless constant agitation is used to keep them suspended.

Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray equipment where agitation is possible.

Advantages:

- Easy to store, transport and handle.
- Less likely than EC's and other petroleum-based pesticides to cause unwanted harm to treated plants, animals and surfaces.
- Easily measured and mixed.
- Less skin and eye absorption than EC's and other liquid formulations.

Disadvantages:

- Inhalation hazard to applicator while pouring and mixing the concentrated powder.
- Require good and constant agitation (usually mechanical) in the spray tank and quickly settle out if agitation is turned off.
- Abrasive to many pumps and nozzles, causing them to wear out quickly.
- Difficult to mix in very hard or very alkaline water.
- Often clog nozzles and screens.
- Residues may be visible.

Soluble powders (SP or WSP)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily and form a true solution. After they are mixed thoroughly, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15 to 95 percent; it usually is over 50 percent. Soluble powders have all the advantages of wettable powders and none of the disadvantages except the inhalation hazard during mixing. Few pesticides are available in this formulation because few active ingredients are soluble in water.

Water-soluble packets (WSP)

Water-soluble packets are not a specific formulation of active and inert ingredients – rather, they serve as a package for wettable powders, soluble powders and gels. Measured amounts of pesticide formulation are packaged in bags that dissolve when they are put into water. This is becoming a popular packaging system because of

reduced applicator exposure during mixing and loading and limited packaging material to dispose of.

Water soluble packaging reduces applicator exposure. Measured amounts of pesticide formulation are packaged in bags that dissolve when they are put into water.

Microencapsulated pesticides (M)

Microencapsulated formulations are particles of pesticides (liquid or dry) surrounded by a plastic coating. The formulated product is mixed with water and applied as a spray. Once applied, the capsule slowly releases the pesticide. The encapsulation process can prolong the active life of the pesticide by providing a timed release of the active ingredient.

Advantages:

- Increased safety to applicator.
- Easy to mix, handle and apply.
- Releases pesticide over a period of time.

Disadvantages:

- Constant agitation necessary in tank.
- Some bees may pick up the capsules and carry them back to their hives where the released pesticide may poison the entire hive.

Water-dispersible granules (dry flowables) (WDG or DF)

Water-dispersible granular formulations are like wettable powder formulations except that the active ingredient is prepared as granule-sized particles. Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine powder. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders except:

- They are more easily measured and mixed.
- They cause less inhalation hazard to the applicator during pouring and mixing.

Impregnates

Some pesticide active ingredients are formulated into plastic, soap, wood or other hard material. Pet collars and tags, livestock ear tags, adhesive tapes and plastic pest strips are impregnated with pesticides. These formulations are often used as repellents and for localized control of pests.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids when packaged under high pressure but change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and so are not formulated under pressure. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor.

Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders. In agricultural pest control, fumigants are used in soil and in greenhouses, for commodities such as Christmas trees, flower bulbs or blueberries, and in grain bins.

Advantages:

- Toxic to a wide range of pests.
- Can penetrate cracks, crevices, wood and tightly packed areas such as soil or grains.
- Single treatment usually will kill most pests in treated area.

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping.
- Highly toxic to humans and all other living organisms.
- Require the use of specialized protective equipment, including respirators.
- Require the use of specialized application equipment.
- Require special pesticide certification credentials even for private applicators.

Comparison of Some Pesticide Formulations

Formulation	Mixing/ loading hazards	Phyto-toxicity	Effect on application equipment	Agitation required	Visible residue	Compatible with other formulations
Wettable powders	Dust inhalation	No	Abrasive	Yes	Yes	Highly
Dry flowables / dispersable granules	Minimal	No	Abrasive	Yes	Yes	Good
Soluble powders	Dust inhalation	Not likely	Non-abrasive	No	Some	Fair
Emulsifiable concentrates	Spills & splashes	Maybe	May affect rubber pump parts	Yes	No	Fair
Flowables	Spills & splashes	Maybe	May affect rubber abrasive pump parts;	Yes	Yes	Fair
Solutions	Spills & splashes	No	Non-abrasive	No	No	Fair
Dusts	Severe inhalation hazards	No	_	Yes	Yes	-
Granules and pellets	Minimal	No	-	No	No	-
Microencaps-ulated formulations	Spills & splashes	No	-	Yes	-	Fair

Adjuvants

An adjuvant is a chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety. Most pesticide formulations contain at least a small percentage of adjuvants. Some of the most common adjuvants are surfactants – "surface active ingredients" – that alter the dispersing, spreading and wetting properties of spray droplets.

Common adjuvants are:

- Wetting agents — allow wettable powders to mix with water.
- Emulsifiers — allow petroleum-based pesticides (EC's) to mix with water.
- Invert emulsifiers — allow water-based pesticides to mix with petroleum carrier.
- Spreaders — allow pesticide to form a uniform coating layer over the treated surface.
- Stickers — allow pesticide to stay on the treated surface.
- Penetrants — allow the pesticide to get through the outer surface to the inside of the treated area.
- Foaming agents — reduce drift or can be used for marking treated sections of the target site.
- Anti-foaming agents — reduce foaming of spray mixtures that require vigorous agitation.
- Thickeners — reduce drift by increasing droplet size.
- Safeners — reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated site.
- Compatibility agents — aid in combining pesticides (and fertilizers) effectively.
- Buffers — allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity.

Abbreviations for Formulations

A = Aerosol
AF = Aqueous Flowable
AS = Aqueous Solution or Aqueous Suspension
B = Bait
C = Concentrate
CM = Concentrate Mixture
CG = Concentrate Granules
D = Dust
DF = Dry Flowables
DS = Soluble Dust
E = Emulsifiable Concentrate
EC = Emulsifiable Concentrate
F = Flowable
G = Granules
GL = Gel
L = Flowable
LC = Liquid Concentrate or Low Concentrate
LV = Low Volatile
M = Microencapsulated
MTF = Multiple Temperature Formulation
P = Pellets
PS = Pellets
RTU = Ready to Use
S = Solution
SD = Soluble Dust
SG = Soluble Granule
SP = Soluble Powder
ULV = Ultra Low Volume
ULW = Ultra Low Weight or Ultra Low Wettable
WS = Water Soluble
WSG = Water-Soluble Granules
WSL = Water-Soluble Liquid
W = Wettable Powder
WDG = Water-Dispersible Granules
WP = Wettable Powder
WSP = Water-Soluble Powder or Water-Soluble Packet

Though these suffixes represent common formulations, new formulations are constantly being developed for improved safety and ease of handling. Some manufacturers use initials on their labels that may not reflect what is listed here. Some suffixes may not describe the formulation but rather how the pesticide should be used or labeled uses in special locations; e.g., H / A = harvest aid, GS = for treatment of grass seed, SD = for uses as a side-dressing, or TVA = for use in the waterways of the Tennessee Valley Authority.

Foaming agents can be used for marking treated sections of a field.

COMPATIBILITY OF PESTICIDES

Two or more pesticides may be combined and applied at the same time. Such mixtures can save time, labor and fuel. Manufacturers sometimes combine pesticides for sale as a premix, but pesticide handlers also sometimes combine pesticides at the time of application.

Under federal law, combining pesticides is legal unless the pesticide labeling of any of the pesticides involved instructs you not to combine them. However, not all pesticides work well when mixed together. They must be compatible — that is, mixing them together must not reduce their safety or effectiveness in any way. The more pesticides you mix together, the greater the chance of undesirable effects.

Several possible types of incompatibility should be considered before an applicator attempts to mix products – physical, chemical, phytotoxicity, placement and timing.

Some pesticide mixtures that are *physically* incompatible make the mixture difficult or impossible to apply and may clog equipment, pumps and tanks. These reactions sometimes cause the pesticide to form lumps or gels, to become solids that fall to the bottom of the mix tank or to separate into layers that cannot be remixed.

Sometimes the combined pesticides create a *chemical reaction* that cannot be seen by looking at the mixture. However, the chemical change can result in:

- Loss of effectiveness against the target pests.
- Increased toxicity to the pesticide handler.
- Injury to the treated surface.

Some pesticide labeling lists pesticides (and other chemicals or fertilizers) known to be compatible with that formulation. If you cannot find information on the compatibility of the two pesticides (or the pesticide and other chemical) that you wish to mix, test a small amount of the mixture before you mix large quantities and contact the manufacturer for information. This process is described in the next section.

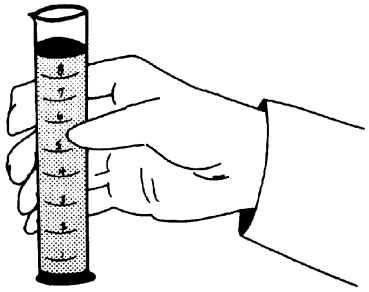
It is necessary to *time* pesticide applications when the pest is at a vulnerable stage of development. When using two or more chemicals to manage different pests, it is of utmost importance that the mixture be applied at the correct time in the life cycles of all pests involved to be effective.

Phytotoxic incompatibility occurs when a product mixture causes injury to plants sprayed with the mixture. This can happen even though each of the pesticides in the mixture, when applied separately, does not cause injury.

Lastly, when mixing two or more pesticides, be sure that they are both required to be *placed* at the site or on the target pest in the same manner – e.g., avoid combining a foliar pesticide with a pesticide that must reach the root zone of a plant.

Remember, never assume that pesticides can be mixed together or mixed with a fertilizer unless the combination is specifically indicated on a product label. If recommendations for use are not given on the label, the products in the mix must be applied at a rate not to exceed the label directions for use of any component product applied alone for the same purpose; and the mix can be applied only if not prohibited on any of the component product labels.

Compatibility testing — First, put on personal protective equipment required by the labeling of any of the pesticides to be combined. Get a large, clean, clear glass container, such as a quart jar. Use the same water (or other diluent) that you will use when making up the larger mixture for application. Add the water and each of the products in the same proportions as you will mix them for your treatment. If you are working with large areas, Table 3.1 will help you mix the proportionate amounts of diluent and pesticide for the compatibility test. (Also see Appendix D for for Compatibility Test for Tank Mixes.)



Unless the pesticide labeling states otherwise, add pesticides to the diluent (usually water) using the "W-A-L-E" plan:

1. Add some of the diluent first.
2. Add **W**ettable and other powders and **W**ater-dispersible granules.
3. **A**gitate thoroughly and add the remaining diluent.
4. Add the **L**iquid products, such as solutions, surfactants and flowables next.
5. Add **E**mulsifiable concentrates last.

Shake the jar vigorously. Feel the sides of the jar to determine if the mixture is giving off heat. If so, the mixture may be undergoing a chemical reaction and the pesticides should not be combined. Let the mixture stand for 15 minutes and feel again for unusual heat.

If scum forms on the surface, if the mixture clumps or if any solids settle to the bottom (except for wettable powders), the mixture probably is not compatible. Some commercially available adjuvants, known as compatibility agents, may be added to overcome physical incompatibilities between certain pesticides. These should be added into the quart jar at the beginning of the compatibility test to determine their effectiveness. Finally, if no signs of incompatibility appear, test the mixture on a small area of the surface where it is to be applied.

Table 3.1 Amounts of pesticide(s) and diluent to use in compatibility test.

Amount of diluent per Acre	Amount of diluent to add to quart jar
10 gallon	0.4 pint (6.4 ounces)
15 gallon	0.6 pint (9.6 ounces)
20 gallon	0.8 pint (12.8 ounces)
25 gallon	1.0 pint
30 gallon	1.2 pints
40 gallon	1.6 pints
Teaspoons of pesticide(s) to be added to quart jar	
1 teaspoon for each quart of **E.C.** recommended per acre.	
1 1/2 teaspoon for each pound of **W.P**. recommended per acre.	

For information about testing for compatibility with fertilizers using the W-A-L-E method, see Appendix D.

CHAPTER 3 PART A

Review Questions

PESTICIDES

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. A pesticide is a chemical that:
   a. Manages only insects and vertebrates.
   b. Directly controls pest populations.
   c. Prevents or reduces pest damage.
   d. Only a certified applicator may apply.
   e. b and c

2. List several classification methods of pesticides and give an example of each.
   1.
   2.
   3.
   4.

3. An insecticide is a pesticide used to manage _____.
   A herbicide is a pesticide used to manage _____.
   A molluscicide is a pesticide used to manage _____.

4. Protectants are pesticides applied to manage pests by rendering them incapable of normal reproduction. (True or False?)

5. A pesticide that controls more than one pest is called:
   a. Systemic.
   b. Broad-spectrum.
   c. Multipurpose.
   d. a and c
   e. b and c

6. What is the difference between a contact and a systemic pesticide?

7. Pesticides that contain carbon are called:
   a. Organic pesticides.
   b. Inorganic pesticides.
   c. Synthetic pesticides.
   d. These don't exist.
   e. Carbonic pesticides.

8. The component of the pesticide that controls the target pest is called the active ingredient. (True or False?)

9. Microbial pesticides:
   a. Kill microorganisms.
   b. Are derived from plants.
   c. May be fungi, bacteria or viruses.
   d. Are broad-spectrum.

10. A pesticide that is synthetic cannot be organic. (True or False?)

11. Pesticide selectivity can be influenced by:
    a. The pesticide's chemistry.
    b. The age of the target pest.
    c. Its placement and timing of application.
    d. All of the above.

12. It is less likely that a pest will develop resistance to a pesticide if products with different modes of action are used to manage it. (True or False?)

13. What types of factors should you consider when you have a choice of formulations for a pest management task?

14. An emulsifiable concentrate (EC) is a _____ formulation of a pesticide which can be mixed with another _____ to form an emulsion.

    a. dry, dry formulation
    b. liquid, dry formulation
    c. liquid, liquid
    d. dry, liquid
    e. none of the above

15. What is a “flowable” formulation?

16. If you had a choice of either a wettable powder or an emulsifiable concentrate for a particular pest management task, which would be better if you were concerned about harming the treated surface?

    Which would be better if you were diluting with very hard or alkaline water?

17. Why are adjuvants sometimes added to pesticide formulations?

18. What type(s) of adjuvants should you consider for reducing drift? for coating a surface evenly? when you wish to combine two or more pesticides for one application?

CHAPTER PART A 4

PESTICIDE LABELING AND REGISTRATION

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Interpret the terms "label" and "labeling."
- Explain the meaning of the restricted use classification and tell where to look for it on pesticide labeling.
- Distinguish among the terms "common name," "chemical name" and "brand name" and know which most accurately identifies a pesticide product.
- Interpret the signal words (and symbols) on pesticide labeling.
- Know the types of hazard precautionary statements on pesticide labeling.
- Interpret the statement "It is a violation of federal law to use this product in a manner inconsistent with its labeling."
- Explain the pesticide user's responsibility to follow use directions and requirements contained in separate documents that, though referenced on the labeling, do not necessarily accompany the product at the time of purchase.

TERMS TO KNOW

Acute effects – Illnesses or injuries that may appear immediately after exposure to a pesticide (usually within 24 hours).

Allergic effects – Harmful effects, such as skin rash or asthma, that some people develop in reaction to pesticides that do not cause the same reaction in most other people.

Carrier – The primary material used to allow a pesticide to be dispersed effectively; for example, the talc in a dust formulation, the water mixed with a wettable powder before a spray application, or the element that disperses the pesticide in an air blast application.

Delayed effects – Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides.

Personal protective equipment (PPE) – Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Pesticide handler – Person who works directly with pesticides, such as during mixing, loading, transporting, storing, disposing and applying, or working on pesticide equipment.

Precautionary statements – Pesticide labeling statements that alert you to possible hazards from use of the pesticide product and that sometimes indicate specific actions to take to avoid the hazards.

Target pest – The pest toward which management measures are being directed.

Pesticide product labeling is the main method of communication between a pesticide manufacturer and pesticide users. The information printed on or attached to the pesticide container is the **label. Labeling** includes the label itself, plus all other information you receive from the manufacturer about the product when you buy it. The labeling may include brochures, leaflets and other information that accompanies the pesticide product. Pesticide labeling gives you instructions on how to use the product safely and correctly. The pesticide label is a legal document. **Pesticide users are required by law to comply with all the instructions and directions for use in pesticide labeling.**

Pesticide users are required by law to comply with all the instructions and directions for use in pesticide labeling.

EPA APPROVAL OF PESTICIDE LABELING

All pesticides sold and used in the United States must be reviewed and approved by the Environmental Protection Agency (EPA). As part of the approval or registration process, EPA requires manufacturers to include specific information on the product label and in some cases in a specific location. For example, the statement "Keep Out of Reach of Children" must appear on the *front panel* of all pesticide labels.

EPA

EPA reviews the labeling to make sure that it contains all the information needed for safe and effective use of the pesticide and the information is supported by data submitted (or cited) by the manufacturer.

Labeling includes the label itself, plus any other information you receive about the pesticide when you purchase it, including brochures and leaflets. The pesticide label is a legal document that must be followed.

TYPES OF PESTICIDE REGISTRATION

There are several types of pesticide registrations which you may encounter:

Federal registrations are the most common. All pesticides for sale in the state must be federally (EPA) registered. You can verify that a pesticide has been registered with EPA by locating the EPA registration number on the label.

State registrations are required, in addition to the federal registration, to sell and use a pesticide in a given state. The state pesticide product registrations are authorized and administered through the Michigan Department of Agriculture.

Special Local Need (section 24(c)s): Special local need (SLN), also known as 24(c) registrations are issued by the Michigan Department of Agriculture to control pest problems specific to the state. Most 24(c) registrations allow the use of a federally registered pesticide on a site or crop not listed on the label. SLN registrations have expiration dates so be sure to check with MDA or Extension to determine if an SLN is still valid.

Emergency Exemptions (section 18s): Section 18 emergency exemptions are applied for by the Michigan Department of Agriculture but granted or denied by EPA. Section 18 exemptions are used when there are no other federally registered pesticides available to control a serious pest problem and there would be significant economic loss without the use of the section 18 pesticide. There are strict controls on these registrations and they are only valid for one growing season. As with 24(c) registrations, pesticide applicators must have and follow the section 18 label as well as the EPA-registered label at the time of application.

PARTS OF PESTICIDE LABELING

The information on pesticide labeling usually is grouped under headings to make it easier for you to find the information you need. Some information is required by law to appear on a certain part of the labeling or under certain headings. Other information may be placed wherever the manufacturer chooses.

Brand Name

The brand name is the name of the product as it appears on the front panel of the label and in advertisements for the product. A single active ingredient may have several brand names and be registered by several different manufacturers. Be careful choosing a pesticide by brand name alone since minor variations in the name can indicate an entirely different product. For example:

- Pest-No = carbaryl
- Pest-No Super = parathion and methomyl
- Pest-No Supreme = carbaryl, parathion and methomyl

Sometimes several companies sell the same pesticide product under different brand names. For example:

- De-Weed 2E = diquat 2 lbs per gallon EC formulated by Company X.
- No Weeds = diquat 2 lbs per gallon EC formulated by Company Z.

Always read the ingredient statement to make sure the active ingredients in a product are the ones you want.

Ingredient Statement

Each pesticide label must list the name and percentage by weight of each active ingredient. The active ingredients will be listed first by the accepted common name followed by the more complex chemical name. Inert ingredients need not be named, but the label must show what percentage of the total contents they make up.

The **chemical name** is a complex name that identifies the chemical components and structure of the pesticide. This name is almost always listed in the ingredient statement on the label. For example, the chemical name of Diazinon is O,O-Diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate.

Because pesticides have complex chemical names, many are given shorter **common names.** Only common names that are officially accepted by the U.S. Environmental Protection Agency may be used in the ingredient statement on the pesticide label. The official common name may be followed by the chemical name in the list of active ingredients. For example, a label with the brand name Sevin 50% WP would read:

Active ingredient:

Carbaryl (1-naphthyl N-methyl carbamate) 50%

Inert ingredients 50%

By purchasing pesticides according to the common or chemical names, you will always be sure to get the right active ingredient.

EPA Registration and Establishment Numbers

Every pesticide which has undergone review and been approved by EPA will have an EPA registration number. The EPA registration number is a unique number which is comprised of one or two company numbers and a serial number of registration. You will most often find this number on the label following the phrase "EPA Reg. No."

The EPA establishment number is a number assigned to a pesticide production plant. It expresses a physical location not a legal entity as does the EPA registration number. It is comprised of a company number, the abbreviation for the state in which the plant resides and a serial number. You will most often find this number on the label following the phrase "EPA Est. No."

In cases of pesticide poisoning, misuse or liability claims, always obtain the EPA registration number and establishment numbers.

Name and Address of Manufacturer

Federal law requires that the name and address of the producer or distributor be on the label.

Net Contents

The label must list the amount of product in each pesticide container. This can be expressed in pounds or ounces for dry formulations or as gallons, quarts, pints or fluid ounces for liquids.

Type of Pesticide

The type of pesticide usually is listed on the front panel of the label. This short statement indicates in general terms what the product will control. Examples:

- "Insecticide for control of certain insects on fruits, nuts and ornamentals."
- "Algaecide for control of all strains of algae."
- "Herbicide for the control of trees, brush and weeds."

Type of Formulation

Most pesticide labels will indicate the formulation of the product often abbreviated as part of the brand name. Examples include WP for wettable powder, D for dust, or EC for emulsifiable concentrate.

Restricted Use Designation

Every pesticide product is classified by the EPA as either "restricted use" or "unclassified." Products in the unclassified category may be and often are referred to as "general use."

If a pesticide is classified as restricted, the statement "Restricted Use Pesticide" (RUP) must appear at the top of the front panel of the label. In addition, a summary statement of the terms of restriction must also appear directly below the Restricted Use Pesticides statement. Pesticides that are unclassified (general use) have no designation on the product label. Examples of restricted use statements on pesticide labels are:

- "RESTRICTED USE PESTICIDE due to acute toxicity and toxicity to birds and mammals. For retail sale and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification."
- "RESTRICTED USE PESTICIDE due to groundwater concern. For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicators' certification. Users must read and follow all precautionary statements and instructions for use in order to minimize potential of [active ingredient] to reach groundwater."

Front Panel Precautionary Statements

Child Hazard Statement – Every pesticide product must have the words "Keep out of reach of children" written clearly on the front panel of the label.

Signal Words and Symbols – Every pesticide must include a signal word on the front panel of the label. This important designation gives the user an indication of the relative toxicity of the pesticide to humans. The signal word is based not on the active ingredient alone, but on the contents of the formulated product. It reflects the hazard of any active ingredients, carriers, solvents or inert ingredients. The signal word indicates the risk of acute effects from the four routes of exposure to a pesticide product – oral, dermal, inhalation and eye – and is based on the one that is greatest. The signal word does not indicate the risk of delayed effects or allergic effects. Following are the four signal words you will encounter on pesticide labels:

DANGER/POISON (Skull and Crossbones) – These words and symbols must appear in red letters on products that are highly toxic by any route of entry (oral, dermal or inhalation) into the body. Peligro, the Spanish word for "danger," will often appear on labels with this signal word.

DANGER – Products with this signal word can cause severe eye damage or skin irritation.

WARNING – This signal word indicates that the product is moderately toxic orally, dermally or through inhalation, or causes moderate eye or skin irritation. Aviso, the Spanish word for "warning" will often appear on labels with this signal word.

CAUTION – This signal word indicates that the product is slightly toxic orally, dermally, or through inhalation or causes slight eye or skin irritation.

Use the signal word to help you decide what precautionary measures are needed for yourself, your workers and other persons who may be exposed.

TOXICITY	HIGH May Cause Death! See a physician immediately.	MODERATE Possible Serious Illness! See a physician if symptoms persist.	LOW or SLIGHT May Cause Illness! See a physician if symptoms persist.
INDICATION ON LABEL	DANGER POISON 	WARNING	CAUTION

The words DANGER and POISON, WARNING, or CAUTION indicate the toxicity level.

Statement of practical treatment (first aid) – This section of the label describes the appropriate medical procedures to follow in the event of a pesticide poisoning. All labels with a signal word of "Danger" are required to have this section on the front panel of the label or refer to its location elsewhere on the label. The location of this section will vary on labels containing the signal words "warning" or "caution."

Precautionary Statements

All pesticide labels contain additional statements to help the applicator decide what precautions to take to protect themselves, and the environment. These statements should be grouped under the general heading "Precautionary Statements" and under one of the following sub-headings:

Hazards to Humans and Domestic Animals – These precautionary statements are required where a hazard exists to humans or domestic animals. These statements indicate the particular hazard, the routes or means of exposure and the precautions to take to avoid an accident, injury or damage. It is important to read this section very carefully since it will tell you what protective clothing and equipment you must wear for proper protection. The precautionary paragraph is preceded by the signal word. Example: "CAUTION. Harmful if swallowed. Avoid breathing vapors."

Many pesticides can cause acute effects by more than one route, so study these statements carefully. These precautionary statements tell you what parts of your body will need the most protection. "DANGER: Fatal if swallowed or inhaled" gives a far different indication than "DANGER: Corrosive — causes eye damage and severe skin burns."

Personal protective equipment statements – immediately following the statements about acute, delayed and allergic effects (if present), the labeling usually lists personal protective equipment requirements. These statements tell you the **minimum** personal protective equipment that you must wear when using the pesticide. Sometimes the statements will require different personal protective equipment for different pesticide handling activities. For example, an apron may be required only during mixing and loading or equipment cleaning. Sometimes the statements will allow reduced personal protective equipment when you use safety systems, such as closed systems or enclosed cabs (tractor, truck, aircraft).

In Michigan, Regulation 637 requires that all pesticide applicators adhere to the label requirements for PPE and establishes a minimum amount of PPE for commercial applicators when the label does not specify PPE. (See the chapter 2, "Laws and Regulations".) Agricultural use products will have early entry PPE requirements within the "Agricultural Use Requirements" box on the label.

Environmental Hazards – This section of the pesticide labeling will indicate precautions for protecting the environment when you use the pesticide. Most pesticide labeling, for example, will warn you not to contaminate water when you apply the pesticide or when you clean

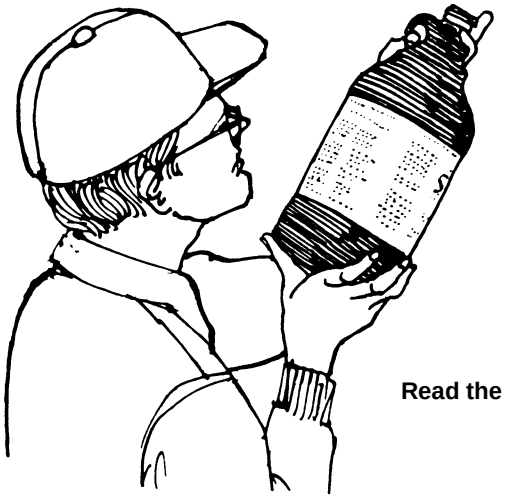
your equipment or dispose of pesticide wastes. The labeling will contain specific precautionary statements if the pesticide poses a specific hazard to the environment. For example, it may warn you that the product is highly toxic to bees or other wildlife.

Physical or Chemical Hazards – Warning statements on the flammability or explosive characteristics of the pesticide are required if the pesticide poses a physical or chemical hazard. Example: "Extremely flammable. Keep away from fire, sparks, and heated surfaces." The location of this section on the label will vary from label to label.

Directions for Use

Directly under the heading "Directions for Use" on every pesticide product labeling is the following statement: "It is a violation of Federal law to use this product in a manner inconsistent with its labeling." The directions for use section also contains sections on storage and disposal and may contain a section on restricted entry into treated areas. This section will contain the specific directions for using the product.

In addition, if the product is labeled for agricultural use, there will be a box on the label containing "Agricultural Use Requirements". This section will contain a statement referencing the Worker Protection Standard, 40 CFR part 170, a restricted-entry statement, PPE for early entry, and, when it's a toxicity class I product, a double notification (field posting and oral warning to workers) requirement. (See the sample label on page 51) If you are using a pesticide with the "Agricultural Use Requirements" on the label, you must comply with the provisions of the Federal Worker Protection Standard. See chapter 1, Part B: "Laws and Regulations" for more information.



Read the label.

The instructions on how to use the pesticide are an important part of the labeling and the best source of information on handling the product correctly. The use instructions will tell you:

- The target pests that the manufacturer claims the product will control.
- The plant, animal or site the product is intended to protect.
- Method of application and application equipment.
- How much pesticide to use (dosage rate).
- Mixing directions.
- Whether the product can be mixed with other often-used products.
- Whether the product is likely to cause unwanted injuries or stains to plants, animals or surfaces.
- Where the material should be applied.
- When and how often it should be applied; for pesticides applied to food crops (or animals), there may be a preharvest or preslaughter interval.
- Restricted entry intervals (REI).
- Storage and disposal procedures.
- Rotational crop restrictions, if necessary.

Use inconsistent with the labeling – It is illegal to use a pesticide in any way not permitted by the labeling. A pesticide may be used only on the plants, animals or sites named in the directions for use. You may not use higher dosages, higher concentrations or more frequent applications. You must follow all directions for use, including directions concerning safety, mixing, diluting, storage and disposal. You must wear the specified personal protective equipment. **The use directions and instructions are not advice – they are requirements.**

Federal law **does** allow you to use pesticides in some ways not specifically mentioned in the labeling. You may:

- Apply a pesticide at any dosage, concentration or frequency less than that listed on the labeling.
- Apply a pesticide against any target pest not listed on the labeling if the application is to a plant, animal or site that is listed.
- Use any appropriate equipment or method of application that is not prohibited by the labeling.
- Mix a pesticide or pesticides with a fertilizer if the mixture is not prohibited by the labeling.
- Mix two or more pesticides, if all of the dosages are at or below the recommended rate. See chapter 3, "Pesticides", for compatibility considerations.

Restricted entry interval (REI) statement – Some pesticide labeling contains a precaution about entering a treated area after application. This statement tells you how much time must pass before people can enter a treated area (restricted entry interval, REI) except under special circumstances. These restricted entry intervals are determined by the EPA. The REI statement may be in a variety of places on the label except on agricultural use products – there the REI statement will always be in the "Agricultural Use Requirements" box.

Storage and disposal – All pesticide labeling contains some instructions for storing the pesticide. These may include both general statements, such as the mandatory statement "Keep out of reach of children," and specific directions, such as "Do not store in temperatures below 32°F."

Pesticide labeling also contains general information about how to dispose of excess pesticide and the pesticide container in ways that are acceptable under federal regulations. Triple- or pressure-rinsing is required for all containers. Michigan has pesticide container recycling options. Contact the MDA for more information.

Directions for use by reference – Some directions for use that pesticide users must obey are contained in documents that are only **referred** to on the product labeling. Such instructions include EPA or other government agency regulations or requirements concerning the safe use of the pesticide product. For example, a pesticide label might state:

> "Use of this product in a manner inconsistent with the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES is a violation of Federal laws. Restrictions for the protection of endangered species apply to this product. If restrictions apply to the area in which this product is to be used, you must obtain the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES for that county."

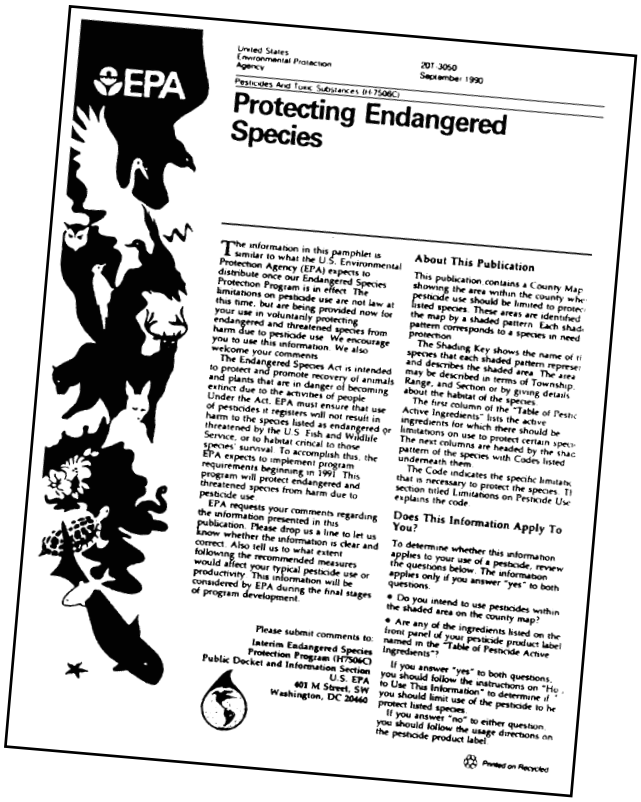
This statement probably would be the only indication on the pesticide label or in the labeling that other use directions and restrictions apply to the product. Currently, 11 counties in Michigan have endangered species interim pamphlets. See Appendix E. The pamphlets include a detailed county map on which the endangered species habitat is indicated, lists of pesticide active ingredients that may harm the species and a description of any pesticide use limitations within that area necessary to protect the species.

You are responsible for determining whether the regulation, bulletin or other document referred to on the pesticide product labeling applies to your situation and your intended use of the pesticide product. These documents do not always accompany the pesticide product when it is sold. Instead, you may have to get the additional directions and requirements from other sources, such as pesticide dealers or company representatives, industry or commodity organizations, or MSU Extension specialists.

References to other documents is a new practice. It is necessary because there is no longer room on the traditional pesticide label to explain the requirements of all laws and regulations that may apply to the user. For example, the EPA has adopted or is considering new requirements concerning:

- Groundwater protection.
- Endangered species protection.
- Pesticide transportation, storage and disposal.
- Worker protection.

Some of these are general use directions that apply to all pesticides, so one copy should be sufficient for each user. In other cases, the instructions and restrictions apply only in certain geographical areas, to certain pesticides or to certain uses of a pesticide product.


EPA

United States Environmental Protection Agency

Pesticides And Toxic Substances (H-7506C)

20T-3050
September 1990

Protecting Endangered Species

The information in this pamphlet is similar to what the U.S. Environmental Protection Agency (EPA) expects to distribute once our Endangered Species Protection Program is in effect. The limitations on pesticide use are not law at this time, but are being provided now for your use in voluntarily protecting endangered and threatened species from harm due to pesticide use. We encourage you to use this information. We also welcome your comments.

The Endangered Species Act is intended to protect and promote recovery of animals and plants that are in danger of becoming extinct due to the activities of people. Under the Act, EPA must ensure that use of pesticides it registers will not result in harm to the species listed as endangered or threatened by the U.S. Fish and Wildlife Service, or to habitat critical to those species' survival. To accomplish this, the EPA expects to implement program requirements beginning in 1991. This program will protect endangered and threatened species from harm due to pesticide use.

EPA requests your comments regarding the information presented in this publication. Please drop us a line to let us know whether the information is clear and correct. Also tell us to what extent following the recommended measures would affect your typical pesticide use or productivity. This information will be considered by EPA during the final stages of program development.

Please submit comments to:
Interim Endangered Species Protection Program (H7506C)
Public Docket and Information Section
U.S. EPA
401 M Street, SW
Washington, DC 20460

About This Publication

This publication contains a County Map showing the area within the county where pesticide use should be limited to protect listed species. These areas are identified on the map by a shaded pattern. Each shaded pattern corresponds to a species in need of protection.

The Shading Key shows the name of the species that each shaded pattern represents and describes the shaded area. The area may be described in terms of Township, Range, and Section or by giving details about the habitat of the species.

The first column of the "Table of Pesticide Active Ingredients" lists the active ingredients for which there should be limitations on use to protect certain species. The next columns are headed by the characteristic pattern of the species with Codes listed underneath them.

The Code indicates the specific limitation that is necessary to protect the species. The section titled Limitations on Pesticide Use explains the code.

Does This Information Apply To You?

To determine whether this information applies to your use of a pesticide, review the questions below. The information applies only if you answer "yes" to both questions.

- Do you intend to use pesticides within the shaded area on the county map?
- Are any of the ingredients listed on the front panel of your pesticide product label named in the "Table of Pesticide Active Ingredients"?

If you answer "yes" to both questions, you should follow the instructions on "How to Use This Information" to determine if you should limit use of the pesticide to help protect listed species.

If you answer "no" to either question, you should follow the usage directions on the pesticide product label.

Printed on Recycled

The EPA decision not to require all of the applicable directions for use to be distributed with each pesticide product places greater responsibility on the pesticide user. One sentence or paragraph on a pesticide label may be the only notice you will receive that additional use directions are required to use the product in compliance with its labeling.

THREE METHODS OF RATING HAZARDOUS MATERIALS

Material Safety Data Sheets (MSDS) – In compliance with OSHA and its final rule on Hazard Communication (29 CFR1910.1200), manufacturers of certain chemical products including pesticides have developed Material Safety Data Sheets (MSDS) as an effective means of informing workers handling such products of any hazards that may exist. These data sheets identify the hazardous chemical components of each product, physical data, the fire and explosion dangers, and potential threats to the safety of persons using the product. First aid procedures, product reactivity data, spill or leak procedures, and other special precautions are also listed. The MSDS for each product must be on file and readily available if the need should arise. Before handling pesticides, have workers read both the label and the MSDS to avoid product misuse and possible injury.

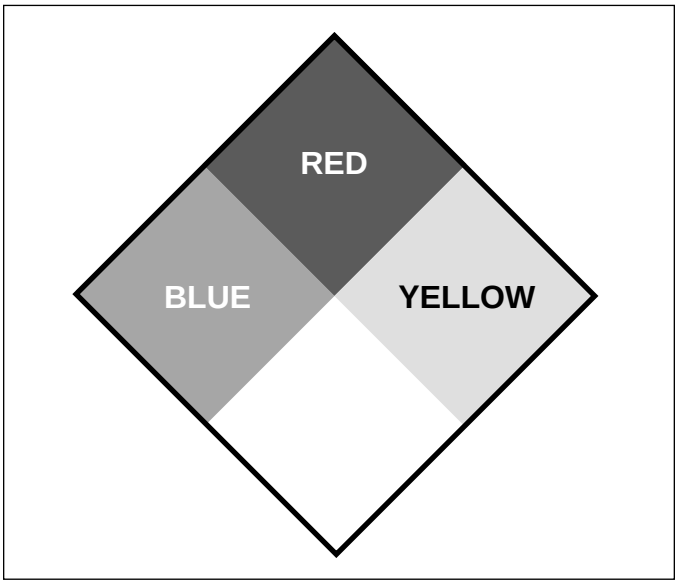
Hazardous Materials Identification System (HMIS®) – In addition to the Material Safety Data Sheets, there is the Hazardous Materials Identification System, or HMIS® program, developed by the National Paint and Coatings Association. Because raw material suppliers are the most knowledgeable about the inherent properties of their

products, they also are the best qualified to provide HMIS® information.

Once you are familiar with the HMIS® rating system, it serves as a quick assessment of a product's hazard. The rating system helps employers comply with OSHA's Hazard Communication Standard (HCS) and uses numerical hazard ratings, labels with colored bars, and icons to define chemical hazards and necessary personal protective equipment. For more information on HMIS® visit the NPCA website at www.paint.org.

Example of a Hazardous Materials Identification System label.

National Fire Protection Association (NFPA) – Another hazardous rating system that may appear on some products is the NFPA Hazard Identification System. This system uses a diamond-shaped warning symbol. The top, left and right boxes refer to flammability, health and instability hazards, respectively, and each contains a number from 0 to 4. The bottom box is used for special hazards; the most common of these is a warning against the use of water. See the diagram below.



Health Hazard—Blue Section

4 – Severe hazard
3 – Serious hazard
2 – Moderate hazard
1 – Slight hazard
0 – Minimal hazard

Flammability Hazard—Red Section

4 – Flammable gases, volatile liquids, pyrophoric materials
3 – Ignites at ambient temperatures
2 – Ignites when moderately heated
1 – Must be preheated to burn
0 – Will not burn

Special Hazard—White Section

OX – Oxidizer
~~W~~ – Avoid use of water

Instability—Red Section

4 – Capable of detonation or explosive decomposition at ambient conditions
3 – Capable of detonation or explosive decomposition with strong initiating source
2 – Violent chemical change possible at elevated temperature and pressure
1 – Normally stable, but becomes unstable if heated
0 – Normally stable

STATEMENT OF PRACTICAL TREATMENT

Contact a doctor (physician), clinic, or hospital immediately in cases of suspected poisoning. Explain that the victim has been exposed to galactothion and describe his/her condition. After first aid is given take victim to clinic or hospital. If breathing has stopped, start artificial respiration immediately and maintain until doctor sees victim.

If swallowed: If patient is conscious and alert, give 2 or 3 glasses of water or milk to drink, and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person. Get medical attention.

If on skin: Immediately flush the skin with plenty of water while removing contaminated clothing and shoes. See doctor immediately. *Galactothion is an organophosphate pesticide that inhibits cholinesterase.*

If inhaled: Remove to fresh air. If not breathing give artificial respiration. Get medical attention.

If in eyes: Hold eyelids open and flush with a steady stream of water for at least 15 minutes. Get medical attention.

Note to Physician

Antidote — administer atropine di-sulfate in large doses. TWO to Four mg. intravenously or intramuscularly as soon as cyanosis is overcome. Repeat at 5 to 10 minute intervals until signs of atropinization appear. 2-PAM chloride is also antidotal and may be administered in conjunction with atropine. **DO NOT GIVE MORPHINE OR TRANQUILIZERS.** Galactothion is a strong cholinesterase inhibitor affecting the central and peripheral nervous system and producing cardiac and respiratory depression. At first sign of pulmonary edema, the patient should be given supplemental oxygen and treated symptomatically. Continued absorption of the poison may occur and fatal relapses have been reported after initial improvement. VERY CLOSE SUPERVISION OF THE PATIENT IS INDICATED FOR AT LEAST 48 HOURS.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS (& DOMESTIC ANIMALS)

DANGER: Fatal if absorbed through skin, fatal if swallowed, and poisonous if inhaled. Do not breathe vapors or spray mist. Do not get on skin or clothing. May be irritating to eyes and may cause mild skin sensitization. Keep away from domestic animals. Discontinue use if allergic reaction occurs.

Signs and symptoms of overexposure

Salivation, muscle tremors, nausea, watery eyes, difficulty breathing, vomiting, pinpoint eye pupils, excessive sweating, diarrhea, blurred vision, abdominal cramps, weakness, headache.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Some materials that are chemical resistant to this product are listed below. If you want more options, follow the instructions for category G on an EPA chemical resistance category selection chart.

Applicators and Other Handlers must wear:

Coveralls over long-sleeve shirt & long pants
Chemical-resistant gloves such as barrier laminate or vitron
Chemical-resistant footwear plus socks
Protective eyewear
Chemical-resistant headgear for overhead exposures
Chemical-resistant apron when cleaning equipment, mixing, or loading
Respirator with either an organic vapor-removing cartridge with a prefilter approved for pesticides (MSHA/NIOSH approval prefix TC-23C) or a canister approved for pesticides (MSHA/NIOSH approval number TC-14G)

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

RESTRICTED USE PESTICIDE

Due to very high toxicity to humans and birds.

For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certificate.

VIP NO PEST GEL

ACTIVE INGREDIENT:

galactothion (0,0-diethyl methyl phosphorothiate)..... 20.9%
related isomers..... 1.1%

INERT INGREDIENTS: 78.00%

Total 100.00%

Net Contents: 5 Gallons

EPA Reg. No. 12345-10 EPA Est. 56787-CO-

VIP Chemical Company
2527 VIP Drive
Biarspond, MI 22315

When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations

Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of the gloves before removing.

ENVIRONMENTAL HAZARDS

This pesticide is highly toxic to aquatic invertebrates and wildlife. Birds in treated areas may be killed. Shrimp and other aquatic organisms may be killed at recommended application rates. Do not contaminate water by cleaning of equipment or disposal of wastes.

PHYSICAL AND CHEMICAL HAZARDS

Do not use or store near heat or open flame. Not for use or storage in or around the home.

KEEP OUT OF REACH OF CHILDREN

DANGER POISON

PELIGRO

Si Usted no entiende la etiqueta, busque a alguien para se la explique a Usted en detalle. (If you do not understand this label, find someone to explain it to you in detail.)

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food or feed by storage or disposal. Do not store under conditions which might adversely affect the container or its ability to function properly.

STORAGE: Do not store below temperature of 0^{o} F.

CONTAINER DISPOSAL: Never reuse empty containers. Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedure approved by state and local authorities.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

GENERAL DIRECTIONS

Spray Preparation: To assure a uniform product, agitate or shake all containers of this product prior to use. Use 50 mesh screens or equivalent slotted strainers in spray system. To prepare for spraying, fill tank to 1/2 the needed volume of water. Add the required amount of this insecticide and mix thoroughly by mechanical or hydraulic agitation. Finish filling tank with water to desired volume and thoroughly mix. Do not store spray mixture for prolonged periods. If tank mixes are to be used, VIP Pest-No must be fully dispersed in water first, followed by addition of the intended tank-mix material. DO NOT USE MIXTURES THAT CURDLE, PRECIPITATE OR BECOME GREASY.

Note: Do not add VIP Pest-No to water with pH values below 3.0 or above 8.5.

DIRECTIONS FOR AERIAL OR GROUND SPRAY APPLICATION

Application timing: Begin application when insect populations reach economic threshold levels. Consult the Extension Service, professional consultants or other qualified authorities to determine appropriate threshold levels for treatment in your area.

Application Instructions: Apply a minimum finished spray volume of 2 gallons per acre by air or 5 gallons per acre by ground unless otherwise directed under crop specific directions. For best results, it is important to obtain thorough and uniform spray coverage of the plant. Use higher dosage rates for heavy infestations, large larvae, or dense foliage. The specific length of control depends on environmental factors, plant growth, dosage rate, and degree of insect infestation

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), notification-to-workers, and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 48 hours. The REI is 72 hours in outdoor areas where the average annual rainfall is less than 25 inches a year.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

— coveralls over long-sleeved shirt & long pants
— chemical-resistant footwear plus socks
— protective eyewear
— chemical-resistant headgear

Notify workers of the application by warning them orally and by posting warning signs at entrances to treated area

CHAPTER 4 PART A

Review Questions

Pesticide Labeling and Registration

Write the answers to the following questions and then check your answers in the back of this manual.

1. Explain the differences between the terms "label" and "labeling."

2. Where would you look to find out whether a pesticide is classified as Restricted Use?

3. Match the signal words and symbols you may see on a pesticide product with the appropriate meaning.

   Caution _____

   Danger_____

   Warning _____

   Poison and the skull and crossbones [symbol]_____

   a. Highly toxic

   b. Moderately toxic

   c. Highly toxic as a poison, rather than as a skin or eye irritant

   d. Slightly toxic or relatively nontoxic

4. Can you use the signal word on a pesticide label to judge the likelihood of suffering acute, delayed or allergic effects if you are overexposed to the product? Explain.

5. What types of hazard statements are on pesticide labeling?

To answer questions 6-17, refer to the VIP Pest-No GEL sample label on page 51.

6. Match the following terms with the appropriate combination from a to e.

   Inert ingredient _____

   Danger _____

   Galactothion _____

   VIP Pest-No GEL _____

   0,0-diethyl methyl phosphorothiate _____

   a. Brand name

   b. Common name

   c. Peligro

   d. Chemical name

   e. 78.0%

7. The EPA registration number refers to the facility where the pesticide product was made. (True or False?)

8. What is the net content of this package of VIP Pest-No GEL?

   a. 20.9%

   b. 22.0%

   c. 78.0%

   d. 5 gallons

9. How is VIP Pest-No GEL classified?
   a. Unclassified.
   b. Restricted use.

10. VIP Pest-No GEL is classified as an RUP because of:
    a. Oncogenicity.
    b. Acute toxicity and toxicity to birds and mammals.
    c. Groundwater concern.
    d. Very high toxicity to humans and birds.

11. If VIP Pest-No GEL had a caution signal word, it would not be required to have the statement "Keep out of reach of children" on the label. (True or False?)

12. If someone accidentally ingests some VIP Pest-No GEL, should vomiting be induced?
    a. Yes
    b. No

13. Galactothion is an organophosphate pesticide that inhibits _____.

14. What kind of formulation is this pesticide?
    a. Wettable powder.
    b. Isomer.
    c. Gel.
    d. Solvent.
    e. Adjuvant.

15. What must applicators wear when using Galactothion?
    a. Coveralls over long-sleeve shirt & long pants.
    b. Chemical-resistant gloves, footwear plus socks.
    c. Protective eyewear.
    d. Respirator with either an organic vapor-removing cartridge with a prefilter approved for pesticides (MSHA / NIOSH approval prefix TC-23C) or a canister approved for pesticides (MSHA / NIOSH approval number TC-14G).
    e. All of the above.

16. What is the restricted entry interval for VIP Pest-No GEL?
    a. 24 hours
    b. Do not enter until the sprays have dried.
    c. 48 hours
    d. 72 hours in outdoors areas where average annual rainfall is less than 25 inches.
    e. c and d

17. It is adequate to orally warn agricultural workers of an application of VIP Pest-No if the locations are explained. (True or False?)

18. A pesticide use bulletin for protection of endangered species may contain limitations on certain pesticide applications in an area where an endangered species habitat exists. (True or False?)

CHAPTER PART A

5

PESTICIDES IN THE ENVIRONMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Explain the meaning of the word "environment."
- Distinguish between point sources and nonpoint sources of environmental contamination by pesticides.
- List factors to consider when a pesticide is accidentally or intentionally released into the environment.
- Describe what a sensitive area may be and the considerations pesticide handlers must observe.
- Name the routes by which pesticides can move off site into the environment.
- Describe factors that influence whether pesticides will move off site in the air or water or on objects, plants or animals.
- Identify pesticide characteristics that influence a pesticide's ability to reach surface or groundwater.
- Describe factors about a given site that influence the potential for a pesticide to reach surface or groundwater.
- Identify and exercise pesticide handling practices that will help prevent surface and groundwater contamination.
- Recognize that nontarget plants and animals can be harmed by both pesticides and pesticide residues.
- Describe harmful effects that pesticides can have on surfaces.

TERMS TO KNOW

Back-siphoning – The movement of liquid pesticide mixture back through the filling hose and into the water source.

Drift – Pesticide movement in air, away from the target site.

Groundwater – Water beneath the earth's surface in soil or rock.

Leaching – The movement of pesticides with water or another liquid downward through soil.

Organic matter – Materials and debris that originated as living plants or animals.

Predator – An organism that attacks, kills and feeds on other organisms.

Release – When a pesticide leaves it's container or the equipment or system that is containing it and enters the environment. Release can be intentional, as in an application, or by accident, as in a spill or leak.

Rinsate – Wash water that contains a small amount of pesticide.

Runoff – Pesticide movement across a surface away from the application site in water or another liquid.

Surface water – Water on top of the earth's surface, such as lakes, streams, rivers, irrigation ditches or storm water drains.

Target – The site or pest toward which control measures are being directed.

Use site – The immediate environment where a pesticide is being mixed, loaded, applied, transported, stored or disposed of, or where pesticide-contaminated equipment is being cleaned.

Volatile – Evaporating rapidly; turning easily into a gas or vapor.

The environment is everything around us, whether we are indoors or outdoors. It includes the natural elements that the word "environment" most often brings to mind. Environment also includes people and the man-made components of our world. It is air, soil, water, plants, animals, houses, restaurants, offices and factories and all that they contain. Anyone who uses a pesticide – indoors or outdoors, in a city or in the country – must consider how that pesticide will affect the environment.

Pesticides can harm all types of environments if used incorrectly. **Responsible pesticide users know and follow practices that achieve effective pest management with little risk of environmental damage.** Labeling statements may alert you to particular environmental concerns that a pesticide product poses.

Both the public and the Environmental Protection Agency (EPA) are becoming increasingly concerned about harmful effects on the environment from the use of pesticides. Hazards to humans had been the primary reason for the EPA to classify a pesticide as a restricted-use product. Pesticides can also be restricted because of their potential environmental effects, such as contamination of groundwater or toxicity to birds or aquatic invertebrate animals.

SOURCES OF CONTAMINATION

When environmental contamination occurs, it is the result of either **point-source** or **nonpoint-source pollution.** Point-source pollution comes from a specific, identifiable place (point). A pesticide spill that moves into a ditch or storm sewer is an example of point source pollution. Nonpoint-source pollution comes from a wide area. The movement of pesticides into streams after broadcast applications is an example of nonpoint-source pollution.

Nonpoint-source pollution from pesticide applications has most commonly been blamed for pesticide contamination in the outdoor environment. Contamination also results from point sources, such as:

- Wash water and spills produced at equipment clean-up sites.
- Improper disposal of containers, water from rinsing containers and excess pesticides.
- Pesticide storage sites where leaks and spills are not correctly cleaned up.
- Spills that occur while mixing concentrates or loading pesticides into application equipment.

As a pesticide handler, especially if you use and supervise the use of restricted use pesticides, you need to be aware of the potential for environmental contamination during every phase of the pesticide operation. Whenever a pesticide is to be released into the environment – whether intentionally or when an accidental release might occur – consider:

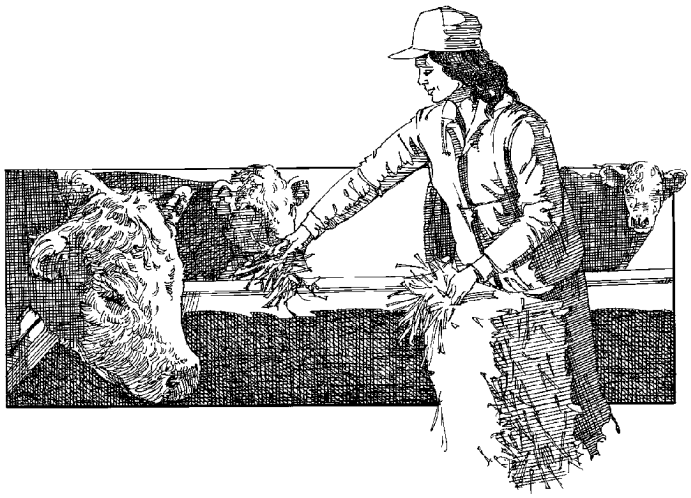
- Whether there are sensitive areas at or near the pesticide use site that might be harmed by the pesticide.
- Whether conditions may cause the pesticide to move off site.
- Whether any factors in the application method or in the target site can be changed to reduce the risk of environmental contamination.

Sensitive Areas

Sensitive areas are sites or living things that are easily injured by a pesticide.

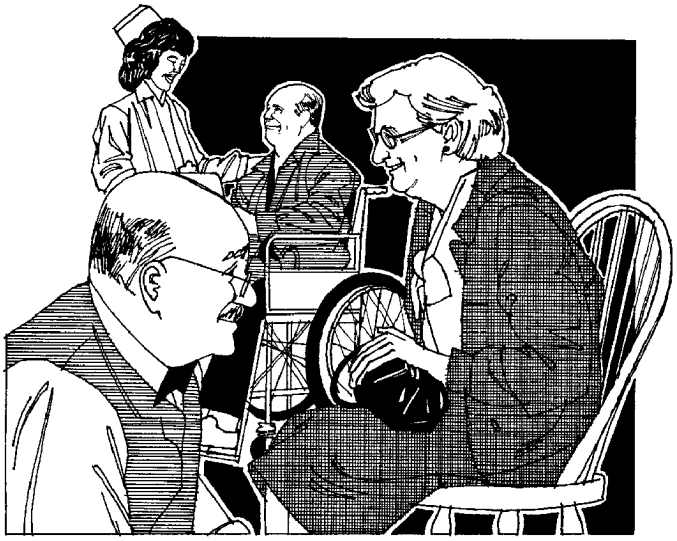
Sensitive areas *outdoors* include:

- Areas where groundwater is near the surface or easily accessed (wells, sinkholes, porous soil, etc.).
- Areas in or near surface water.
- Areas near schools, playgrounds, hospitals and other institutions.
- Areas near the habitats of endangered species.
- Areas near apiaries (honeybee sites), wildlife refuges, or parks.
- Areas near ornamental gardens, food or feed crops, or other sensitive plantings.



Sensitive areas *indoors* include:

- Areas where people – especially children, pregnant women, the elderly or the sick – live, work or are cared for.
- Areas where food or feed is processed, prepared, stored or served.
- Areas where domestic or confined animals live, eat or are otherwise cared for.



Take special measures to avoid pesticide contact with sensitive areas.

Sensitive areas may be part of a larger target site. Take special measures to avoid direct pesticide contact with sensitive areas. For example, leaving an untreated buffer zone around sensitive areas is often a practical way to avoid contamination. Commercial applicators should be aware of sensitive areas as defined by Regulation 637.

PESTICIDE MOVEMENT

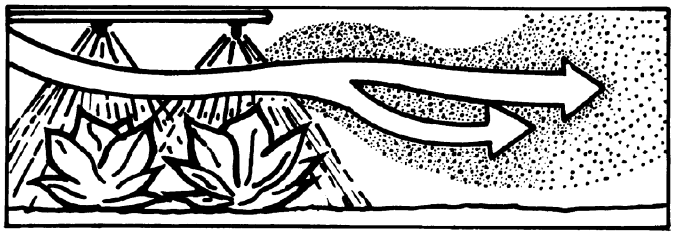
Pesticides can move away from application sites, indoors or outdoors, and may cause harm in both environments. Pesticides move in several ways, including:

- In air, through wind or through air currents generated by ventilation systems.
- In water, through runoff or leaching.
- On or in objects, plants or animals (including humans) that move or are moved off site.

Air

Pesticide movement away from the target site in the air is called drift. Pesticide particles, dusts and spray droplets all may be carried off site in the air. High-pressure and fine nozzles produce very small spray droplets that are very likely to drift. Lower pressure and coarse nozzles produce larger droplets with less drift potential. Pesticides will vary in their potential to drift.

The likelihood that pesticides will drift off site depends partly on the way they are applied, and, for outdoor treatments, on wind conditions. Pesticides released close to the ground are not as likely to be caught up in air currents as those released from a greater height. Pesticides applied in an upward direction or from an aircraft are the most likely to be carried away on air currents.



Prevent pesticide spray drift.

Volatilization occurs when a solid or liquid turns into a gas. A pesticide in a gaseous state can be carried away from a treated area by air currents; movement of pesticide vapors is called **vapor drift.** Unlike the drift of sprays and dusts that can sometimes be seen during an application, vapor drift is invisible.

Volatilization of pesticides increases with higher air temperature and air movement, higher temperature at the treated surface (soil, plant, etc.), low relative humidity and decreasing size of droplets. Pesticides also volatilize more readily from coarse-textured soils than from other soil types. Pesticide volatilization increases on medium- to fine-textured soils when they have a high moisture content.

Avoid applying volatile pesticides when conditions favor volatilization. The vapor pressure rating of the pesticide may help indicate the volatility of the material. The higher the vapor pressure, the more volatile the pesticide. Volatilization can be reduced through the use of low volatile formulations and by incorporating the pesticide into the soil.

Heed all warning statements on the labeling of volatile pesticides. Any time a volatile pesticide is used in an enclosed area, consider the hazards not only to yourself and fellow workers, but also to people, animals and plants that are in or near the site or that may enter the area soon after the application.

Water

Pesticides may be carried off site in water. Pesticides can enter water through:

- Drift, leaching and runoff from nearby applications.
- Spills, leaks, and back-siphoning from mixing, loading, storage and equipment clean-up sites.
- Improper disposal of pesticides, rinsates and containers.

Most pesticide movement in water is across a surface (runoff) or downward from the surface (leaching). Runoff and leaching may occur when:

- Pesticides are spilled onto a surface or overapplied.
- Too much rain or irrigation water gets onto a surface containing pesticide residue.

PESTICIDE RUNOFF POTENTIAL *INCREASES* WHEN PESTICIDES ARE:

- Overapplied
- Applied to sloping sites.
- Applied to saturated soils.
- Applied to compacted or paved surfaces.
- Spilled and not cleaned up.

PESTICIDE LEACHING POTENTIAL *INCREASES* WHEN PESTICIDES ARE:

- Overapplied.
- Applied to sandy soils.
- Rated as "leacher" and receive excessive water (rain or irrigation) soon after application.
- Spilled and not cleaned up.

Runoff water in the outdoor environment may travel into drainage ditches, streams, ponds or other surface water. The amount of pesticide runoff depends on the grade or slope of an area, the erodibility and texture of the soil, soil moisture content, the amount and timing of irrigation or rainfall,and the properties of the pesticides. For example, a pesticide application made to a heavy clay soil already saturated with water is highly susceptible to runoff. Pesticide losses from runoff are greatest when heavy rainfall occurs shortly after a pesticide application. If heavy rainfall is expected, delay applying pesticides. Established vegetation, plant residues and compost reduce runoff because of their ability to retain soil and moisture.

Runoff water in indoor environments may get into domestic water systems and from there into surface and groundwater. Runoff can flow into floor drains or other drains, such as utility sinks, and into the water system. When rinsing pesticide containers and equipment, do not allow the rinsate to go down a sink's drain. Apply it to a labeled site or, if appropriate, use it as a diluent for the next application.

In contrast to runoff, which occurs as water moves across a surface, leaching occurs as water moves downward through the soil. Pesticides that leach through the soil can reach the groundwater. Groundwater contamination is a major concern associated with the leaching of pesticides from treated fields, mixing and rinsing sites, waste disposal areas and manufacturing facilities. Refer to the "Groundwater" section in this chapter for information on how to prevent contamination.

On or in Objects, Plants or Animals

Pesticides can move from the application site when they are on or in objects or organisms that move (or are moved) off site. Pesticides may stick to shoes or clothing, to animal fur or to blowing dust and be transferred to other areas. When pesticide handlers bring home or wear contaminated personal protective equipment or work clothing, residues can rub off on carpeting, furniture and laundry, and onto pets and people.

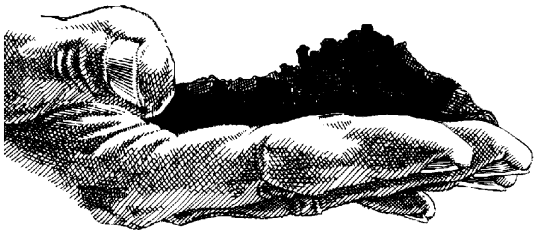
Crop removal is another pesticide transfer process. When treated crops are harvested or animals are slaughtered, any pesticide residues present are removed with them and transferred to a new location. After harvest, many agricultural commodities are washed or processed, which remove or degrade much of the remaining residue. To protect consumers, the federal government has set legal limits (tolerances) on how much pesticide residue may remain on crops or animal products that are sold for food or feed.

PROCESSES AFFECTING PESTICIDES

When a pesticide is released into the environment, it is affected or broken down by various processes. Above we discussed the movement of pesticides. In this section, we will examine the processes that affect pesticide stability and persistence following an application, disposal or spill. Pesticide breakdown is necessary to avoid contamination problems and reduce potential environmental impacts resulting from their use.

Adsorption

Adsorption is the binding of chemicals to soil particles. (This term is sometimes confused with absorption. See the next section.) The amount and persistence of pesticide adsorption varies with pesticide properties, soil moisture content, soil acidity and soil texture. Soils high in organic matter or clay are the most adsorptive; coarse, sandy soils that lack organic matter or clay are much less adsorptive.



Soils with more clay and organic matter tend to hold water and chemicals longer.

Pesticides vary in their degree of binding or adsorption to soil particles. Those that are strongly adsorbed (bound) are less likely to be carried from the treated area by surface water or to leach through the soil; they may, however, be moved readily by soil erosion. Pesticides vary in their degree of water solubility. Those with greater solubility have a greater potential for both movement and water contamination.

A soil-adsorbed pesticide is also less likely to volatilize, photodegrade or be degraded by microorganisms. When pesticides are tightly held by soil particles, they are less available for absorption by plants. For this reason, certain pesticides used on highly adsorptive soils often require higher labeled rates or more frequent applications to compensate for the pesticide that binds to the soil particles.

Absorption

Absorption is the process by which chemicals are taken up by plants and other organisms. It is another process that can transfer pesticides in the environment. Once absorbed, most pesticides are metabolized or degraded within organisms.

Microbial Degradation

Microbial degradation occurs when microorganisms such as fungi and bacteria break down pesticides and use them as a food source. Microbial degradation is an extremely important environmental clean-up system. Most microbial activity occurs in the top 12 inches of soil. Microbial degradation can be rapid and thorough under soil conditions favoring microbial growth: warm temperatures, favorable pH levels, and adequate soil moisture, aeration (oxygen) and fertility. The amount of adsorption also influences microbial degradation. Adsorbed pesticides are more slowly degraded because they are less available to the microorganisms. The chemical structure of the pesticide also influences the ability of microorganisms to break it down. In particular, compounds with chlorine in their structures resist degradation and can persist in the environment for a long time.

Microbial populations that easily degrade certain pesticides can build up in the soil. If similar pesticides are repeatedly applied to an area, the pesticide may be consumed and broken down by the microbes so rapidly that it will not provide the desired pest control. This enhanced microbial degradation has occurred with many soil insecticides and some herbicides. This can be avoided or delayed by alternating types of pesticides used, spot-treating and applying pesticides only when needed.

Chemical Degradation

Chemical degradation of a pesticide involves reactions that change its chemical bonds, reducing the pesticide's original structure into less complex components. The rate and type of chemical reactions that occur are influenced by the adsorption of pesticides to soil, pH levels, temperature and moisture. Many pesticides, especially the organophosphate insecticides, readily degrade by hydrolysis (a chemical reaction that splits bonds and adds the elements of water) in high pH (alkaline) soils or spray mixes. The addition of buffers to the spray mix can help slow hydrolysis reactions.

Once pesticides are absorbed into plants or other organisms, chemical reactions can take place that breakdown the compound.

Photodegradation

Photodegradation is the breakdown of pesticides by the action of sunlight. Pesticides applied to foliage, the soil surface or structures vary considerably in their stability when exposed to natural light. Like other degradation processes, photodegradation reduces the amount of chemical present. Soil incorporation by mechanical methods during or after application, or by managed amounts of irrigation water or rainfall following application, can reduce pesticide exposure to sunlight.

SURFACE WATER CONTAMINATION

Pesticides in surface water have not received as much media attention as pesticides in groundwater, but they are of equal concern. Pesticides can reach surface water in runoff, from drift, through storm sewers, from point-source discharges or in groundwater that is discharging into surface water. Some also reach surface waters in rainfall. Some of the pesticides found in rainfall were probably in the atmosphere because they are very volatile, while other non-volatile compounds were probably transported into the atmosphere through wind erosion or drift.

A 1989 study by the U.S. Geological Survey reported that 55 percent of streams tested in 10 Midwestern states had measurable levels of pesticides prior to spring agricultural field applications, and 90 percent had measurable levels shortly after the applications. Though most detections were of very small quantities, numerous samples exceeded the health advisory limits for atrazine and alachlor. Pesticide levels detected in a river in Michigan exceeded health advisory levels. Efforts must be taken to reduce the potential of pesticides moving into surface water.

Pesticides can most easily reach surface water when applied to areas adjacent to lakes, streams, wetlands and fields containing natural drainageways. The risk is increased when the soil is bare or has a thin vegetative cover. Vegetation buffer strips are being planted along waterways to help filter contaminants before they reach the water. The agricultural community can use conservation tillage in their management programs to help protect surface water. **All pesticide applicators can:**

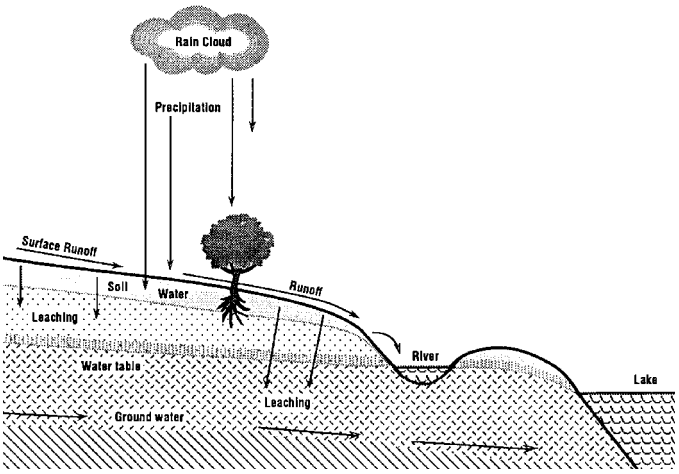
- Implement non-chemical pest management strategies when practical.
- Consider weather conditions before application.
- Select pesticides with low runoff and leaching potentials (ratings listed in many MSU recommendation bulletins).
- Follow best management practices and use integrated pest management (IPM).
- Use the lowest effective rates and frequency.
- Use setbacks to keep safe distances from water bodies when making applications.
- Follow label precautions and water advisories.
- Apply pesticides with calibrated, well functioning equipment.
- Properly store and dispose of pesticides, rinsates and containers.

Many of the proactive efforts used to prevent groundwater contamination described in the next section also help protect surface water quality.

GROUNDWATER CONTAMINATION

Groundwater provides drinking water for over half of Michigan residents and is basically the only source of clean drinking water available to Michigan's rural residents.

Groundwater is contained in the cracks and pores of rocks and the space between sand grains, minerals and other soil particles. Because we can not see it, it is difficult to visualize groundwater and its interactions with the rest of the environment. Groundwater is part of the water cycle. Rain hits the ground and either soaks in or runs off the surface into lakes, wetlands or rivers. Water filtering through the soil moves into the unsaturated zone where pores contain both air and water. Some of this water is taken up by plants. The rest continues downward to the groundwater or saturated zone, where pores are completely filled with water. The top of the saturated zone is called the water table. Layers of rock, sand, gravel, silt or clay that contain groundwater are called *aquifers*.



Pesticides in Groundwater

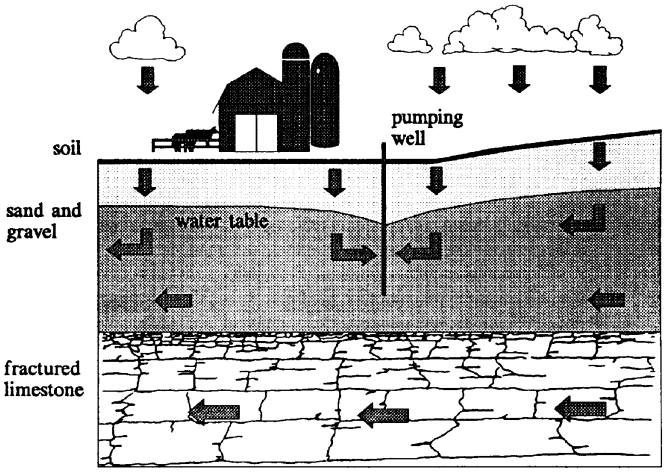
It was once thought that soils and subsurface clay layers protected groundwater from contamination. In the 1970s, a soil fumigant was detected in several California wells. By 1986, 20 pesticides had been detected in the groundwater of 24 states, and by 1990, the EPA had documented the contamination of groundwater by 46 different pesticides. Fifteen pesticides have been detected in Michigan's groundwater (see Table 1.). In some cases, pesticide contamination of groundwater appears to be due to spills and leaky storage containers, but field application appears to be the most common cause.

Water Movement

Groundwater is always moving, and sooner or later it surfaces at low spots such as springs, lakes or wetlands, or it is pumped to the surface from wells. Groundwater is replenished by rain and snow that has seeped into the soil and moved through unsaturated sediments and cracks down to the water table.

Areas where water is seeping down to the water table are called recharge areas. Areas where groundwater flows to the surface are called discharge areas. In humid climates such as Michigan, streams, lakes and wetlands are usually fed by groundwater. Groundwater flows toward the streams, often at nearly right angles.

Groundwater moves relatively slowly through most aquifers, flowing at rates from a few inches per year through shale or rock with few fractures to a few inches per day through some sands. In areas with highly fractured rock and in areas with lots of caves and sinkholes, water can flow very quickly through the cracks and caves just as if they were pipes.



Arrows indicate the direction of water flow. Water from rainfall and snowmelt seeps down into the ground until it reaches a point where all of the cracks between the grains of sand and gravel are filled with water. This is the water table. Below the water table, the groundwater is moving slowly toward a stream. The pumping well in the diagram is causing water in the vicinity of the well to flow towards it.

Sources of Pesticides in Groundwater

In many cases, pesticide contamination of groundwater in a particular area has been traced to a point source – that is, a place where a spill or mishap allowed abnormally large amounts of chemical to reach the water table. Other instances of contamination in an aquifer are known to be from non-point sources: regular field applications. For example, some wells have been contaminated because of spills or mishandling at mixing/loading sites, while others became contaminated as a result of pesticides used according to label directions. It may be impossible to identify the source of a pesticide in groundwater.

Because of the frequency with which pesticides have been detected in groundwater, the EPA has changed the way it handles pesticide registration. The MDA, as well as other state agencies, will have to develop a Pesticide State Management Plan (PSMP) for specific pesticide active ingredients that pose a threat to groundwater or the EPA will prohibit the use of the pesticides in that state. Five pesticides are currently expected to require a PSMP: alachlor, atrazine, cyanazine, metolachlor and simazine.

Table 1. Pesticides of Groundwater Concern

Pesticide (common name)	Detected nationally	Detected Michigan	PSMP expected
acifluorfen		X	
alachlor	X	X	X
atrazine	X	X	X
bentazon	X	X	
cyanazine			X
dacthal	X		
dicamba		X	
dibromochloropropane	X		
dichloropropane		X	
dinoseb		X	
diphenamid		X	
ethylene dibromide	X	X	
ethylene thiourea	X		
hexazinone		X	
lindane	X		
metolachlor		X	X
metribuzin		X	
prometom	X	X	
propazine		X	
simazine	X	X	X

PSMP = Pesticide State Management Plan.

Health Effects of Pesticides in Groundwater

The impact of pesticide-contaminated groundwater on human health depends on the chemical present, the amount that is in the water, and the amount of water that a person drinks or comes in contact with over time. To help avoid health problems that might arise from ingesting the relatively small quantities of pesticides that occur in contaminated groundwater over a long period of time, federal and state drinking water guidelines for pesticide residues set limits on the amount of contamination that may be present in drinking water.

The process by which maximum allowable contamination levels (MCL's) are set for each pesticide uses the toxicity research that must be completed for each active ingredient before a pesticide is registered. Uncertainties arise because it is difficult to use short-term studies with laboratory animals to predict long-term effects on humans living in complex environments. To adjust for these uncertainties, safety factors are built into the equations that federal and state agencies use to set allowable contamination levels from the research data.

Economic and Environmental Costs of Groundwater Contamination

The costs to society of pesticide-contaminated groundwater are difficult to quantify. Losses of pesticide chemicals through leaching represent lost investments by the applicator. Contaminated groundwater can be very costly to the communities and families that rely on it for drinking water. Once groundwater has become contaminated, it is difficult, if not impossible, to do anything about it. The best solution is to prevent the contamination in the first place.

FACTORS AFFECTING SURFACE AND GROUNDWATER CONTAMINATION

The factors that influence whether a pesticide will reach groundwater or surface water from normal use can be divided into three categories:

- Characteristics of the pesticide.
- Characteristics of the site.
- The applicator's management practices.

Pesticide Characteristics

In many MSU recommendation bulletins, pesticide active ingredients are listed with ratings for leaching and runoff potentials. The following characteristics were calculated into the ratings.

Adsorption – A pesticide's chemical structure influences its adsorptivity. As discussed, pesticides that are strongly adsorbed or bound to soil particles are less likely to leach to groundwater than those that are not. They can reach surface waters when carried by eroding soil particles, however.

Solubility – The solubility of a pesticide in water – how readily it dissolves in water – affects whether it will be flushed from the soil and carried away by runoff or leaching waters.

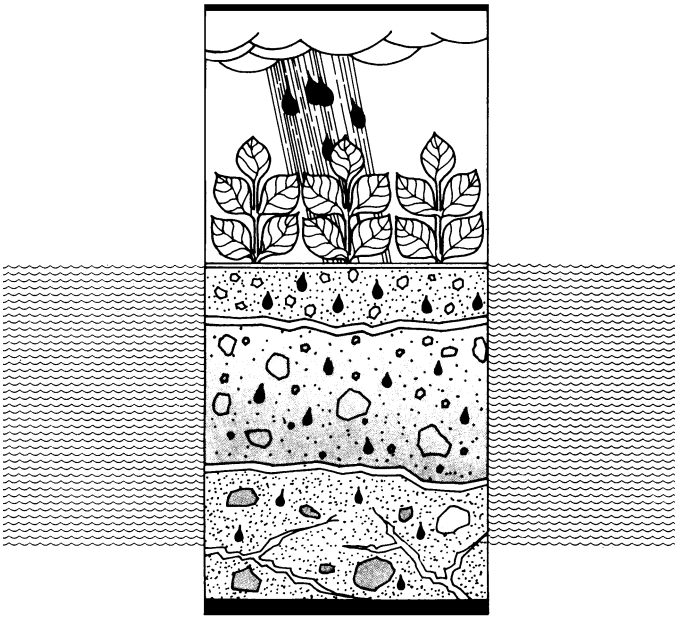
Persistence – The longer the pesticide remains in the soil without breaking down – the greater its persistence - the greater the chance that it will be moved off site. Most preemergent-applied herbicides are persistent.

Site Characteristics

Soil – Soils that have high organic matter content, a medium to fine texture (silt or clay) with good structure and drainage are relatively good at "capturing" pesticides. Even in these soils, however, chemicals can move rapidly along with rainwater flowing through cracks and holes (such as root and worm holes) in the soil profile.

Pesticides are most likely to leach through soils that are very coarse (sandy or gravelly), shallow (less than 20 inches), poorly drained or drought-prone. Pesticides are more likely to be lost in runoff from areas with crusted or compacted soils or in areas surrounded by paved surfaces that do not allow rainfall to soak in, particularly on sloping sites.

Subsoil – Pesticides that leach through the soil may also be "captured" by the sediments below the soil (subsoil) before reaching the water table. This is more likely to occur if the water table is not close to the surface and if the materials below the soil do not allow rapid water movement. Sand, gravel and bedrock with large fractures allow leaching contaminants to move downward with little chance for further filtering.



Density of vegetation, soil properties and subsoil characteristics all influence the ability of a chemical to reach groundwater.

Other Site Factors – The shallower the depth to groundwater – the higher the water table – the less the filtering action of the soil and the fewer the opportunities for degradation or adsorption of pesticides. Spring and fall generally are the times of greatest groundwater recharge and, therefore, also of highest water table elevations. In areas with very shallow water tables and permeable soils, heavy rains may carry dissolved pesticides to groundwater in only a few days.

Under certain conditions, pesticides may easily reach groundwater even if the water table is far below the surface. If there is any conduit from the surface to the water table at or near the site of application, such as a sinkhole or a well that is not completely sealed, pesticides can be washed directly into the groundwater without any filtering at all.

Summary of Factors Affecting Groundwater Contamination

Greatest vulnerability:

Pesticide
- – High solubility
- – Low adsorption
- – Persistent

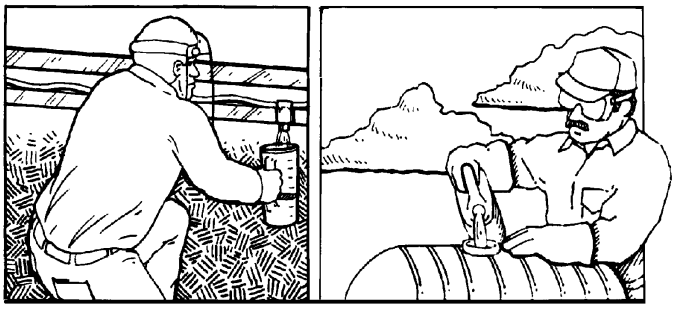
Soil
- – Sandy
- – Low in organic matter

Site
- – Shallow depth to groundwater
- – Wet climate or soils or extensive irrigation management
- – Sinkholes or unsealed wells

Management Practices

How pesticides are handled, mixed/loaded, applied, stored and disposed of greatly influences the potential for groundwater contamination. Sloppy application and handling practices that release into the environment more chemical than is needed can lead to contamination. Excessive irrigation can cause runoff or leaching by applying more water than the soil can absorb or the plants can use. If you work with homeowners who have in-ground, automated irrigation systems, the potential for excessive irrigation is high. Communicate what makes up good cultural practices and coordinate your pest management and their watering practices.

In Michigan, a 1989 survey revealed that 48 percent of pesticide sprayers sampled were *overapplying* by greater than 10 percent, and 15 percent were underapplying by greater than 10 percent. Overapplication not only poses a risk to water resources but also wastes money and affects pesticide efficacy.



Calibrate your equipment and measure, mix and load accurately to avoid over- or underapplying and to reduce the potential for water contamination.

Keeping Pesticides Out of Surface and Groundwater

To lower the risk of water contamination and loss of pesticides through leaching or runoff, applicators must be concerned with all three factors described above (pesticide and site characteristics and management practices). For example, an application of a pesticide with a low potential for leaching or runoff applied to an area with good soil for preventing chemical movement can still cause contamination if it is done haphazardly. First and foremost, the applicator has a responsibility to follow label directions and all Michigan regulations for handling and applying pesticides. To further minimize the risk of pesticide contamination of water resources:

- Evaluate the need, method and frequency of chemical control. Use chemical pest management methods only when needed. An integrated pest management program using scouting techniques allows a pest manager to apply control methods only when pests reach economically damaging levels and only where necessary.
- When selecting a pesticide product, take into account its chemical characteristics (adsorptivity, solubility, persistence) and whether it has a high potential to leach or run off the site where it's applied. Refer to the leaching and runoff ratings generated by the Natural Resources Conservation Service (formerly Soil Conservation Service) found in the back of many MSUE chemical recommendation bulletins. Consider using postemergent herbicides rather than pre-emergent.
- Determine the soil characteristics at the application site. Soil texture and organic matter content influence chemical movement. Natural Resources Conservation Service offices have soil survey maps that will provide much of this information. Compare the soils at your application site with the leaching and runoff potentials of the pesticides to select the safest product to use at the site.
- Consider the geology at the application site. When planning pesticide applications, be aware of the water table depth and the permeability of the geologic layers between the surface soil and groundwater. Some of this information may be obtained from well driller's records on file at the Public Health Department.
- Apply the pesticide at the appropriate time. Fewer applications are required if they are carefully timed in relation to the pest's life cycle. Extension can provide information to help you determine the right time.
- Use the lowest effective rate of a pesticide product and follow label directions. Calibrate sprayers to ensure that you are applying at the correct rate.
- Use back-siphoning prevention devices. When diluting any chemical, use a backflow prevention device when obtaining water directly from a well, public water supply, pond or stream. The end of the fill hose should remain above the water level in the spray tank at all times to prevent back-siphoning of chemical into the water supply. This practice also reduces the likelihood of the hose becoming contaminated with pesticides. For more information on backflow prevention devices, refer to MSU Extension bulletin E-2349, "Protect Your Water Supply From Agricultural Chemical Backflow".
- Calibrate and maintain equipment properly. Correctly calibrating application equipment reduces the chance of applying too much. Check application equipment regularly for leaks, malfunctions and calibration.
- Avoid spills – clean up spills. When spills occur, contain and clean them up quickly. Chemicals spilled near wells and sinkholes can move directly and rapidly into groundwater.
- Schedule irrigation applications so only the amount of water required by the crop is applied. Some computer models are available to assist with water use decisions. Inquire at your local MSU Extension office.
- Avoid pesticide applications when the forecast calls for heavy rain.
- Maintain records of where and when you have applied pesticides. Certain records are mandatory. Refer to chapter 2, "Laws and Regulations," for information on recordkeeping requirements.
- Dispose of wastes properly. All pesticide wastes must be disposed of in accordance with local, state and federal laws. Instructions for triple-rinsing and power-rinsing are included in the pesticide storage and disposal chapter. Pour the rinse water into the spray tank for use on a labeled site. Never pour unused pesticides or rinse water into drains, sewers, streams or other places where they will contaminate the water.
- Store pesticides safely. Pesticide storage facilities should be situated away from pumps, wells and other water sources.
- Properly close non-functioning wells. Old wells can be a direct pipeline for contaminants to groundwater. Many properties still have open but unused wells. Contact the MDA Groundwater Program for information on technical assistance and cost-share programs for well closure.
- Obtain the Farm∗A∗Syst or Turf∗A∗Syst self assessment worksheets to evaluate your farm and business operations as they relate to groundwater protection.

Evaluating the potential for water contamination from pesticide use and altering application practices where they pose a high risk of contamination is an important task. References and contact agencies listed in Appendix E can help you.

Summary

Some preventive applicator practices that protect water resources:

1. Use pesticides only when needed.
2. Identify soil type.
3. Identify nearby water sources.
4. Check the well system.
5. Avoid using highly leachable pesticides.
6. Follow the label.
7. Apply at the right time.
8. Measure carefully.
9. Accurately calibrate application equipment.
10. Avoid spills and clean up if they occur.
11. Avoid overapplying.
12. Delay irrigation after pesticide applications (if irrigation is not required as part of the application).
13. Avoid irrigation runoff.
14. Triple- or pressure-rinse: dispose of pesticide wastes and containers properly.
15. Store pesticides safely.
16. Maintain records.

PESTICIDE EFFECTS ON NONTARGET PLANTS AND ANIMALS

Nontarget organisms may be harmed by pesticides in two ways:

- The pesticide may cause injury by contacting the nontarget organism directly, or
- The pesticide may leave a residue that causes later injuries.

Harmful Effects from Direct Contact

Pesticides may harm nontarget organisms that are present during a pesticide application. Poorly timed applications can kill bees and other pollinators that are active in or near the target site. Pesticides may harm other wildlife and endangered species, too. Even tiny amounts of some pesticides may harm them or destroy their source of food or habitat. Choose pesticides required for large area applications – such as in mosquito, biting fly and forest pest control – with great care to avoid poisoning nontarget plants and animals in or near the target sites. Follow all warnings and directions on the pesticide labeling carefully to avoid harming nontarget organisms or their habitat during a pesticide application.

Drift from the target site may injure nontarget organisms. For example, drift of herbicides can damage sensitive nearby plants, including crops, forests or ornamental plantings. Drift also can kill beneficial parasites and predators that are near the target site.

Pesticide runoff may harm fish and other aquatic animals and plants in ponds, streams and lakes. Aquatic life also can be harmed by careless tank filling or draining and by rinsing or discarding used containers incorrectly.

Harmful Effects from Residues

A *residue* is the part of a pesticide that remains in the environment for a period of time following application or a spill. Pesticides usually break down into harmless components after they are released into an environment by the processes we discussed above. The breakdown time ranges from less than a day to several years. The rate of pesticide breakdown depends mostly on the chemical structure of the pesticide active ingredient but also on environmental conditions – soils, sunlight, temperature, moisture, microbial organisms, etc.

Persistent pesticides leave residues that stay in the environment without breaking down for long periods of time. These pesticides are sometimes desirable, because they provide long-term pest management and may reduce the need for repeated applications. However, some persistent pesticides that are applied to or spilled on soil, plants, lumber and other surfaces or into water can later harm sensitive plants or animals, including humans, that contact them. When pesticides build up in the bodies of animals or in the soil, they are said to **bioaccumulate.**

Animals could be harmed if they feed on plants or animals that have pesticide residues on or in them. A special concern is for predator birds or mammals that feed on animals that have been killed by pesticides.

Typical pesticide labeling statements that alert you to these concerns include:

- "Toxic to fish, birds and wildlife. This product can pose a secondary hazard to birds of prey and mammals."
- "Animals feeding on treated areas may be killed and pose a hazard to hawks and other birds-of-prey. Bury or otherwise dispose of dead animals to prevent poisoning of other wildlife."

Endangered species – To minimize the impact of pesticides on federally endangered and threatened species, and to ensure that these species and their habitat will no longer be jeopardized, the EPA is developing a new program of use restrictions under the Endangered Species Act. In the new program, it is anticipated that every pesticide posing a threat to an endangered or threatened species or its habitat will have a warning statement regarding its use within the geographic range of the species. The statement will instruct applicators in actions they need to take to safeguard endangered and threatened species. These instructions may prohibit use in a certain location or prohibit a specific method of application, such as aerial. These instructions may only be referred to on the label. See "Directions for use by reference" section in chapter 4, "Pesticide Labeling and Registration". Eleven Michigan counties have brochures available for protecting the Kirtland's Warbler. See Appendix E.

HARMFUL EFFECTS ON SURFACES

Pesticides or pesticide residues may harm surfaces. Some surfaces may become discolored; others may be pitted or marked by contact with some pesticides. Some pesticides can corrode metal or obstruct electronic systems. When applying a pesticide, keep an adequate distance from things that could be damaged by pesticide contact. If in a confined space, remove items from the area or cover them to prevent contact with pesticides.

CHAPTER 5 PART A

Review Questions

Pesticides in the Environment

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. What is the environment?

2. Point-source pollution:

a. Comes from a specific, identifiable place.
b. Could be a pesticide spill that moves into a storm sewer.
c. Comes from a wide area.
d. May be the movement of pesticides into streams after broadcast field applications.
e. a and b

3. List some ways to prevent point-source pollution.

4. What environmental factors should you consider any time you accidentally or intentionally release a pesticide into an environment?

5. What is a "sensitive area"?

a. Sites or living things in environments that are easily injured by a pesticide.
b. Schools, playgrounds, hospitals and other places where people are present.
c. Places where there are animals – endangered species, bees, other wildlife, livestock, pets.
d. Places where crops, ornamental plants or other sensitive plants are growing.
e. All of the above.

6. Droplet or particle size, height and direction of release are factors that influence whether a pesticide will move off site in the air. (True or False?)

a. True
b. False

7. Vapor drift is:

a. Pesticide particles, dusts and spray droplets carried away from the target site in the air.
b. Less likely to occur from medium-textured soils with high moisture content.
c. When a pesticide is moved away from the treated area by air currents in a gaseous state.
d. Visible from a short distance.
e. Not likely to occur when spray droplets are small and relative humidity is low.

8. Pesticides with a high degree of water solubility have a greater potential for both movement and water contamination. (True or False?)

   a. True

   b. False

9. Pesticides that are strongly adsorbed to soils:

   a. Are less likely to be carried from the treated area by surface water.

   b. Are more likely to be leached.

   c. Are not likely to be moved with soil erosion.

   d. Stay in the soil longer, giving microbes more opportunity to degrade them.

   e. None of the above.

10. _____are more adsorptive than _____.

   a. Sandy soils; clay soils.

   b. Sandy soils; soils with high percentage of organic matter.

   c. Soils high in organic matter or clay; sandy soils.

11. In structural settings, runoff water can flow into floor drains and into water systems. (True or False?)

   a. True

   b. False

12. When chemicals are taken up by plants, humans or other organisms, the process is known as:

   a. Adsorption.

   b. Absorption.

   c. Microbial.

   d. Poisoning.

   e. Bioaccumulation.

13. Microbial pesticide degradation is enhanced when:

   a. Pesticides are adsorbed to soil surfaces.

   b. Pesticides leach deep into the soil profile.

   c. Soils are warm and moist.

   d. There is a limited amount of oxygen to volatilize the pesticide.

   e. Soil fertility is low and microbes must obtain energy from the pesticide.

14. Pesticides can reach surface water from drift, rainfall or groundwater that is discharging into surface water. (True or False?)

   a. True

   b. False

15. Layers of rock, sand, gravel, silt or clay that contain groundwater are:

   a. The recharge zone.

   b. Called the water table.

   c. Able to have water extracted only by wells.

   d. Called aquifers.

16. Though pesticides have not been detected in Michigan's groundwater, it is a serious concern because the potential for contamination is there. (True or False?)

   a. True

   b. False

17. List management practices and pesticide handling methods that can help prevent surface and ground water contamination.

18. Give some examples of ways that pesticides can move off site on or in objects, plants or animals.

19. In addition to direct contact with the pesticide during application or through drift or runoff, how else may nontarget plants and animals be harmed by a pesticide?

20. Pesticides may cause surfaces to become discolored, pitted or corroded, or be left with a visible deposit. (True or False?)

   a. True

   b. False

CHAPTER PART A 6

PESTICIDES AND HUMAN HEALTH

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Explain the concepts of hazard, exposure and toxicity and how they relate to one another.
- List the four routes by which your body can be exposed to pesticides, and name the route that should be of most concern to you.
- List three factors that determine how quickly pesticides will be absorbed through your skin.
- Explain the three main types of harmful effects that pesticides can cause in humans.
- Describe how to avoid harmful effects from pesticides.
- Recognize some general signs and symptoms of pesticide poisoning and pesticide irritation effects.
- Perform appropriate first aid for pesticide exposures.
- Define "heat stress" and recognize some signs and symptoms of heat stress.
- Perform appropriate first aid for heat stress.

TERMS TO KNOW

Acute effects – Illnesses or injuries that may appear immediately after exposure to a pesticide (usually within 24 hours).

Active ingredients – The chemicals in a pesticide product that control the target pest.

Acute toxicity – A measure of the capacity of a pesticide to cause injury as a result of a single or brief exposure.

Chronic effect – Illness or injury that appears a long time – up to several years - after exposure to a pesticide.

Chronic exposure – Exposure to repeated doses of a pesticide over a longer period of time.

Chronic toxicity – A measure of the capacity of a pesticide to cause injury as a result of repeated exposures over a period of time.

Delayed effects – Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides.

Exposure – Coming into contact with a pesticide; getting a pesticide on a surface or in or on an organism.

Formulation – Pesticide product as sold, usually a mixture of active and inert ingredients.

Hazard – The likelihood that an injury will occur as a result of a given level and duration of exposure.

Inert ingredients – Inactive compounds in a pesticide formulation that are used to dilute the pesticide or make it safer, more effective, easier to measure, mix and apply, and more convenient to handle.

Local effects – Effects that occur at the site where the pesticide makes initial direct contact with body (e.g. skin, eye, nose, mouth, trachea, esophagus, stomach, GI tract, etc.). Local effects may occur immediately or may take longer to appear. These may include such effects as local (contact site) skin irritation (rash, irritation, ulceration) or local irritation of mucous membranes of eyes, nose, mouth, throat, etc.

Personal protective equipment (PPE) – Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Precautionary statements – Pesticide labeling statements that alert you to possible hazards from the use of the pesticide product and may indicate specific actions to take to avoid the hazards.

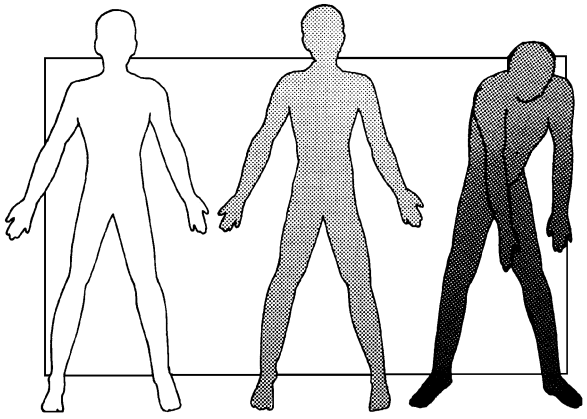
Signal words – Standardized designations of relative levels of toxicity that must, by law, appear on pesticide labels. The signal words used are DANGER, or DANGER-POISON, WARNING or CAUTION.

Solvent – A liquid – such as water, kerosene, xylene or alcohol – that will dissolve a pesticide (or other substance) to form a solution.

Systemic effects – Effects that occur at sites other than the point of entry into the body following absorption and distribution through the circulatory system, possible chemical reaction within the body, or contact with critical target sites or organs. These transport or transformation processes may take time, so these effects generally take longer to appear than local effects.

PESTICIDE HAZARDS

Most pesticides are designed to harm or kill pests. As living organisms, however, humans and pests share many basic features, so pesticides also may harm or even kill people. Fortunately, we can usually avoid the harmful effects of pesticides by avoiding exposure to them.



Some pesticides are highly toxic to humans – only a few drops in the mouth or on the skin can cause extremely harmful effects. Other pesticides are less toxic, but too much exposure to them will also cause harm. Hazard is the risk of harmful effects from pesticides. To help you determine the risk of handling a pesticide, consider the following formula:

HAZARD = TOXICITY x EXPOSURE

Toxicity is a measure of a pesticide's ability to cause injury. It is a property of the chemical itself, its concentration and its formulation. Exposure is the actual contact with the pesticide. Hazard, on the other hand, is the **potential** for injury. It reflects both the toxicity of the pesticide and the likelihood that significant exposure will occur in a particular situation. Pesticide applicators should be concerned with both the hazards associated with exposure to the chemical and with the toxicity of the chemical itself.

The best way to avoid or minimize the hazards of pesticide use is to know what you are using and how to use it. This means reading the label carefully and following the instructions. The attitude of the applicator is of utmost importance. If applicators mistakenly think they know exactly how to use a pesticide or do not care about the precautions that should be taken, the chance of an accident increases. Taking adequate precautions and practicing good common sense with safety in mind should minimize accidents from pesticide usage.

If you or others are accidentally exposed to pesticides, you must know how to react. Pesticide poisonings do occur and can cause serious injuries. Later sections in this chapter address what to do in these situations.

EXPOSURE: HOW PESTICIDES ENTER THE BODY

Obviously, you must be exposed to a toxic chemical to be affected by it. Though many pesticides can damage the skin and eyes upon contact, the most harmful effects usually occur when pesticides enter the body. There are four main routes by which pesticides can enter the body:

- Dermal exposure (pesticide contact with skin).
- Oral exposure (pesticide in mouth or swallowed).
- Inhalation exposure (when pesticide vapors or dusts are breathed).
- Eye exposure.

Pesticide exposure can happen whenever pesticides are handled: during mixing and loading, applying or disposing of them. Some of the more common ways in which applicators can be exposed to pesticides are listed in Table 1. We will discuss how you can protect yourself from exposure to pesticides in the next chapter.

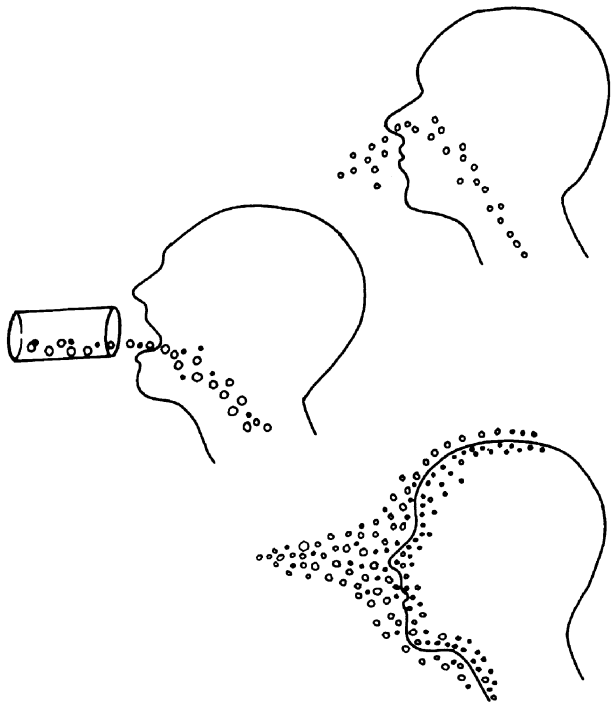
Dermal Exposure

The skin receives the greatest amount of exposure to pesticides. In fact, the EPA estimates that 97 percent of all exposure when spraying pesticides is to the skin. Therefore, absorption through the skin is the most common route by which pesticides enter the body. Wearing the appropriate clean PPE can reduce this exposure.

The amount of pesticide that skin absorbs depends not only on the chemical itself and the extent of the exposure, but also on the product's formulation, the area of the body that is exposed and the condition of the exposed skin.

Table 1. Common ways in which pesticide exposure occurs.

Dermal exposure	Oral exposure	Inhalation exposure	Eye exposure
Not washing hands after handling pesticides or their containers.	Not washing hands before eating, smoking or chewing.	Spraying in confined or poorly ventilated areas.	Rubbing eyes or forehead with contaminated gloves or hands.
Splashing or spilling pesticide on skin.	Splashing pesticide into mouth.	Being exposed to drift.	Splashing pesticides in eyes.
Wearing pesticide-contaminated clothing.	Accidentally applying pesticide to food.	Mixing/loading dusts, powders or other dry formulations.	Applying pesticides in windy weather; drift exposure.
Applying pesticides in windy weather; drift exposure.	Storing pesticides in drink containers.	Using an inadequate or poorly fitting respirator.	Mixing/loading dry formulations without wearing goggles.
Touching treated plants or soil.	Getting drift on lip or in mouth.		



Exposed skin – Various areas of the body absorb pesticides at different rates. The genital area tends to be the most absorptive. Therefore, always wash your hands before using the bathroom. The scalp, ear canal and forehead are also highly absorptive, so wear head protection. Pesticides enter the body through cuts and scrapes more easily than through unbroken skin. Hot, sweaty skin will absorb pesticides more readily than dry, cool skin.

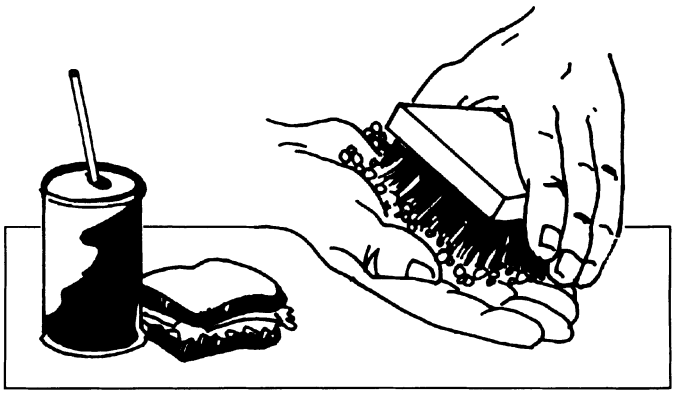
Pesticide formulation – In general, oil-based pesticides (e.g., ECs) are absorbed most readily. Water-based formulations and dilutions (e.g., WPs, SPs) are absorbed more readily than dry formulations (e.g., Ds, Gs, undiluted WPs). Remember, though, that it is easy to get dusts and powders on your hands accidentally. If you don't wash your hands after handling these products, you run the risk of additional exposure by contaminating other parts of your body with your hands.

Oral Exposure

Oral exposure to pesticides is very dangerous but relatively rare – it is almost always due to inexcusable carelessness. In fact, the most common cause of oral exposure is putting pesticides into unlabeled bottles or food containers.

A person who swallows a pesticide may not only be poisoned, but may also suffer severe burns in the mouth and throat.

Oral exposure may also occur from dusts or sprays that accidentally get on the lips or tongue. To avoid this, wash your hands thoroughly before eating, drinking or using tobacco products (smoking or chewing).



Inhalation Exposure

Inhalation exposure is particularly hazardous because the lungs can rapidly absorb pesticides, especially vapors and extremely fine particles. Inhaled pesticides can damage nose, throat and lung tissue.

The inhalation hazard is generally low when you apply dilute sprays with conventional equipment because such applications produce relatively large droplets. When you make low- or ultra-low-volume applications, however, very small droplets of concentrated material are produced that can travel deep into the lungs and increase the inhalation hazard.

Eye (Ocular) Exposure

Eyes are particularly absorbent. Your eyes may not only be damaged by a pesticide, but may absorb enough of it to make you seriously or even fatally ill. Ocular pesticide exposure may result in eye irritation, impaired vision, or temporary or permanent blindness.

ACUTE TOXICITY AND SIGNAL WORDS

Acute exposure is exposure to a single dose of a pesticide; acute toxicity is the pesticides's ability to cause harm from a single exposure. The harmful effects that occur from a single exposure by any route of entry are termed *acute effects*. Acute effects usually occur within minutes or hours after exposure. They may be measured as acute *dermal toxicity* (including eye *effects*), acute *oral toxicity* and acute *inhalation toxicity*. Acute exposures result in the most common type of pesticide poisoning.

Acute toxicity is usually expressed as LD_{50} (lethal dose 50) and LC_{50} (lethal concentration 50). This is the amount (mg/kg) or concentration (ppm) of a toxicant required to kill 50 percent of a test population of animals under a standard set of conditions.

The LD_{50} and LC_{50} values are used to compare the toxicity of various active ingredients as well as different formulations of the same active ingredient. Pesticides with greater acute toxicities have lower LD_{50} and/or LC_{50} values – that is, it takes less of the chemical to kill 50 percent of the test population. Pesticides with high LD_{50} values are considered the least acutely toxic to humans when used according to the directions on the product label.

Note that the LD_{50} measures only one toxic effect: death. It does not indicate what dose may lead to other, less serious toxic effects. The LD_{50} also is limited because it looks at a single-exposure situation. It cannot be used to determine chronic toxicity – several exposures to the same substance – or toxicity from a mixed exposure – when the applicator is exposed to more than one substance at a time. Applicators should not assume that high LD_{50} or LC_{50} values (low toxicity) mean that adverse health effects are not possible.

The acute toxicity values determine the toxicity category of a pesticide and the signal word(s) required on the label. Thus, the signal words indicate the relative toxicity of the pesticide. The toxicity category is assigned on the basis of the highest measured toxicity, be it oral,

Table 2. Toxicity Category

Measure of toxcicity	I Highly toxic	II Moderately toxic	III Slightly toxic	IV Relatively non-toxic
Oral LD50 (mg/kg)	0 – 50	50 – 500	500 – 5,000	>5,000
Demal LD50 (mg/kg)	0 – 200	200 – 2,000	2,000 – 20,000	>20,000
Inhalation LC50	0 – .2 mg/L	From .2 thru 2 mg/L	From 2 thru 20 mg/L	>20 mg/L
Eye Effects	Corrosive	Irritation persisting for 7 days	Irritation reversible within 7 days	None
Skin Effects	Corrosive	Severe Irritation	Moderate Irritation	Mild Irritation
Signal Word/ Symbol	Danger or Danger/ Poison with Skull & Crossbones symbol	Warning	Caution	Caution
***Approx. Oral lethal dose for a 150-pound person**	A few drops to 1 teaspoon	1 teaspoon to 1 ounce	1 ounce to 1pint or pound	More than 1 pint or pound

Source: 40 CFR 162.10

* "Basic Guide To Pesticides", Briggs et al. Washington, D.C.: Hemisphere Publishing, 1994, p.12, and "Reading a Pesticide Label", bulletin E-2182, Kamrin, M., Michigan State University Extension, May 1989, p.4.

dermal or inhalation; effects on the eyes and external injury to the skin also are considered. Table 1 shows the relationship between acute toxicity value, toxicity category and signal words.

ACUTE EFFECTS AND FIRST AID

Though we may not know exactly how a pesticide acts on the body, some symptoms of poisoning are quite well known. These warning responses of the body can be recognized by anyone working with pesticides.

Acute effects are illnesses or injuries that may appear immediately after exposure to pesticides (usually within 24 hours). Acute effects often are reversible if appropriate medical care is given.

Symptoms of pesticide poisoning are largely nonspecific – that is, a number of common illnesses such as flu or even a hangover may cause similar symptoms. Nevertheless, if any symptoms appear after contact with a pesticide, assume they are caused by the pesticide and seek medical attention.

Learn to recognize and be alert to early symptoms of acute poisoning. If any sign of poisoning develops, you should be able to respond immediately in an appropriate manner. Doing so may prevent additional exposure and minimize injury – it may even save a person's life. Stop working with pesticides or in known treated areas if you don't feel well; leave the treated area immediately.

First aid is the initial effort to help a victim while medical help is on the way. **The best first aid in pesticide emergencies is to stop the source of pesticide exposure as quickly as possible.** If you are alone with the victim, make sure the victim is breathing and is not being further exposed to the pesticide before you call for emergency help. If you are trained to do so, give artificial respiration if the victim is not breathing. Do not become exposed to the pesticide yourself while you are trying to help.

Symptoms of Acute Effects and First Aid Response

In an emergency, look at the pesticide labeling, if possible. If it gives specific first aid instructions. Follow those instructions carefully. Watch for these acute effects from pesticide exposure and follow these general guidelines for first aid:

Effects when a substance is touched: skin irritation (drying and cracking), skin discoloration (reddening or yellowing) or itching.

First aid for pesticide on skin:

- Drench skin and clothing with plenty of water. Any source of relatively clean water will serve. If possible, immerse the person in a pond, creek or other body of water. Even water in ditches or irrigation systems will do, unless you think they may have pesticides in them.
- Remove contaminated clothing and equipment.
- Wash skin and hair thoroughly with a mild liquid detergent and water. If one is available, a shower is the best way to completely and thoroughly wash and rinse the entire body.
- Dry victim and wrap in blanket or any clean clothing at hand. Do not allow victim to become chilled or overheated.
- If skin is burned or otherwise injured, cover immediately with loose, clean, dry, soft cloth or bandage.
- Do not apply ointments, greases, powders or other drugs to burns or injured skin.

Effects when a substance is ingested: mouth and throat irritation, chest pains, nausea, stomachache, diarrhea, muscle twitching, sweating, headache and weakness.

First aid for pesticides in mouth or swallowed:

- Rinse mouth with plenty of water.
- Give victim large amounts (up to 1 quart) of milk or water to drink.
- Induce vomiting only if instructions to do so are on the labeling.

  Procedure for inducing vomiting:

  - Position victim face down or kneeling forward. Do not allow victim to lie on his back because the vomit could enter the lungs and do additional damage.
  - Put finger or the blunt end of a spoon at the back of victim's throat or give syrup of ipecac.
  - Do not use salt solutions to induce vomiting.

  Do *not* induce vomiting:

  - If the victim is unconscious or is having convulsions.
  - If the victim has swallowed a corrosive poison. A corrosive poison is a strong acid or alkali. It will burn the throat and mouth as severely coming up as it did going down. It may get into the lungs and burn there, also.
  - If the victim has swallowed an emulsifiable concentrate or oil solution. Emulsifiable con centrates and oil solutions may cause death if inhaled during vomiting.

Effects when a substance is inhaled: burning sinuses, throat and lungs, accompanied by coughing, hoarseness and upper respiratory congestion.

First aid for inhaled pesticides:

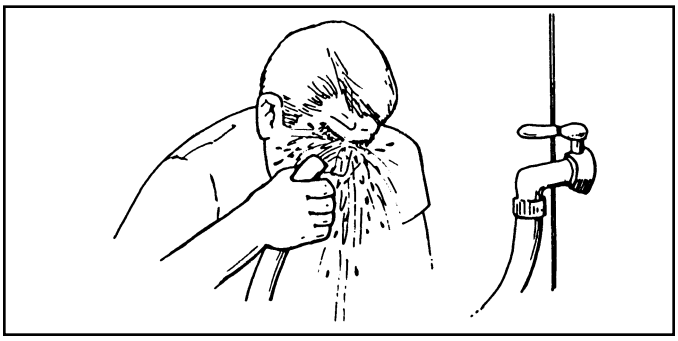
- Get victim to fresh air immediately.
- If other people are in or near the area, warn them of the danger.
- Loosen tight clothing on victim that would constrict breathing.
- Apply artificial respiration if breathing has stopped or if the victim's skin is blue. If pesticide or vomit is on the victim's mouth or face, avoid direct contact and use a shaped airway

tube, if available, for mouth-to-mouth resuscitation.

Effects when a substance gets in the eyes: temporary or permanent blindness or severe irritation. Some pesticides may not irritate the eyes but pass through the eyes and into the body. These pesticides can travel throughout the body, causing harm in a variety of ways such as those listed above.

First aid when pesticides get in the eyes:

- Wash eyes quickly but gently.
- Use an eyewash dispenser, if available. Otherwise, hold eyelid open and wash with a gentle drip of clean running water positioned so that it flows across the eye rather than directly into the eye.
- Rinse eye for 15 minutes or more.
- Do not use chemicals or drugs in the rinse water – they may increase the injury.



Use clean water to gently flush pesticides from the eyes for at least 15 minutes.

Post at all work sites the name, address and telephone number of the physician, clinic or hospital emergency room that will provide care in the event of a pesticide poisoning. The telephone number from anywhere in the United States for Poison Control is:

1-800-222-1222

This telephone number will connect you with the regional poison control center closest to your location. Post this number near telephones and in work areas. MSUE bulletin AM-37 provides pesticide emergency telephone numbers; AM-37-SP provides the information in Spanish. If possible, have the pesticide label available for reference when you call. When pesticide poisoning is suspected, get medical assistance and take the pesticide container (or the labeling) to the physician.

INSECTICIDE POISONINGS

Though all pesticides can cause the acute effects described above, the insecticides in the organophosphate and carbamate chemical groups deserve closer attention. These insecticides inhibit *cholinesterase*, an enzyme critical for normal functioning of the nervous system.

Organophosphates

The organophosphates, because of their widespread use and frequently high acute toxicity, are involved in more pesticide poisonings than any other class of pesticides. The organophosphates interfere with the activity of cholinesterase. When the cholinesterase enzyme cannot perform its normal function, the nerves in the body send "messages" to the muscles continuously. Muscle twitching and weakness commonly result. If the poisoning is severe, the victim may have "fits" or convulsions and may even die.

Organophosphates are irreversible cholinesterase inhibitors – without medical treatment, the level of enzyme activity will return to normal only after several days, weeks or even months. Additive effects of small repeated doses over time, such as a growing season, may finally cause poisoning.

Symptoms may appear almost immediately after excessive exposure to some organophosphates (e.g., mevinphos); with others, symptoms may be delayed for several hours (e.g., parathion, azinphosmethyl or phorate). If the initial appearance of symptoms occurs more than 12 hours after exposure to pesticides during routine handling and application operations, the problem is not acute organophosphate poisoning.

The common symptoms associated with organophosphate poisoning are given below.

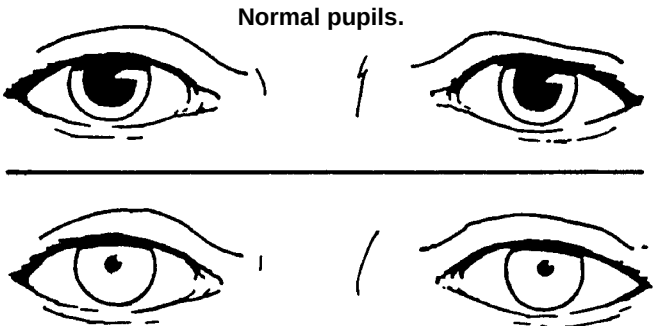
Mild poisoning	Moderate poisoning	Severe poisoning
Fatigue	Inability to walk	Unconsciousness
Headache	Weakness	Severe constriction of pupil of eye
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of pupil of eye	Secretions from mouth and nose
Excessive sweating and salivation	Earlier symptoms become more severe	Breathing difficulty
Nausea and vomiting	Stomach cramps or diarrhea	Coma and death or diarrhea

Carbamates

The effects of carbamates and organophosphates are similar because they both inhibit cholinesterase. They differ, however, in that the action of carbamates is naturally reversible (they will be degraded in and/or expelled from the body). Thus, carbamates can cause severe acute poisoning but they don't normally produce long-term, cumulative poisoning. The symptoms of acute carbamate and organophosphate poisoning are essentially the same. The most commonly reported symptoms, which often appear in progression and

depend, in part, on whether the chemical was touched, inhaled or ingested, are:

- Headache.
- Visual disturbances (blurred vision).
- Pupillary abnormalities (primarily pinpoint pupils but, on rare occasions, dilated pupils).
- Greatly increased secretions such as sweating, salivation, tearing and respiratory secretions.



More severe poisonings result in nausea and vomiting, pulmonary edema (the air spaces in the lungs begin to fill with fluid), changes in heart rate, muscle weakness, respiratory paralysis, mental confusion, convulsions, or coma and death.

If you work with organophosphate or carbamate insecticides for an extended time (farmers, PCO's, pesticide manufacturers, formulators), you should establish a regular cholinesterase test program with your doctor. For a farmer, such a program might consist of an initial cholinesterase test to determine a baseline level. This test should be made in the off-season (January or February). Then, when insecticides are used during the summer, similar tests should be conducted periodically and the results compared with the baseline level. Through this testing procedure, you can learn of any changes in cholinesterase levels when you are exposed to these insecticides. When cholinesterase levels are low, your doctor may advise you to limit or stop your exposure to these pesticides until the cholinesterase level returns to normal.

Table 3. Common organophosphate insecticides

Active ingredient: Some product names
Chlorpyrifos: Lorsban, Dursban, Lentrek
Diazinon: Diazinon, Knox-out
Dichlorvos: Vapona
Dimethoate: Cygon, Dimethoate
Malathion: Malathion, Cythion, Fyfanon
Mevinphos: Phosdrin
Naled: Dibrom
Parathion: Parathion
Phorate: Thimet, Phorate

CHRONIC AND OTHER DELAYED EFFECTS

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. Adverse effects may be delayed for weeks, months or even years after the first exposure to a pesticide. Whether delayed effects occur depends on the pesticide, the extent and route of exposure(s), and how often exposure occurred. The label will list any delayed effects that the pesticide might cause and how to avoid exposures that might lead to such effects. Delayed effects may be caused by either:

- Repeated exposures to a pesticide (or pesticide group) over a long time (usually years).
- A single exposure to a pesticide that causes a harmful reaction that does not become apparent until much later.

Types of delayed effects are:

- Chronic effects.
- Developmental and reproductive effects.
- Systemic effects.

Chronic effects are illnesses or injuries that appear a long time, usually several years, after repeated exposures to a pesticide. The following are terms used to define particular agents that may cause chronic effects:

- A *carcinogen* is a substance that can cause cancer.
- An *oncogen* is a substance that can cause tumor formation; the tumor may or may not be cancerous.
- A *mutagen* is a substance that tends to increase the frequency or extent of mutations (changes, usually harmful, in inherited genetic material).

Table 4. Common carbamate insecticides

Active ingredient: Some product names
Aldicarb: Temik
Bendiocarb: Ficam, Dycarb, Turcam, Bendiocarb
Carbaryl: Sevin, Carbaryl
Carbofuran: Furadan
Methomyl: Lannate
Oxamyl: Vydate, Oxamyl
Propoxur: Baygon
Thiodicarb: Larvin

Chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to an active ingredient. Pesticides are required to include chronic toxicity warning statements on the product label if effects may occur. Because of the variety of effects that pesticides may cause and the amount of time it might take for the effects to appear, it is prudent to reduce exposure to all pesticides as much as possible.

Developmental and reproductive effects – *A developmental effect* can be an injury or illness that occurs to a fetus in the womb of a female who has been exposed to a pesticide. Developmental effects may also occur after birth of a child – e.g., lead exposures of young children resulting in abnormal brain or central nervous system morphology or function.

A *reproductive effect* is an injury to a person's reproductive system. These effects include infertility or sterility in males and females and impotence in men.

Some developmental or reproductive effects could occur immediately after an exposure even though they may not be apparent for some time afterward. For example, a birth defect isn't observable until after the birth.

Systemic effects – A systemic effect is a delayed illness or injury to a bodily system; again, it does not appear within the first 24 hours after an exposure. Systemic effects occur at sites other than the point of entry into the body following absorption and distribution through the circulatory system, possible chemical reaction within the body, or contact with critical target sites or organs. Because these transport or transformation processes may take time, these effects generally take longer to appear than local effects. A good example of a systemic effect would be inhibition of cholinesterase enzymes in the nervous system following oral, dermal or inhalation exposure to certain pesticides (see below). Some examples of systemic effects are:

- Blood disorders (hemotoxic effects), such as anemia or an inability to clot.
- Nerve or brain disorders (neurotoxic effects), such as paralysis, excitation, trembling, blindness or brain damage.
- Lung and respiratory disorders, such as emphysema and asthma.
- Liver and kidney disorders, such as jaundice and kidney failure.

Determining delayed effects – Because of the time lapse between exposure and observable effects and because other types of exposures may have occurred during the delay, it is often hard to identify the cause of delayed effects. In addition, delayed effects, especially chronic and developmental/reproductive effects, are initially detected in laboratory animals – predicting what effects will occur in humans is difficult. People who have been exposed to a pesticide must be monitored over a period of years. These epidemiological investigations can support animal tests on delayed effects.

Several pesticides may cause cancer or other delayed effects in humans, though the evidence is still not conclusive. When there is clear evidence that a pesticide may cause delayed effects in humans, the EPA determines the appropriate steps for reducing the risk. Options include canceling the product, requiring label warning statements, changing label directions and classifying the pesticide as restricted use. Remember that pesticide signal words (toxicity) do not indicate or measure potential chronic health impacts.

ALLERGIC EFFECTS

Allergic effects are harmful effects that some people, but not others, develop when they are exposed to a pesticide. It usually takes more than one exposure for a person's body to develop the response chemicals that result in an allergic reaction to a substance. This process is called *sensitization.*

Once your body is sensitized to a substance, you will have an allergic reaction whenever you are exposed to the substance. Common reactions include:

- Systemic effects, such as asthma or even life-threatening shock.
- Skin irritation, such as rashes, blisters or open sores.
- Eye and nose irritation, such as itchy, watery eyes and sneezing.

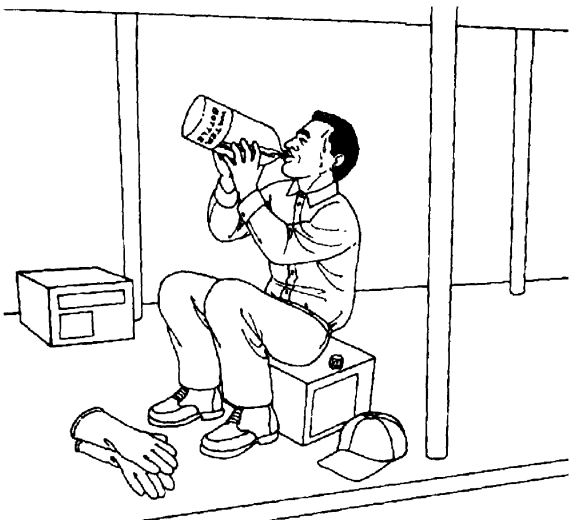
There is no way to predict who will be allergic to any given pesticide. Unlike acute and delayed effects, allergic effects are not properties of the pesticides but rather of the people who use them. In other words, a pesticide's toxicity does not affect the likelihood of an allergic response. Such responses are no different than allergic reactions to common items such as grass, wheat or chocolate. People who are allergic to many things in their environment may be more likely than others to become allergic to some pesticide products.

HEAT STRESS

Heat stress occurs when your body is subjected to more heat than it can cope with. Heat stress is not caused by exposure to pesticides, but it may affect pesticide handlers who are working in hot conditions. Personal protective equipment worn during pesticide handling activities can increase the risk of heat stress by limiting your body's ability to cool down. Work during the cooler parts of the day (early morning), drink adequate amounts of water and take frequent breaks to help prevent overheating.

Signs and Symptoms of Heat Stress

Mild cases of heat stress will make you become tired sooner, feel weak, be less alert and be less able to exercise good judgment. Severe heat stress is a serious illness. Unless victims are cooled down quickly, they can die. Severe heat stress is fatal to more than 10 percent of its victims, even young, healthy adults. Many who survive suffer permanent damage and sometimes remain sensitive to heat for months.



Learn the signs and symptoms of heat stress and take immediate action to cool down if you suspect you may be suffering from even mild heat stress. Signs and symptoms may include:

- Fatigue (exhaustion, muscle weakness).
- Headache, nausea, and chills.
- Dizziness and fainting.
- Severe thirst and dry mouth.
- Clammy skin or hot, dry skin.
- Heavy sweating or complete lack of sweating.
- Altered behavior (confusion, slurred speech, quarrelsome or irrational attitude).

First Aid for Heat Stress

It is not always easy to tell the difference between heat stress illness and pesticide poisoning. The signs and symptoms are similar. Don't waste time trying to decide what is causing the illness – get medical help.

First aid measures for heat stress victims are similar to those for persons who are overexposed to pesticides:

- Get the victim into a shaded or cool area.
- Cool victim as rapidly as possible by sponging or splashing skin – especially face, neck, hands and forearms – with cool water or, when possible, immersing in cool water.
- Carefully remove equipment and clothing that may be making the victim too warm.
- Have the victim, if conscious, drink as much cool water as possible.
- Keep the victim quiet until help arrives.

Severe heat stress or heat stroke is a medical emergency! Brain damage and death may result if treatment is delayed.

HEAT CRAMPS

Heat cramps can be quite painful. These muscle spasms in the legs, arms or stomach are caused by loss of body salt through heavy sweating. To relieve cramps, have the victim drink lightly salted water or sports drinks such as Gatorade. Stretching or kneading the muscles may temporarily relieve the cramps. If you suspect that stomach cramps are being caused by pesticides rather than heavy sweating, get medical help right away.

CHAPTER 6 PART A

Review Questions

Pesticides and Human Health

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. What is the difference between toxicity and hazard?

2. The scalp, ear canal and forehead are especially vulnerable to dermal exposure to pesticides. (True or False?)

3. Pesticide residues are absorbed through the skin at relatively the same rate on different parts of the body. (True or False?)

4. What are the four main routes of human exposure to pesticides?

5. What action/behavior most commonly results in oral exposure to pesticides?
   a. Not wearing PPE.
   b. Splashing pesticide into mouth.
   c. Accidentally applying pesticide to food.
   d. Storing pesticides in drink containers.

6. Which pesticide formulation is most readily absorbed through the skin?
   a. Water-based.
   b. Carbamates.
   c. Organophosphates.
   d. Oil-based.
   e. Dusts and powders.

7. Toxicity from repeated exposures to a pesticide over a period of time is called _____.

   Toxicity from one exposure is _____.

8. Which LD50 is representative of a relatively non-toxic pesticide?
   a. 640 mg/kg
   b. 5,800 mg/kg
   c. 12,840 mg/kg
   d. 380 mg/kg
   e. 46 mg/kg

9. Exposure to a relatively non-toxic pesticide will never cause adverse health effects. (True or False?)

10. The signal word on a pesticide label indicates the pesticide's:
    a. Effectiveness.
    b. Relative toxicity.
    c. Compatibility.
    d. Formulation.
    e. Ability to cause tumors.

11. Circle all of the following that are characteristic of a pesticide in toxicity category II, moderately toxic?
    a. CAUTION signal word.
    b. 1 teaspoon to 1 ounce = approximate lethal oral dose for a 150-pound person.
    c. Severe skin irritation.
    d. Eye irritation reversible within 7 days.
    e. WARNING signal word.

12. Acute oral exposure may produce which of the following symptoms?
    a. Respiratory congestion and impaired vision.
    b. Itching and vomiting.
    c. Chest pains and muscle twitching.
    d. Sweating and diarrhea.
    e. c and d

13. Cholinesterase is inhibited by:
    a. Herbicides.
    b. Organophosphates.
    c. Most fungicides.
    d. Carbamates.
    e. b and d

14. List three common organophosphate and three common carbamate insecticides.

15. Delayed effects of pesticides are illnesses or injuries that:
    a. Appear 24 hours after exposure.
    b. May be caused by repeated exposures over time or by a single exposure.
    c. May result in developmental and reproductive effects.
    d. Are easily tracked to the exposure incident.
    e. b and c

16. What pesticide-related document should you take with you when you take a pesticide-poisoning victim to the doctor?

17. What is the telephone number for the Michigan Poison Control System?

18. List the first aid measures you should do when someone has been dermally exposed to pesticides.

19. Never induce vomiting in a pesticide-poisoning victim if:
    a. The victim swallowed an emulsifiable concentrate or oil solution.
    b. The victim is unconscious or is having convulsions.
    c. The pesticide involved is corrosive.
    d. All of the above.
    e. b and c only

20. List the first aid measures you should do when someone has inhaled a pesticide.

21. To reduce the risk of human pesticide poisoning, the applicator should choose pesticides that have lower _____ and reduce _____ .

22. Unless victims of severe heat stress are cooled down quickly, they can die. (True or False?)

23. Signs and symptoms of heat stress may include:
    a. Dizziness and fainting.
    b. Clammy skin.
    c. Hot, dry skin.
    d. Heavy sweating or complete lack of sweating.
    e. All of the above.

24. If someone is experiencing heat cramps, what should he/she do?

CHAPTER 7 PART A

PERSONAL PROTECTIVE EQUIPMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- List basic safety questions you should ask yourself whenever you or those you supervise handle pesticides.
- Define the term chemical-resistant, and explain how to tell when a material is not chemical-resistant to a particular pesticide.
- Explain the importance of wearing gloves while handling pesticides.
- Be able to select appropriate personal protective equipment (PPE) for pesticide handling.
- Know when to wear protective headgear and describe appropriate headgear.
- Properly clean and maintain personal protective equipment.

TERMS TO KNOW

Concentrates - Pesticides that have a high percentage of active ingredient.

Diluent - Anything used to dilute a pesticide.

Exposure - Coming into contact with a pesticide; getting a pesticide on a surface or in or on an organism.

Labeling - The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

MSHA - Mine Safety and Health Administration.

NIOSH - National Institute for Occupational Safety and Health.

OSHA - Occupational Safety and Health Administration in the U.S. Department of Labor.

Personal protective equipment (PPE) - Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Pesticide handler - Person who directly handles pesticides, such as during mixing, loading, transporting, storing, disposing and applying or working on pesticide equipment.

Residue - The part of a pesticide that remains in the environment for a period of time following application or a spill.

Solvent - A liquid – such as water, kerosene, xylene or alcohol – that will dissolve a pesticide (or other substance) to form a solution.

PERSONAL SAFETY CONSIDERATIONS

Before handling pesticides, take precautions to ensure the safety of yourself, others and the environment. By making a few simple safety decisions, you can prevent many pesticide accidents and reduce the severity of others. Ask yourself these basic safety questions:

Have I read the labeling?

Always read the pesticide label before beginning any pesticide handling activity. Pesticide labeling contains precautions and instructions that may be specific to your task and that you must follow to use the product safely and appropriately.

How can I avoid exposure to pesticides?

The key to personal safety when handling pesticides is to avoid exposure to them. Always keep personal clothing, food, drinks, chewing gum, tobacco products and other belongings away from where pesticides are stored or handled.

When you take a break, wash your gloves on the outside, remove your gloves, and wash your hands and face thoroughly. Avoid getting pesticide on yourself when you use the toilet – the skin in the genital area has been shown to absorb more pesticides than any other skin area.

Be aware of other ways you might be exposed to pesticides on the job. Protect yourself not only during mixing, loading and application, but also while rinsing equipment, cleaning up a spill and repairing or maintaining equipment, and when transporting, storing or disposing of pesticide containers that are open or have pesticides on their outer surface.

What personal protective equipment is needed?

Personal protective equipment (PPE) is clothing and devices that are worn to protect the human body from contact with pesticides or pesticide residues. Personal protective equipment includes such items as coveralls or protective suits, footwear, gloves, aprons, respirators, goggles and headgear. Decide what PPE you and the people you supervise will need. You must use what the labeling requires, and you may decide that you need additional equipment. Regulation 637 requires that all applicators use the personal protective equipment (PPE) required by the label and establishes minimum PPE requirements for commercial applicators. Commercial applicators must wear long pants, protective footwear, gloves and long-sleeved clothing unless wash water or waterless soap is immediately available. Make sure that the PPE is clean and in good condition and that you know how to use it correctly.

Wash your gloves on the outside before removing them.

Is the application equipment ready and safe?

Gather the application equipment necessary for your task and be sure that it is clean and in good operating condition. Make sure that anyone who will use the equipment knows how to operate it safely and correctly. Do not allow children, livestock or pets, or unauthorized adults to touch the equipment. If they are injured or poisoned, you are responsible.

SAFETY: PROTECT YOURSELF FROM PESTICIDES

The greatest risk and potential for exposure to the pesticide applicator occurs during mixing and loading and application of pesticide concentrates. Though application of diluted material is usually less hazardous, the hazard increases when significant drift occurs or when the person handling the pesticides does not follow appropriate safety and application procedures. The danger of exposure also exists when someone is cleaning up pesticide spills, making equipment repairs and entering treated areas prematurely.

Remember:

HAZARD = Toxicity x Exposure

To limit the hazard, choose pesticides with lower toxicity and reduce exposure by wearing PPE. Pesticide labeling lists the minimum personal protective equipment you must wear while handling the pesticide. Sometimes the labeling lists different PPE requirements for different activities – e.g., mixing and loading vs. application.

When pesticide labeling requires you to wear chemical-resistant PPE, you must select a material that will be resistant for the period of time that you will be exposed to the pesticide. Most chemical-resistant personal protective equipment items are made of plastic or rubber. These materials are not equally resistant to all pesticides and in all circumstances.

Factors Affecting Chemical Resistance

PPE materials differ in protection, durability and longevity. How chemical-resistant a material will be depends on the length of exposure, the exposure situation and the chemical to which the material is exposed.

Length of exposure – Not all types of materials that are resistant to a particular pesticide will protect you for the same amount of time. Chemical resistance is often stated in terms of exposure time. For example, neoprene is resistant to acetone for 30 minutes or less and to diesel fuel for more than 4 hours. If you wear neoprene gloves while handling pesticides with an acetone solvent, you must change the gloves at least every 30 minutes – otherwise, the acetone and the pesticide will penetrate to the skin.

Exposure situation – Even a chemical-resistant material will not continue to protect you if it becomes damaged during pesticide handling. For tasks that involve handling sharp or pointed objects or walking through rough terrain, for example, use heavy-duty or sturdy material to ensure chemical resistance.

Type of chemical – Very few materials will protect you from all pesticide products. The level of chemical resistance may depend not only on what the active ingredient is, but also on the pesticide formulation – whether liquid or dry and what diluents or solvents are used.

CHOOSING CHEMICAL-RESISTANT MATERIALS

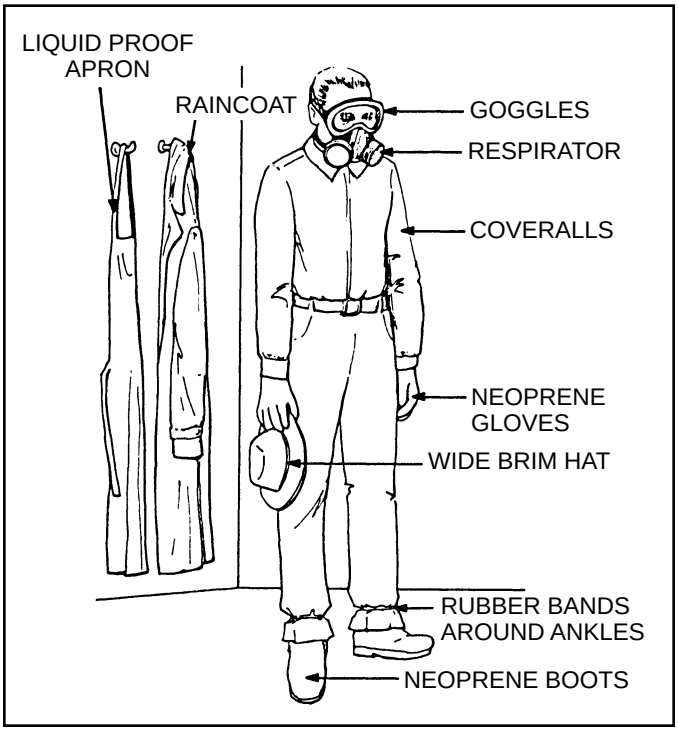
Always read the pesticide labeling to see what materials are resistant to the pesticide product. Pesticide producers or PPE manufacturers and distributors may also offer guidance. Refer to the MSDS to obtain information that may help you select PPE.

Remember all PPE has a limited life (length of time it will adequately provide protection). How clothing and equipment are used, the length of time and the types of chemicals to which they are exposed will affect their performance. Replace your PPE frequently.

Neoprene, nitrile, polyvinyl chloride (PVC) and butyl rubber are chemical-resistant materials available in various thicknesses as gloves, coveralls, hoods, boots and other PPE. Each varies in its ability to withstand chemical permeation. Select the material that best suits your particular needs. Latex rubber has natural pores and is not recommended for protection against chemical exposure.

Some labels will refer to chemical resistance categories (A-H) for PPE. The categories are based on the solvents used in the pesticides, NOT on the pesticides themselves. Therefore, there will be times two different formulations of the same pesticide (WP and EC, for example) will require PPE from two different chemical resistance categories. MSUE bulletin AM-106 is the EPA Chemical Resistance Category Chart (see appendix B). Also provided is the duration of time for which the materials in the categories will prevent pesticides from penetrating.

We will briefly discuss the various types of personal protective clothing and equipment and review some important considerations for their selection and use.



PROTECTIVE CLOTHING

At a minimum, protective clothing should include protective footwear, gloves, a long-sleeved shirt and long trousers that are clean and made of a tightly woven fabric or a water-repellent material. A T-shirt and shorts do not provide adequate protection to a person applying pesticides. Common denim provides better protection than more loosely woven fabrics. Pesticide handlers should also wear protective footwear that is impervious to the pesticides being handled. Specific items of protective clothing are described in the following sections.

Coveralls, Aprons, Raincoats

Coveralls, whether disposable or reusable, vary in their comfort and durability and the degree of protection they provide. Coveralls should be made of sturdy material such as cotton, polyester, a cotton-synthetic blend, denim or a non-woven fabric. A liquid-proof apron or raincoat (or rainsuit) should be worn when you're pouring and mixing concentrates and using highly toxic pesticides – coveralls usually do not provide adequate protection against spills and splashes of these chemicals. A rainsuit should be worn whenever mist or spray drift is likely to substantially wet the work clothes or coveralls. Liquid-proof aprons and rainsuits should be made of rubber or a synthetic material resistant to the solvents in pesticide formulations. The apron should cover the body from the chest to the boots.

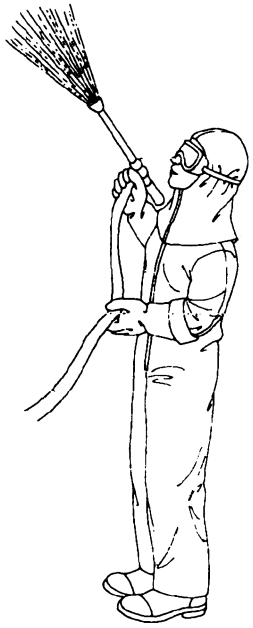
Gloves

Unlined, chemical-resistant gloves should be worn when handling or applying pesticides. Gloves should be long enough to cover the wrist and should not have a fabric wristband. Check gloves carefully to be sure there are no leaks – fill them with water and squeeze. Each exposure to a pesticide reduces the gloves' ability to protect you the next time you wear them. Gloves are intended to be disposable. Replace them often.

Be certain that gloves are approved for use with chemicals – e.g., rubber gloves should not be used for some fumigant and wood preservative products. Some rubber products react with certain solvents and become sticky as the rubber dissolves. If this occurs, dispose of the gloves and use gloves approved for use with the specific pesticide.

If you will be working with your hands and arms overhead, put the gloves outside of your shirt sleeves and turn up the cuff of the gloves to catch material that might run down your arms. Wash chemicals off the gloves with soap and water before removing them. This avoids contamination of your hands when removing the gloves.

Hats



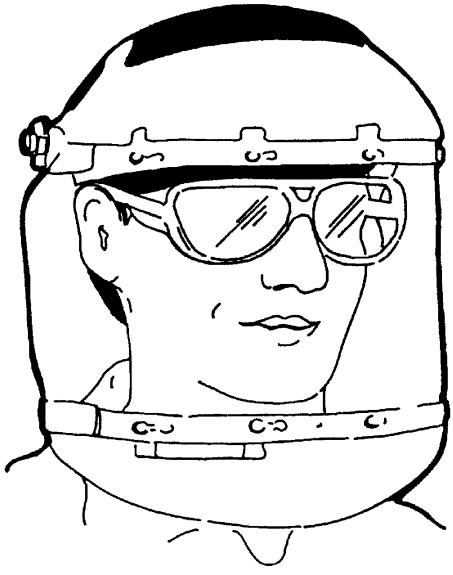
Protective head coverings should be liquid-proof and have a wide brim to protect the face, ears and neck. Hats should be either disposable or easy to clean with soap and water – they should not contain any absorbent materials such as leather, straw or cloth. Baseball hats do not provide adequate protection.

Shoes and Boots

Boots should be unlined and made of rubber. Because of their absorbency, boots of leather, canvas or cloth should never be worn when handling pesticides. Trouser legs should be worn outside the boots to prevent pesticides from running down the leg and into the boot. Wash your boots after each use. Replace them after repeated chemical exposure and wear.

Goggles and Face Shields

Tight-fitting, non-fogging goggles or a full-face shield should be worn when there is any chance of getting pesticide in your eyes. This is especially important when pouring or mixing concentrates or handling dusts or toxic sprays. Those who wear contact lenses may want to consult an eye doctor or physician before using pesticides.



Goggles provide a secure shield around the entire eye area, protecting against hazards coming from many directions. Wear goggles with indirect ventilation when exposed to splash hazards. Face shields that are cupped inward toward your throat give better protection than straight face shields. Goggles and face shields should be kept clean at all times. Wash them with soap and water, and sanitize by soaking equipment for two minutes in a mixture of 2 tablespoons chlorine bleach in 1 gallon of water. Rinse thoroughly with clean water and allow to air dry. In particular, pay attention to the goggle headbands. They are often made of absorbent material that requires frequent replacement.

Respirators

For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system. From the blood capillaries of the lungs, the toxic substances are rapidly transported throughout the body.

Respiratory protective devices vary in design, use and protective capability. In selecting a respiratory protective device, first consider the degree of hazard associated with breathing the toxic substance, and then understand the specific uses and limitations of the available equipment. Select a respirator that is designed for the intended use, and always follow the manufacturer's instructions on the use and maintenance of your respirators for different chemicals or groups of chemicals. Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA). The NIOSH-approval products have numbers that begin with the letters TC. MIOSHA regulations may require a pulmonary exam prior to use of a respirator for some people.

You can check the fit of a respirator by placing your hands over the cartridges, inhaling and holding your breath. The respirator should collapse and stay collapsed on your face. Also, check the information provided by the cartridge manufacturer to determine when the respirator cartridges will expire. Be aware that beards and other facial hair keep the respirator from sealing around your face and therefore make the respirator useless.

After each use of the respirator, remove all mechanical and chemical filters. Wash and sanitize the face piece using the same procedure recommended for goggles. Store the respirator face piece, cartridges, canisters and mechanical filters in a clean, dry place, preferably in a tightly sealed plastic bag. **Do not store your respirator with pesticides or other chemicals.**

LAUNDERING PESTICIDE-CONTAMINATED CLOTHING

All protective clothing and equipment should be washed at the end of each day. Pesticide contaminated clothing should be stored and washed separately from the family laundry. Remember to wear gloves during these handling and laundering steps and be sure to check the label for any specific instructions. Note: clothing that has become saturated with a concentrate should be properly disposed of.

Some residues may be removed by hosing the contaminated clothing with water or presoaking it in a container that can be rinsed free of residues. Washing in hot water removes more pesticide from the clothing than washing in water at lower temperatures. The hotter the better – cold water might save energy, but it is relatively ineffective in removing pesticides from clothing.

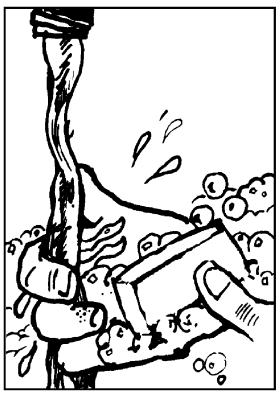
Laundry detergents – whether phosphate, carbonate or heavy-duty liquids –are similarly effective in removing most pesticides from fabric. However, heavy-duty liquid detergents typically have better oil-removing ability and therefore are more effective than other detergents in removing emulsifiable concentrates. The ease of pesticide removal through laundering depends not on toxicity but on the formulation of the pesticide. Bleach or ammonia may possibly help in the removal or breakdown of certain pesticides. **Bleach and ammonia should never be mixed because they react to form chlorine gas, which can be fatal for those who inhale it.**

Washing should be done at the full water level. After washing, it is important to rinse the washing machine with an "empty load," using hot water and the same detergent. Line drying is recommended for two reasons. First, it eliminates the possibility of residues collecting in the dryer. Second, residues of many pesticides will break down when exposed to sunlight.

Wash hands and arms after the laundering procedure. Keep protective clothing separate from the pesticide storage area. A magnet displaying laundering tips is available for adhering to the washing machine. The magnet (Extension bulletin E-2413) is available in both English and Spanish (E-2413-SP).

PERSONAL CARE AFTER APPLICATION

After cleaning application equipment and protective clothing, personal cleanup is next. In particular, wash your hands and face thoroughly with soap and hot water before eating, drinking or smoking. Shower and change clothing as soon as possible. Be sure to scrub your scalp and neck, behind your ears and under your nails.



CHAPTER 7 PART A

Review Questions

Personal Protective Equipment

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. To ensure safety, what questions should you ask yourself before performing pesticide handling tasks?

2. What is considered the minimum amount of PPE for commercial applicators according to Regulation 637?

3. Complete the following equation:

   HAZARD = Toxicity x _____

4. What are two things you can do to limit the hazard?

   a.

   b.

5. Synthetic plastic materials will always provide equal protection from pesticide exposure as rubber. (True or False?)
   a. True
   b. False

6. Where can you find information for selecting the most appropriate material for PPE and a given pesticide?

7. Which of the following appropriately describe gloves worn as PPE?
   a. Unlined.
   b. Chemical-resistant.
   c. Wear when handling or applying pesticides.
   d. Replace them often.
   e. All of the above.

8. Trouser legs should be worn inside boots to prevent contaminating lower pant leg. (True or False?)
   a. True
   b. False

9. Goggles or face shields should be:
   a. Tight-fitting.
   b. Shatter-proof.
   c. Sanitized after use by soaking for two minutes in a mixture of 2 tablespoons chlorine bleach in 1 gallon water.
   d. Worn when pouring or mixing pesticide concentrates.
   e. a, c and d

10. PPE used for respiratory protection must be approved by the National Institute of Occupational Safety and Health. (True or False?)
    a. True
    b. False

CHAPTER 8 PART A

SAFE PESTICIDE HANDLING

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Protect the water source at the pesticide mixing site.
- Select types of protection that pesticide handlers may need while mixing or loading pesticides.
- Properly rinse and dispose of empty pesticide containers.
- Explain proper pesticide container rinsing methods; triple- and pressure-rinsing.
- Recognize pesticide application tasks for which applicators may need to wear more personal protective equipment than the minimum required by the pesticide labeling.
- Explain what to do with excess pesticides that are still usable.
- Name actions to take when mixing, loading and application activities are over.
- Describe what to do with rinsates from equipment cleanup.
- Explain "closed system mixing and loading" and "enclosed application systems".
- Explain the use of pesticide containment systems.
- Describe safety features of a pesticide storage facility.
- Name actions needed to establish and maintain a safe storage site.
- Select the contents for a pesticide spill kit.
- List safety precautions for transporting pesticides in a vehicle.
- Respond correctly when a pesticide container leaks.
- Explain the three C's of spill management and steps to take in each.
- List sources of assistance for managing a spill.

TERMS TO KNOW

Active ingredient - The chemicals in a pesticide product that control the target pest.

Acute effects - Illnesses or injuries that may appear immediately after exposure to a pesticide (usually within 24 hours).

Back-siphoning - The movement of liquid pesticide mixture back through the filling hose and into the water source.

Chemical-resistant - Able to prevent movement of the pesticide through the material during the period of use.

Collection pad or tray - A safety system designed to contain and recover spills, leaks, rinsates and other pesticide-containing materials.

Concentrates - Pesticides that have a high percentage of active ingredient.

Decontamination - To rid of a polluting or harmful substance.

Delayed effects - Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides.

Diluent - Anything used to dilute a pesticide.

Dilute - To make less concentrated.

Drift - Pesticide movement in the air, away from the application / release / target site.

Exposure - Coming into contact with a pesticide.

Formulation - Pesticide product as sold, usually a mixture of active and inert ingredients.

Labeling - The pesticide label and other accompanying materials that contain directions that pesticide users are legally required to follow.

Leaching - The movement of pesticide in water or another liquid downward through soil.

MSHA - Mine Safety and Health Administration.

NIOSH - National Institute for Occupational Safety and Health.

Personal protective equipment (PPE) - Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Pesticide handling - Directly working with pesticides, such as during mixing, loading, transporting, storing, disposing and applying, or working on pesticide equipment.

Rinsate - Wash water that contains a small amount of pesticide.

Runoff - The movement of a pesticide in water or another liquid flowing horizontally across the surface.

Soluble - Able to be dissolved in another substance, usually a liquid.

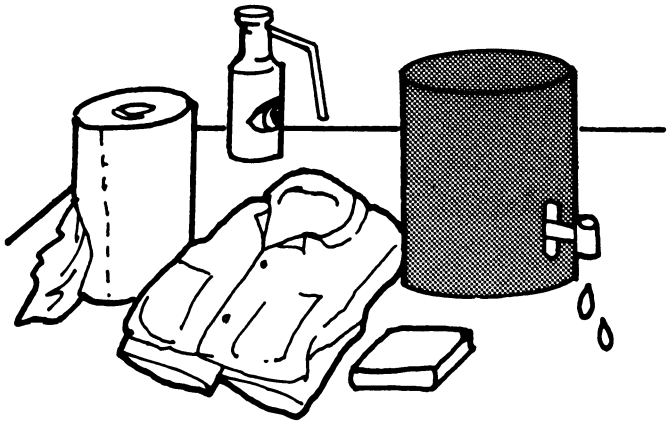
Volatile - Evaporates rapidly; turning easily into a gas or vapor.

Danger of exposure always exists whenever pesticides are handled. The greatest risk to the applicator is in handling and applying highly toxic materials and in mixing and loading pesticide concentrates.

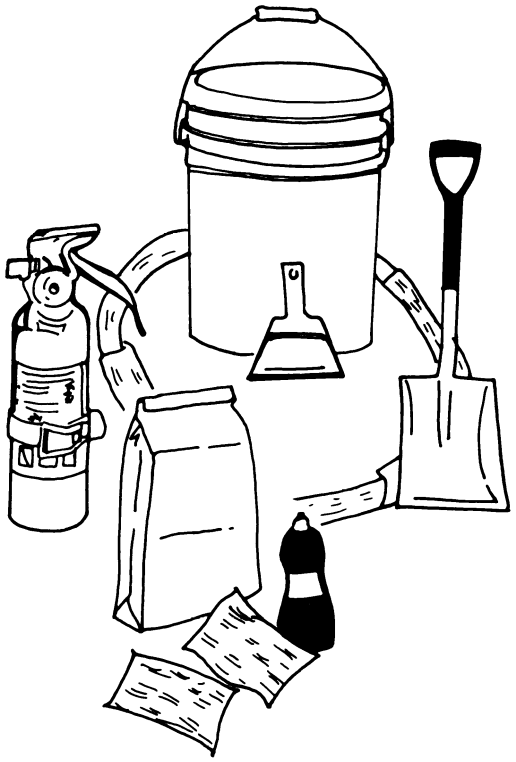
ARE YOU PREPARED FOR EMERGENCIES?

Before beginning pesticide handling activities, be sure you are prepared to deal with emergencies such as spills, injuries and poisonings. Emergency supplies should include at least:

- Personal decontamination equipment and supplies: clean water, detergent and paper towels in a protected container to allow for fast decontamination in an emergency. Have an extra coverall-type garment nearby.



- First aid equipment: a well stocked first aid kit, including a plastic eyewash dispenser that has a gentle flushing action.
- Spill cleanup equipment: all the items needed for prompt and complete spill cleanup, and personal protective equipment to protect you while you clean up the spill.



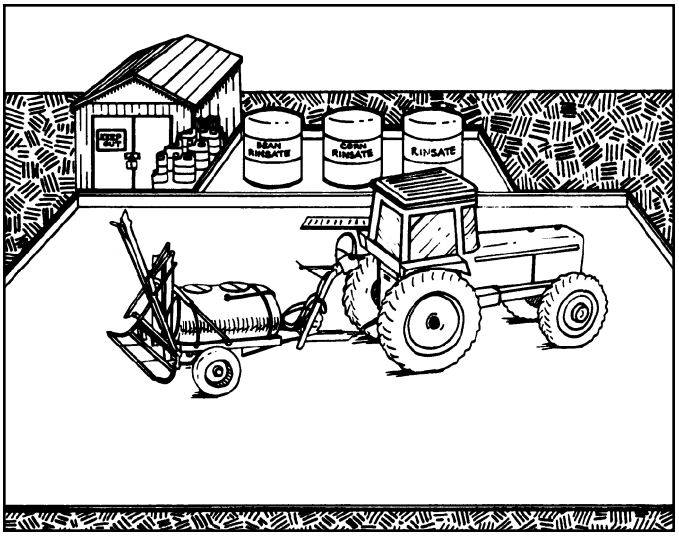
Know whom to call in a medical emergency, and be familiar with the signs and symptoms of poisoning caused by the pesticides you handle.

SAFE MIXING AND LOADING PRACTICES

Handlers who mix and load concentrated pesticides have an especially high risk of accidental poisoning. Observe some simple precautions to reduce the risks involved with this part of the job.

Select an Appropriate Mix/Load Area

The pesticide mixing and loading area should be outdoors or in a well ventilated, well lighted area away from unprotected people, animals, food and other items that might be contaminated.



Protect Your Water Source

Protect water sources by keeping the water pipe or filling hose well above the level of the pesticide mixture. This prevents contamination of the hose and keeps pesticides from back-siphoning into the water source. If water is pumped directly from the source into a mix tank, use a check valve, antisiphoning device or backflow preventer to prevent back-siphoning if the pump fails.

Use mixing equipment where spills, leaks and overflows will not flow towards a drain or into the water supply. Commercial applicators who will often be mixing or loading at one site may be required by Regulation 637 to install a containment pad. (See p. 89.)

Personal Protective Equipment (PPE)

The appropriate personal protective equipment (PPE) should be put on before opening a pesticide container. By law, pesticide handlers must use all PPE that the pesticide labeling requires. Michigan's Regulation 637 requires minimum PPE for commercial applicators.

Front of body protection — If splashing may occur during mixing or loading tasks, or if you will need to lean against contaminated equipment, consider wearing a bib-top apron made of butyl, nitrile or foil-laminate material. The style that includes built-in gloves and sleeves is especially protective.

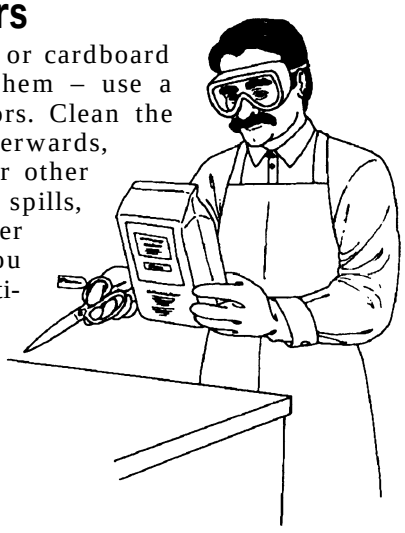
Face protection — If you will be pouring liquid pesticide or adding dry pesticide to a liquid, consider wearing a face shield to keep splashes and dusts off your face and out of your nose and mouth.

Protection from dusts — When handling dusts, consider wearing a dust/mist-filtering respirator. Choose a dust/mist respirator with NIOSH/MSHA approval. Also wear eye protection, such as shielded safety glasses, goggles or a face shield.

Protection from vapors — If you handle pesticides that produce vapors that could cause your eyes, nose or throat to sting or that cause other discomforts, wear eye protection and a vapor-removing respirator with NIOSH/MSHA approval.

Opening Containers

Do not tear paper or cardboard containers to open them – use a sharp knife or scissors. Clean the knife or scissors afterwards, and do not use it for other purposes. To prevent spills, close containers after each use. Even if you plan to mix more pesticide soon, close the container tightly each time.



Transferring Pesticides

When pouring any pesticide from its container, keep the container and pesticide below face level. If there is a breeze outdoors or a strong air current indoors, stand so the pesticide cannot blow back on you. Never leave a tank unattended while it is being filled.

Cleaning and Disposing of Pesticide Containers

If empty pesticide containers cannot be refilled, reconditioned, recycled or returned to the manufacturer, crush, break or puncture them to make them unusable. Do not leave pesticide containers unattended at the mixing, loading or application site – return them to a secured storage area until they can be disposed of. Dispose of containers in accordance with label directions and with federal, state and local laws and regulations.

Non-rinsable containers — Some bags, boxes and other containers of dry pesticides can not be rinsed, but should be emptied as completely as possible. Some containers are designed to be returned to the pesticide dealer or manufacturer.

Rinsable containers — When diluting pesticides, immediately rinse the empty pesticide containers, because the residues can dry quickly and become difficult to remove. While rinsing, add the rinsate to your pesticide mixture.

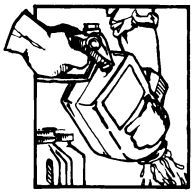
Triple- or pressure-rinsing empty pesticide containers allows them to be disposed of as non-hazardous waste. Clearly mark and puncture rinsed containers and safely store them for later disposal.

To triple-rinse a container, wear protective clothing and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.
2. Fill approximately 20 percent of the container volume with water, replace the lid and shake the container so all the interior surfaces are rinsed.

3. Drain the rinse water into the spray tank, allowing it to drain for at least 30 seconds.

4. Repeat the procedure two more times.



Pressure-rinsing is an effective way to make a pesticide container non-hazardous. Pressure-rinsing requires the use of a special nozzle that directs high-pressure water into the container. Check with your local agricultural chemical dealer for availability. Studies have indicated that pressure-rinsing may be up to three times more effective than triple-rinsing and can take less time. Puncturing the container with the rinse nozzle also renders the container unusable.

To pressure-rinse, wear protective clothing, especially gloves and goggles or face shield, and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.
2. Push the pointed pressure-rinse nozzle through the bottom or side of the pesticide container while holding it over the spray tank.
3. Pressure-rinse the container for 30 seconds, allowing the rinse water to drain into the spray tank.
4. Triple-rinse the container cap with a slower flow of water, capturing the rinse water in the spray tank.

APPLYING PESTICIDES SAFELY

Applicators have two major responsibilities when applying pesticides:

- Protecting themselves, others and the environment.
- Making sure that the pesticide is applied correctly.

Personal Protective Equipment (PPE)

By law, applicators must wear the PPE and other clothing that the pesticide labeling requires (see Regulation 637 in the "Laws and Regulations" chapter). Consider using additional protection for some types of pesticide application tasks such as those listed below.

Hand-carried application equipment — When carrying application equipment, such as hand-held sprayers or shake cans, a dripping or partially clogged nozzle, a leaky hose or a loose connection is extremely likely to cause exposure. Consider wearing extra PPE to protect the area of your body that is in contact with the equipment.

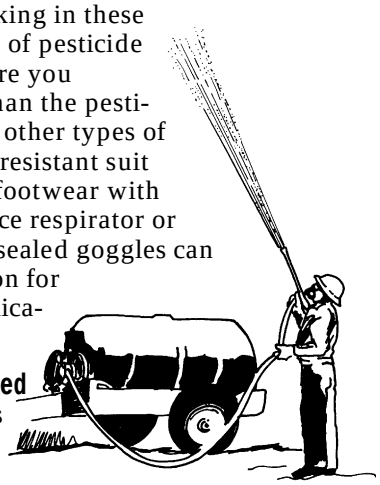
Entering the path of the applied pesticide — Many applications performed while on foot cause the applicator to walk into the path of the pesticide being applied. Whenever possible, apply pesticides so that you are backing out of the treated area.

If you must walk into the path of the pesticide, consider wearing shin-high or knee-high boots or protective footwear with chemical-resistant pants. Spraying a thick coating of fabric starch or fabric stain protectant on the lower legs of your coveralls can provide a temporary barrier for low-toxicity pesticides and also makes the coveralls easier to clean.

If you must walk into the path of the pesticide, consider wearing shin-high or knee-high boots or protective footwear with chemical-resistant pants.

High-exposure applications — Certain pesticide applications pose a special exposure risk because they engulf the applicator in pesticide fallout. They include:

- Mist blower or airblast applications.
- Aerosol and fog applications, especially indoors.
- Some applications using high-pressure sprayers and power dusters.
- Applications directed upward over your head, such as to tree canopies or roof eaves.



Whenever you're working in these situations, large amounts of pesticide fallout are likely. Therefore you should wear more PPE than the pesticide labeling requires for other types of applications. A chemical-resistant suit with a hood, gloves and footwear with sealed cuffs, and a full-face respirator or half-face respirator with sealed goggles can provide enough protection for these high-exposure applications.

Applications in enclosed spaces — Pesticides sometimes are applied in enclosed spaces such as warehouses, factories and homes; rail-car, ship and truck cargo areas; silos, elevators and other grain storage areas; and greenhouses. Applying pesticides in enclosed spaces increases the risk of inhalation exposure. Consider using a respirator even if you would not need one for the same application outdoors.

Application Procedures

To ensure pesticides are being applied safely and effectively, follow these basic procedures:

1. Take the time to be sure that the pesticide is reaching the surface or space to which you are directing it.
2. Apply the pesticide evenly and in the right amounts. No puddles of liquid pesticide or mounds of dry pesticide should be deposited in the application area. Be especially careful in areas where you turn or pause.

   When the pesticide is applied to the first part of the target area or space, check to be sure that the correct proportion of pesticide has been used.
3. During the application, notice whether the pesticide looks the way it should. Applications of wettable powders (WPs) usually are whitish. Granules and dusts should appear dry and not form clumps. Emulsifiable concentrates (ECs) usually look milky. If the pesticide does not look right, be sure that you have the right mixture and that it is still blended evenly.
4. Before applying a pesticide, clear all unprotected people from the area. Even when the pesticide application is a narrowly directed one, such as a crack and crevice treatment, keep people and animals out of the immediate area during the application.

   Check the pesticide labeling to find out when people and nontarget animals can go back into the application area.
5. Turn equipment off whenever you pause for any reason. When you stop an application to take a break, to move to another site or to make repairs, depressurize any pressurized tanks. Turn off the main pressure valve on the tank and release any pressure remaining at the nozzles.

Check hoses, valves, nozzles, hoppers and other equipment parts occasionally during the application.

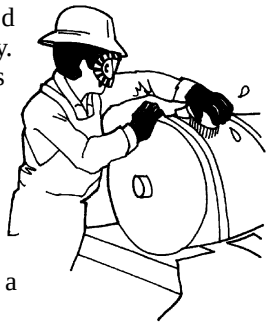
AFTER MIXING, LOADING AND APPLICATION

After mixing, loading or applying a pesticide, a few important follow-up tasks need to be done. Take the time to properly clean the pesticide equipment and yourself. While the facts of the application are still fresh in your mind, record all aspects of the application to satisfy your future reference needs and to comply with the law.

If you have left over pesticide, apply it to a labeled site, being careful not to exceed label rates.

Equipment Cleaning

Always clean mixing, loading and application equipment as soon as you finish using it – do not leave equipment with pesticides on or in it at the mixing and loading site or at the application site. Avoid washing equipment repeatedly in the same location unless you use a containment pad or tray.



Persons who clean pesticide-contaminated equipment should be instructed on pesticide safety. Equipment cleaning presents as great a risk of exposure to pesticides as do many other pesticide handling tasks. When cleaning pesticide-contaminated equipment, wear the PPE that the labeling requires for handling jobs, plus a chemical-resistant apron.

Benefits of correct cleaning — Sloppy cleanup practices are one of the main causes of equipment failure or malfunction. Even small amounts of pesticide residues can damage equipment by causing corrosion or clogging. Some liquid pesticides will settle out, form a solid or separate into two or more liquids that cannot easily be remixed or applied.

Dry pesticides that become wet from humidity, rain, dew or other moisture tend to clump and stick and cannot be applied later or easily removed from the equipment.

Cleaning procedures — After the equipment is empty, clean both the inside and the outside thoroughly, including nozzles or hopper openings. The diluent used in the pesticide mixture (kerosene or high-grade oil), special cleaning agents or water under pressure may need to be used to get the equipment clean.

Rinsates — Rinsates created when cleaning equipment contain pesticides and can be harmful to people and the environment. Do not allow rinsates to flow into water systems, including sink or floor drains, rainwater culverts, wells, streams, lakes or rivers. Collect rinsates and apply them to labeled sites at or below labeled rates.

Equipment rinsate may be used as a diluent for future mixtures of pesticides if:

- The pesticide in the rinsate is labeled for use on the target site where the new mixture is to be applied.
- The amount of pesticide in the rinsate plus the amount of pesticide product in the new mixture does not exceed the labeling rate for the target site.
- The rinsate is used to dilute a mixture containing the same or a compatible pesticide.
- You comply with other application instructions specified on the labeling, including any specific labeling instructions for application as an excess pesticide.

The rinsate **cannot** be added to a pesticide mixture if:

- The rinsate contains strong cleaning agents, such as bleach or ammonia, that might harm the plant, animal or surface to which the pesticide will be applied.
- The rinsate would alter the pesticide mixture and make it unusable; for example, if the pesticides are physically or chemically incompatible.

SAFETY SYSTEMS

Closed mixing and loading systems, enclosed application systems and pesticide containment systems are excellent investments for pesticide handlers who handle large quantities of pesticides or who handle pesticides that are very hazardous to humans or to the environment. These systems may be required for certain pesticides or when pesticides are used in or near sensitive areas.

Closed Mixing and Loading Systems

A *closed mixing and loading* system is designed to prevent pesticide from coming in contact with handlers or other persons during mixing and loading. The labeling of some pesticides, usually products with a high risk of causing acute effects or that may cause delayed effects, requires the use of a closed mixing and loading system.

Closed systems can:

- Increase handler safety.
- Allow for less personal protective equipment.
- Reduce spills.
- Provide more accurate measurement, which reduces overdosing or underdosing and may save money.

There are two primary types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment; the other type uses soluble packaging.

1. **Mechanical systems** — Mechanical systems are often a series of interconnected equipment that allows you to remove a pesticide from its original container, rinse the empty container, and transfer the pesticide and rinse solution to the application equipment without being exposed to the pesticide.

Closed mixing and loading systems are often custom-made, with components from several commercial sources. Because pesticide container openings, shapes and sizes vary, no single closed system can be used with all containers. The mechanical systems now available remove the pesticide concentrate from the original container in one of two ways — by gravity or by suction.

Mini-bulk containers range in volume from 40 to 600 gallons and may provide container and application safety advantages. Most of them are adapted to closed systems so the applicator can attach the mini-bulk tank to the sprayer without exposure to the chemical. Typically a pump and drive unit delivers the product, while a meter allows accurate measuring from the mini-bulk to the applicator's sprayer. Most meters require calibrating to be accurate. The mini-bulks are returned for refilling or for a deposit. This process eliminates the applicator's need to triple- or pressure-rinse multiple small containers and reduces the volume of plastic going to landfills or for recycling.

There is reduced applicator exposure with mini-bulk containers adapted to closed systems that attach to the sprayer.

2. **Soluble packaging** — Soluble bags or containers are a much less complex type of closed-system mixing and loading. The pesticide package is designed to be placed, unopened, into the mixing tank. The container (package) dissolves in the solvent (usually water) in the tank.

Enclosed Application Systems

An *enclosed application* system, such as a cab or cockpit, surrounds the occupant(s) and prevents exposure to the pesticides being applied.

When working in an enclosed application system, the required PPE must be kept inside the cab (clean and readily available) and worn any time you get out of the cab in the treated area.

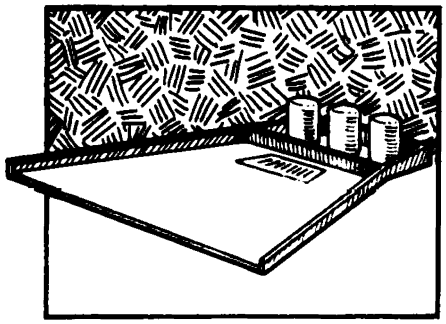
When working in an enclosed application system, pesticide labeling directions and current pesticide regulations may allow you to wear less PPE than is required for ordinary application. However, the required PPE must be kept inside the cab (clean and readily available) and worn any time you get out of the cab in the treated area. Remove the used PPE before you get back into the cab. Either store the contaminated (used) PPE outside the cab or place it in a chemical-resistant container, such as a plastic canister or trash bag, that can be closed tightly.

Pesticide Containment Systems

If you often mix and load pesticides in one place or clean equipment at one location, a pesticide collection pad or tray may be required by law. Refer to Regulation 637 for details. Containment pads and trays are designed to catch spills, leaks, overflows and wash water and allow them to be recovered for reuse or disposal. Large pads may be permanently installed, but smaller portable pads and trays are available. If equipment is full, keep it parked on the pad while not in use.

These pads make spill cleanup easier, and they reduce pesticide waste by allowing the rinse water and spill cleanup water to be reused. They also help prevent environmental damage that spills and runoff can cause.

Containment pads — A containment pad is suitable for mixing, loading and equipment cleaning sites where large quantities of pesticides are handled and large equipment is cleaned.



The containment pad must be made of an impermeable material, such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners or no-wax sheet flooring (other materials are acceptable, according to the MDA). The pad should be concave or should have curbs, berms or walls high enough to hold the largest amount of spill, leak or equipment wash water likely to be created at the site. It also must be equipped with a system for removing and recovering spilled, leaked or released material — either an automatic sump system or a manually operated pump.

Rather than returning the sprayer to the containment pad for cleaning and rinsing, a practice that is encouraged and gaining acceptance is to carry an auxiliary tank of water on the sprayer that can be used to wash and rinse the sprayer at the application site. If appropriate, this leaves the pesticide in dilute form in the target area and prevents the buildup of chemicals at the loading pad. For more information on containment pads and associated practices, contact the MDA at (517) 335-6544.

PESTICIDE STORAGE

Proper pesticide storage helps prolong chemical shelf life while protecting the health of people, animals and the environment. Consult the pesticide product label for specific storage information. A correctly located, designed and maintained pesticide storage site is the key to safety. For information in addition to the following descriptions, refer to Extension bulletin E-2335, "On-farm Agrichemical Storage and Handling."

Location of a Storage Site

To avoid contamination of surface and groundwater by runoff, leaching or drainage, consider the soil and land characteristics when locating a chemical storage area. Existing pesticide storage areas should be located a minimum of 50 feet from any private water well and a minimum of 200 feet from surface water. New pesticide storage areas should be located a minimum of 150 feet from any private water well and a minimum of 200 feet from surface water. Where these minimum distances cannot be maintained, water source protection measures, such as runoff diversions, a covered well head, a sealed well casing into a deep aquifer, etc., should be used. Public water supplies require greater setbacks.

Storage Buildings

It is preferable to have a separate, dedicated building for pesticide storage. When pesticides are stored in a general purpose building, they should be on the ground floor and should not be stored in a building that contains office or other work space unless pesticide storage is well isolated and good ventilation is maintained in the storage area, and vapor barriers are used in the walls and ceiling to prevent fumes from entering the work areas.

If a small amount of pesticide is to be stored, a portable storage unit may be acceptable. Plan for security, ventilation, containment and spill cleanup to ensure safe storage. Always post the storage area as a pesticide storage facility. Fire and Hazmat placards are also useful information for emergency responders.

Fire resistance —The storage building material and design should be selected for fire resistance. Locate a chemical-type fire extinguisher near the door where it is accessible and provide fire warning (i.e., smoke detectors or alarms) as needed. Outside shutoffs for all electrical and water systems are recommended.

Floors and walls — A sealed concrete floor with curbing to contain spills is best. Porous walls and floor materials, including concrete, should be sealed with an epoxy-type coating to prevent absorption and facilitate cleanup.

Floor drains — Because water is needed for mixing, rinsing and cleanup, a waste-handling system is necessary. Floor drains must not be connected to the wastewater sewer or septic tank, however. Sump drains must direct water to a holding tank until it can be used as a diluent or disposed of properly.

Ventilation — Pesticide storage areas should be ventilated to reduce fumes and dust. Fans to provide three to six air exchanges per hour are usually adequate, with a minimum ventilation rate of 150 cubic feet per minute recommended for any size facility.

Temperature control — Temperature extremes must be avoided to preserve the integrity of the chemicals. The area should be insulated and maintain a minimum temperature of 40 degrees F and a maximum temperature of 100 degrees F. Pesticides should be kept cool, dry and out of direct sunlight. Check label for specific temperature ranges of each product.

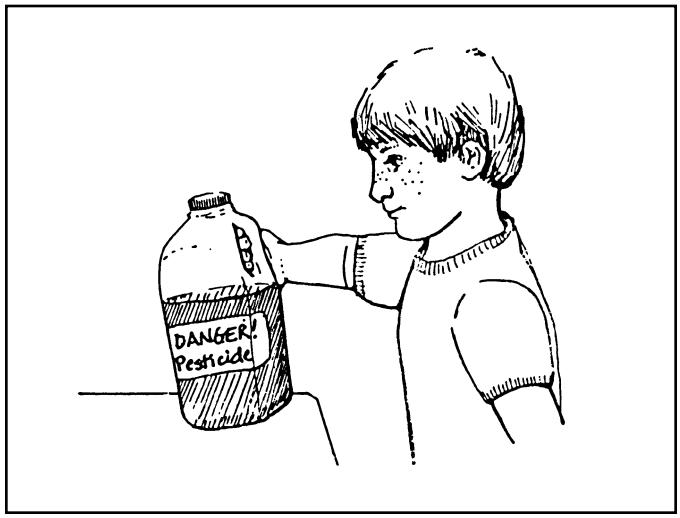
Security —The pesticide storage area must be locked when not in use or not being supervised, and posted with pesticide warning signs. All pesticides should be kept out of the reach of children, pets, livestock and irresponsible adults. Around the home, the same rules apply–pesticides should be kept in a locked area and out of the reach of children.

Characteristics of a Proper Pesticide Storage Facility

Separate facility
Containment for overall storage area
Containment of individual containers
Located a safe distance from water sources
Fire-resistant construction materials
Chemical fire extinguisher near door
Well ventilated
Temperature controlled
Adequate lighting
Metal shelving with containment
Pesticides kept in original containers
Legible pesticide labels on all containers
Secured
Posted as pesticides storage area
Waste-handling system in place
Spill cleanup kit readily available
Decontamination kit/equipment
Supply of clean water
First aid kit
Emergency plan with emergency contact numbers

Pesticides and Their Containers

Store pesticides in their original containers with labels attached. Never use soft drink bottles, fruit jars or other types of non-pesticide containers. Serious poisonings could result because children as well as most adults associate the shape of a container with its contents.



Pesticides should never be stored in food or beverage containers. They may be swallowed accidentally.

Keep the original label attached to the container. Keep labels legible by protecting them with transparent tape. Remember, the label is the most important safety factor in the use of pesticides – do not let it become damaged or destroyed.

Securely close containers when not in use. Dry formulations tend to cake when wet or subjected to high humidity. Opened bags of wettable and soluble powders, dusts and granules can be placed into sealable plastic bags or other suitable containers. This reduces moisture absorption by the material and prevents spills should a tear or break occur.

Store liquid formulations and small containers of dry formulations on metal shelving. Metal shelving will not absorb spilled pesticides and is easier to clean than other surfaces.

Store pesticide containers in secondary containment trays for extra protection against leaks.

Store volatile pesticide products, such as some types of 2,4-D, separately. Vapors from opened containers of volatile pesticides can contaminate other pesticides.

Store pesticides in the original containers under cool conditions. Too much heat can cause some containers to break or explode. Place larger metal drums and non-metallic containers on pallets. Store liquids on lower shelves and dry formulations on upper shelves.

Check containers regularly for leaks, breaks, rust and corrosion. If a leak or break occurs, place the container inside another container, or transfer the contents to an empty container that originally held the same material and has the same label attached.

Shelf Life of Pesticides

Keep an up-to-date inventory of all stored pesticides and mark each container with the purchase date. If a product has an effective shelf life recorded on the label, dating the product enables you to determine quickly whether the product is still usable. If you have doubts about the shelf life of a pesticide, call the dealer or manufacturer. Pesticide deterioration may be apparent during mixing as excessive clumping, poor suspension, layering or abnormal coloration. Sometimes, however, pesticide deterioration from age or poor storage conditions is apparent only after application. Poor pest control or damage to the treated crop or surface can occur.

To minimize storage problems, buy only as much as you anticipate needing for the job or the season – recommendations may change by next season. Keep records of previous usage to make good estimates of future needs.

Reporting Requirements

Title III of the federal Superfund Amendments and Reauthorization Act of 1986 (SARA) is also called the Emergency Planning and Community Right-to-Know Act. This Act requires, among other things, the reporting of inventories of certain pesticides if the amount stored is greater than a "threshold planning quantity" (see Chapter 2, "Laws and Regulations"). It is good policy to inform your local fire department if you store chemicals (including fertilizers). Chemical fires cannot usually be extinguished by ordinary means, and the smoke from the fire can be extremely hazardous to firefighters. The fire department must be properly prepared in the event of a chemical fire. For more information on these requirements, see Michigan State University Extension bulletin E-2575 or contact the MDEQ Title III office at (517) 373-8481.

PREVENT PESTICIDE FIRES

Some pesticides are highly flammable. The labeling of pesticides that require extra precautions often will contain a warning statement in either the "Physical/Chemical Hazards" section or the "Storage and Disposal" section. Pesticides that contain oils or petroleum-based solvents are the ones most likely to contain these warning statements.

Store combustible pesticides away from open flames and other heat sources, such as steam lines, heating systems, kerosene heaters or other space heaters, gas-powered equipment or incinerators. Do not store glass containers in sunlight where they can focus the heat rays and possibly explode or ignite. Install fire detection systems, and equip each storage site with a working fire extinguisher that is approved for all types of fires, including chemical fires.

In the Event of a Pesticide Fire:

- Clear all persons from the area to a safe distance upwind from the smoke and fumes.
- Call the fire department and inform the firefighters of the nature of the pesticides involved. Material Safety Data Sheets (MSDS), which provide technical information, should be filed where they are accessible in an emergency. MSDS are available from chemical dealers – request them at the time of purchase.
- Firefighters must bring and wear the proper protective clothing and equipment (especially respirators).
- Be aware of the potential for explosion of overheated pesticide containers. Nearby containers should be moved or kept cool.
- The principal objective is to contain the fire and prevent contamination of surrounding areas. Use only as much water as is absolutely necessary. Heavy hose streams should be avoided, and any necessary dikes should be built to prevent flow of contaminated runoff into lakes, ponds, streams, wells or sewers.

TRANSPORTATION OF PESTICIDES

You are responsible for the safe transport of pesticides in your possession. Accidents can occur even when transporting materials a short distance. Do all you can to prevent a mishap, but be prepared in case of emergency. Carry a spill cleanup kit.

Before transporting pesticides, know what to do if a spill occurs. If any pesticide is spilled in or from the vehicle, take immediate action to clean up the spill.

Vehicle Safety

The safest way to transport pesticides is in the back of a truck. Flatbed trucks should have side and tail racks. Steel or plastic-lined beds are best, because they can be more easily cleaned if a spill occurs.

Never carry pesticides in the passenger section of your car, van or truck. Hazardous vapors may be released and make the driver and other passengers ill. If spills occur, it is nearly impossible to completely remove chemicals from the fabric of seats and floor mats.

Never allow children, other passengers or pets to ride with pesticides.

Never transport pesticides with feed, food, clothing or other things meant to be eaten by or in contact with people or animals. Even small amounts of pesticide could contaminate these highly sensitive items.

Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are responsible and liable if curious or careless people are accidentally poisoned by the pesticides. Whenever possible, transport pesticides in a locked compartment.

Consider transporting highly volatile pesticides in separate trips from other chemicals.

Transporting Pesticides

Transport pesticides only in containers with undamaged and readable labels. Inspect containers before loading to be sure that all caps, plugs and other openings are tightly closed and that there are no pesticides on the outside of the containers.

Anchor all containers securely to keep them from rolling or sliding. Protect paper and cardboard containers from moisture.

Protect pesticides from extreme temperatures during transport. Extremely hot or cold temperatures can damage pesticide containers and also may reduce the usefulness of the pesticides.

When transporting pesticides for commercial application use, Regulation 637 requires that the name of the applicator firm, its business telephone number and address, or the U.S. Department of Transportation census number of the applicator firm be printed on the exterior of each vehicle.

PESTICIDE SPILL MANAGEMENT

As careful as people try to be, pesticide spills can and do occur. Know how to respond correctly when a spill occurs. The faster a spill is contained, absorbed and disposed of, the less chance there is that it will cause harm.

The following guidelines for pesticide spill cleanup can be remembered as the three C's: CONTROL the spill, CONTAIN the spill and CLEAN UP the spill.

Control The Spill

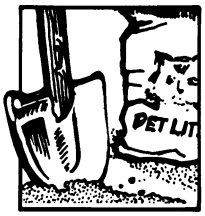
Put on PPE and, if possible, stop the source of the spill. If a small container is leaking, place it into a larger chemical-resistant container. If a spray tank is overflowing, stop the inflow and try to cap the tank. Larger spills, such as a sprayer that has tipped over or a tank truck or rail car that spills its cargo, may not be possible to handle alone.

Isolate the spill area – keep people and animals well back. Rope off the contaminated area, if necessary. Avoid coming into contact with any drift or fumes that may be released.

Stay at the site. Do not leave the spill site until another knowledgeable and correctly protected person arrives. Someone should be at the spill site continuously until the spill is cleaned up.

Contain the Spill

As the source of the spill is being controlled, contain the spill material to as small an area as possible. Prevent the spill from spreading by using containment "snakes" to surround the spill. For larger spills, use a shovel or other tool to make a dike of soil, sod or other absorbent material around the spill area. Prevent a spill from reaching any water source by blocking or redirecting it.



Liquid spills can be further contained by spreading absorbent materials such as fine sand, vermiculite, clay or pet litter over the entire spill. These pesticide-containing materials can later be applied to a labeled site according to label rates and directions as a method of disposal. Absorbent pillows can be used to dike spill areas and absorb the chemical spill, but they do not have the same disposal advantages as other absorbent materials.

In the case of a spilled dry formulation pesticide, prevent it from becoming airborne by lightly misting the

material with water (do not use a hose) or cover it with a sweeping compound or plastic cover until it can be cleaned up.

Clean Up the Spill

If you haven't already done so, spread absorbent material on spilled liquid pesticides and shovel or sweep it up and place it into a leak-proof container. Keep adding absorbent material until the spilled liquid is soaked up and removed. If the pesticide was spilled on an impervious floor, use a heavy-duty detergent to clean and decontaminate the area.

Spills of dry pesticides should be swept up and reused, if possible.

Spill Assistance

The Chemical Transportation Emergency Center (Chemtrec) is a public service of the Chemical Manufacturing Association. Located in Washington, D.C., Chemtrec is staffed 24 hours a day by trained persons who can advise you on how to manage chemical emergencies. The Chemtrec number is **(800) 424-9300**.

When you request help from Chemtrec or any other source, have the product label on hand. Many pesticide labels list an emergency telephone number that gives you direct access to the manufacturer and people who know how to manage emergencies involving that product.

In the event of a pesticide spill:

Protect personal safety first.

Control/stop the source, if possible.

Contain the spill.

Notify local emergency response personnel, if necessary (police, fire, LEPC).

Call MDA Agriculture Pollution Emergency (APE) Hotline (800-405-0101) for assistance.

Call MDEQ PEAS hotline (800-292-4706) about all uncontained spills.

Call National Response Center (800-424-8802) if spill is of a reportable quantity (see appendix C).

Clean up spill or contact private spill response company for assistance.

Call Chemtrec hotline (800-424-9300) for additional assistance.

Call the MDEQ Waste Management Division (517-373-2730) for additional assistance.

For assistance with an agricultural spill, call MDA Agriculture Pollution Emergency (APE) hotline at 800-405-0101 or the MDEQ Pollution Emergency Alerting System (PEAS) hotline at 800-292-4706. This contact will put you in touch with personnel that will request information about the spill and a telephone number where you can be reached. Information will be passed on to the MDA or MDEQ personnel and they will respond to your call. They can provide information on immediate containment and cleanup procedures along with contacts for emergency response companies. If necessary, these hotline numbers may be able to alert other first-response personnel.

Spill Followup

After a spill has been controlled and contained, you are responsible for reporting the incident to the MDEQ and/or MDA, no matter what the chemical or the amount spilled, especially if the potential exists for the chemical to reach any source of water. If the chemical and the volume spilled are on the EPA's Extremely Hazardous Substances list, you will need to report it to the Local Emergency Planning Committee (LEPC) and the State Emergency Response Commission (SERC). Extension bulletin E-2575 explains how this process works and has a list of common pesticides and fertilizers with their reportable quantities. For more information, contact the MDEQ Title III office at (517) 373-8481. Major spills must also be reported to the National Response Center, (800)424-8802, or the EPA, (913) 236-3778.

Suggested spill kit contents

- Emergency telephone numbers (MSU bulletin AM-37).
- Personal Protective Equipment (PPE).
- Absorbent materials, such as absorbent clay, saw dust, pet litter, activated charcoal, vermiculite, paper or spill pillows to soak up liquid spills.
- Sweeping compound to keep dry spills from drifting or wafting during cleanup.
- Shovel, broom and dustpan.
- Heavy-duty detergent.
- Fire extinguisher rated for all types of fires.
- Other spill cleanup items specified on the labels of products used regularly.
- Closable, sturdy plastic container that will hold the quantity of pesticide from the largest pesticide container being handled.

CHAPTER 8 PART A

Review Questions

Safe Pesticide Handling

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. How can an applicator protect the water source at the pesticide mixing site?
   a. Submerge the filling hose while mixing.
   b. Mix in areas of well drained soils.
   c. Use backflow prevention devices.
   d. Mix on a containment pad.
   e. c and d

2. What types of PPE might pesticide handlers need while mixing or loading highly toxic pesticides?
   a. Leather boots.
   b. Chemical-resistant aprons.
   c. Denim pants.
   d. Face shield.
   e. b and d

3. What are two ways to properly rinse empty pesticide containers?
   1.
   2.

4. For what pesticide application tasks would applicators possibly need to wear more personal protective equipment than the minimum required by the pesticide labeling?
   a. In an enclosed area.
   b. Using a power duster.
   c. Indoor aerosol and fog applications.
   d. Applications directed upward into tree canopies.
   e. All of the above.

5. Explain what to do with excess pesticides that are still usable.

6. What actions should occur after mixing, loading and application activities?
   a. Record information relating to the application.
   b. Drink plenty of water and rest.
   c. Clean all equipment used during the activities.
   d. Wash yourself.
   e. All of the above except b; although b is good advice.

7. What should be done with the rinsates created from equipment cleaning?
   a. Dilute them and dispose of them in an old container.
   b. Save them to dilute the next mixture of the same or compatible pesticide.
   c. Apply them to a labeled site.
   d. Add bleach or ammonia to neutralize the active ingredient.
   e. b and c

8. A closed system mixing and loading system can:
   a. Increase handler safety.
   b. Allow for less personal protective equipment.
   c. Reduce spills.
   d. Provide more accurate measurement, which reduces overdosing or underdosing and may save money.
   e. All of the above.

9. Water-soluble packaging is considered a closed system for mixing and loading. (True or False?)

10. List several features that a containment pad should have to be a suitable mixing, loading and equipment cleaning site where large quantities of pesticides are handled and large equipment is cleaned.

11. Describe safety features of a pesticide storage facility.

12. Select the contents of a pesticide spill kit.
    a. PPE.
    b. Shovel, broom and dustpan.
    c. Closable, leak-proof container.
    d. Absorbent material, such as activated charcoal, pet litter, clay.
    e. All of the above.

13. What are the "three C's" of spill management?

    C _____ .

    C _____ .

    C _____ .

14. List sources of assistance for managing a spill.

Pesticide Applicator Core Training Manual

Certification, Recertification and Registered Technician Training

Part B – In addition to Part A, this is required reading for:

- Private pesticide applicators

The private applicator certification exam covers information from Part A and Part B of this Core Manual.

CHAPTER PART B 1

LAWS AND REGULATIONS

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Have a general understanding of the types of laws and regulations that may affect private pesticide applicators.
- Be aware of the importance of having up-to-date knowledge about how to comply with all laws and regulations that affect your operation.
- Perform *direct* supervision as required by pesticide labeling.
- Understand and provide the basic elements required by the WPS.

TERMS TO KNOW

EPA - U.S. Environmental Protection Agency.

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

Mitigate - To lessen, decrease or make less severe.

OSHA - Occupational Safety and Health Administration, part of the U.S. Department of Labor.

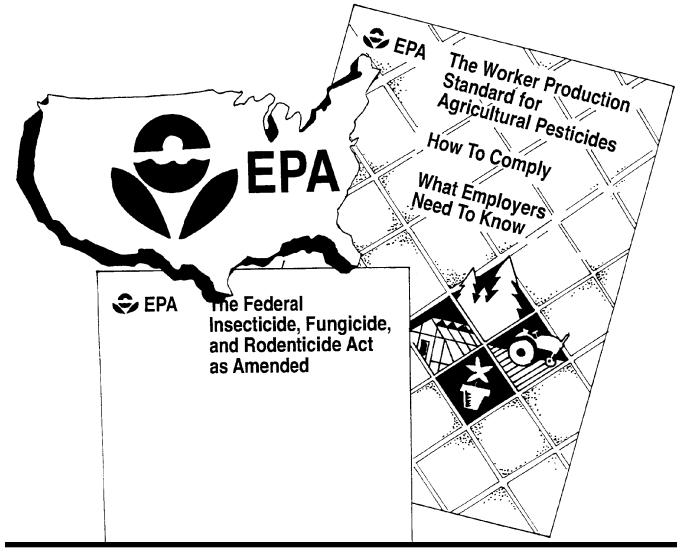
SARA - Superfund Amendments and Reauthorization Act — amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

USDA - U.S. Department of Agriculture.

WPS - Worker Protection Standard for agricultural pesticides.

This chapter describes some of the federal and state laws that affect many private pesticide applicators. For more complete information on pesticide laws and regulations, refer to chapter 2, Part A: "Laws and Regulations" in this manual. You may need to learn more about the laws and regulations that apply to your specific situation.

Keep up to date with legal requirements at all governmental levels – laws and regulations change frequently as pesticide application becomes more complex and more is learned about potential hazards. Ignorance of the law is never an accepted excuse for a violation.



FEDERAL LAWS

FIFRA

A law passed by Congress in 1947 and substantially amended several times regulates the registration, manufacture, sale, transportation and use of pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act is commonly referred to by its initials — FIFRA. It is administered by the U.S. Environmental Protection Agency (EPA).

FIFRA affects certified applicators in many ways. The major provisions of FIFRA are outlined in the "Laws and Regulations" chapter in Part A of this manual.

If you violate FIFRA or regulations issued under it, you are subject to civil penalties. Penalties can be as much as $1,000 for each offense for private applicators. Before the EPA can fine you, you have the right to ask for a hearing in your own city or county.

Some violations of the law also may subject you to criminal penalties. These can be as much as $1,000 and/or 30 days in jail for private applicators.

Federal Food, Drug, and Cosmetic Act

The EPA sets food and feed residue tolerances that are enforced by the Federal Food and Drug Administration (FDA) under the Federal Food, Drug, and Cosmetic Act. Any pesticide that remains in or on food or feed is called a **residue.** A long-lasting residue is sometimes desirable for long-term pest control. Residues that remain in food or feed at harvest or slaughter, however, are carefully monitored to avoid hazards to the humans and domestic animals that will consume them.

The federal government sets residue tolerances for all pesticides used in the production of crop and animal products intended for food or feed, and for pesticides applied after harvest. A **tolerance** is the maximum amount of pesticide residue that may legally remain on or in treated crops or animals (and animal products, such as milk or eggs) that are to be sold for food or feed. The same pesticide may have a different tolerance on different products. The Federal Food, Drug and Cosmetic Act provides for monitoring of food crops and animal products for pesticide residues and allows the FDA to enforce tolerances.

Federal and state agencies monitor food and feed products for tolerance violations. Any products that exceed the tolerances may be condemned and seized, and violators may be subject to enforcement actions.

Only by following labeling instructions can pesticide applicators be sure that treated products will have residues at or below tolerance levels when marketed. Especially important are instructions on correct application rate and on minimum days between the pesticide application and harvest, slaughter, freshening or grazing.

Worker Protection Standard

The U.S. Environmental Protection Agency's Worker Protection Standard (as revised in 1992) covers pesticides used on agricultural establishments (farms, forests, nurseries and greenhouses) for the production of agricultural plants. The Worker Protection Standard (WPS) requires employers to provide agricultural workers and pesticide handlers with protection against possible harm from pesticides.

Persons who must comply with the WPS include owners/operators of the agricultural establishment, owners/operators of commercial businesses that are hired to apply pesticides or to perform crop advising tasks on the agricultural establishment, and anyone who hires or contracts for the services of agricultural workers.

Owners and immediate family members who work on the agricultural establishment are exempt from *some* of the WPS requirements.

The WPS requires employers to take steps to protect **workers** and **pesticide handlers** from exposure to pesticides. A **worker** is anyone who is: (1) employed (including self-employed) for any type of compensation and (2) doing tasks such as harvesting, weeding or watering relating to the production of agricultural plants on a farm or in a forest, nursery or greenhouse. This term does not include persons who are employed by a commercial establishment to perform tasks as crop advisors.

A **pesticide handler** is anyone who is: (1) employed (including self-employed) for any type of compensation by an agricultural establishment that uses pesticides in the production of agricultural plants on a farm or in a

forest, nursery or greenhouse, and (2) doing any of the following tasks:

- Mixing, loading, transferring or applying pesticides.
- Handling opened containers of pesticides.
- Cleaning, handling, adjusting or repairing the parts of mixing, loading or application equipment that may contain pesticide residues.
- Assisting with the application of pesticides, including incorporating the pesticide into the soil after the application has occurred.
- Entering a greenhouse or other enclosed area to:
  - Operate ventilation equipment.
  - Adjust or remove coverings, such as tarps, used in fumigation.
  - Check air concentration levels, after application and before the inhalation exposure level (listed on the product labeling) has been reached, or one of the WPS ventilation criteria has been met.
  - Entering a treated area outdoors after application of any soil fumigant to adjust or remove soil coverings, such as tarpaulins.
  - Disposing of pesticides or pesticide containers.

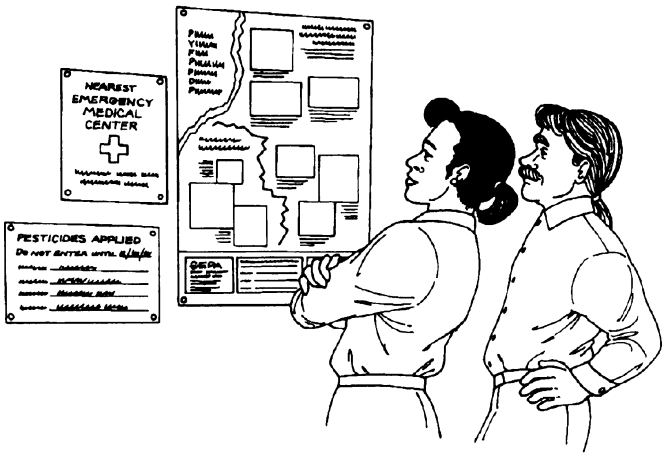
WPS Requirements

If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide to your employees and, in some cases, to yourself and to others:

- Information about exposure to pesticides.
- Protection against exposures to pesticide.
- Ways to mitigate (lessen or reduce) exposures to pesticides.

Information

To ensure that employees will be informed about exposure to pesticides, the WPS requires:



An EPA pesticide safety poster must be displayed for workers and handlers.

- **Pesticide safety training** — for workers and handlers. Michigan pesticide applicator certification credentials satisfy the requirement for both worker and handler training.
- **Pesticide safety poster** — to be displayed for workers and handlers.
- **Access to labeling information** — for pesticide handlers and early-entry workers.
- **Access to specific information** — a centrally located application list of pesticide treatments on the establishment.

Protection

To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying a pesticide in a way that will expose workers or other persons.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI. Requirements include special instructions and duties related to correct use of personal protective equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.
- Protect handlers during handling tasks. Requirements include monitoring while handling highly toxic pesticides and duties related to correct use of PPE.

Mitigation

To mitigate pesticide exposures that employees may receive, the WPS requires:

- Decontamination sites — providing handlers and workers an ample supply of water, soap and towels for routine washing and emergency decontamination, and a change of clothing for handlers.

- Emergency assistance — making transportation available to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide, and providing information about pesticide(s) to which the person may have been exposed.

For detailed information about your responsibilities under the WPS, see the EPA's manual "Worker Protection Standard for Agricultural Pesticides — How To Comply." It will tell you what you need to do to comply with the federal worker protection requirements. The manual is available from EPA regional offices, state or tribal pesticide agencies, Extension Services, the Government Printing Office and other commercial sources.

Field Sanitation

The Field Sanitation Standard is a 1987 Occupational Safety and Health Administration (OSHA) regulation. In general, it applies to agricultural employers who employ more than 10 field workers or who maintain a labor camp.

The Field Sanitation Standard requires these employers to provide three things to their employees who are exposed to agricultural chemicals: toilet facilities, handwashing facilities and clean drinking water.

The Standard also requires employers to inform each employee to:

- Use the water and facilities provided for drinking, hand washing and elimination.
- Drink water frequently, especially on hot days.
- Urinate in designated facilities as often as necessary.
- Wash hands both before and after using the toilet.
- Wash hands before eating and smoking.

Pesticide Recordkeeping

The 1990 Farm Bill mandated certified private pesticide applicators to keep records of federal restricted-use pesticide applications. This recordkeeping is administered by the USDA's Agricultural Marketing Service.

The federal pesticide recordkeeping regulations, the federal Worker Protection Standard and the Michigan Right-to-Farm program all have requirements related to pesticide recordkeeping. The following table is intended to help clarify which data are required for each of these

Recordkeeping requirements for private pesticide applicators.

Data to record	Federal recordkeeping regulations	Worker Protection (WPS)	Michigan Right-to Farm (voluntary guidelines)
Month / day / year	X	X	X
Pesticide brand / product name	X	X	X
EPA registration number	X	X	X
Crop, commodity, stored product or site that received application	X		X
Total amount of pesticide applied	X		X
Size of area treated	X		X
Applicator's name	X		X
Applicator's certification number	X		X
Location of application	X	X	X
Time of application		X	
Active ingreient(s)		X	
Restricted-entry interval		X	
Method of application			X
Target pest			X
Rate per acre or unit			X

Developed by the Michigan State Pesticide Education Program (1 / 94)

pieces of legislation. The federal recordkeeping regulations and worker protection standards are laws. Right-to-Farm is a set of voluntary guidelines that, if followed, may reduce a farmer's nuisance liability.

There is no required form for this recordkeeping. Any form is acceptable as long as the required information is included. Records must be made within 14 days of the application. You must keep the RUP records for two years from the date of the pesticide application.

If a commercial applicator performs work for you, that applicator must provide you with a written copy of the necessary information about the application within 30 days.

If you do not comply with the recordkeeping requirements, you may be fined up to $500 for a first offense and not less than $1,000 for any later offense (unless it is determined that you have made a good-faith effort to comply).

MICHIGAN LAWS

Michigan Pesticide Control Act of 1976, ACT 171

To assure that pesticides are properly registered and applied, the Michigan Legislature passed the Pesticide Control Act of 1976. The Act was amended in 1988 and 1993. This legislation gives the Director of the MDA authority to certify or register private and commercial applicators and to prescribe standards for certification and registration. The MDA also registers, suspends and cancels pesticides; investigates the use and misuse of pesticides; enacts rules; licenses restricted use pesticide (RUP) dealers; issues oral and written orders; and conducts enforcement actions.

Two classes of applicators are defined under the law: private and commercial. Private applicators are those persons who use or supervise the use of restricted use pesticides to produce an agricultural commodity on their own or their employer's land, or on rented lands. "Production of an agricultural commodity" means production for sale into commerce and includes crops, livestock, ornamentals, forest products and other products regarded as agricultural commodities.

When private applicators use a pesticide with a label that requires direct supervision, the certified applicator supervising the RUP application must be physically present the first time a non-certified applicator uses a particular RUP on an agricultural commodity or structure. This includes supervising the following processes: equipment calibration, mixing, application, operator safety and disposal of pesticides. After the initial direct supervision, the certified applicator must be available to the applicator but not necessarily on site. The certified applicator is responsible or liable for the pesticide application made by the persons under his/her supervision.

A certified private applicator can receive protection from civil liability for injuring people or property by his/her pesticide practices if those practices involved following legal application procedures.

Other Regulations

Other federal regulations may affect some of the tasks you perform as a certified private pesticide applicator. In some cases, the pesticide label will alert you to laws or regulations you must comply with.

For more information about laws that affect all categories of certified applicators, see chapter 2, Part A: "Laws and Regulations" of this manual.

CHAPTER 1 PART B

Review Questions

Laws and Regulations

Write the answers to the following questions and then check your answers with those found in the back of this manual.

1. A pesticide that remains in or on raw farm products or processed foods is called a _____. A _____ is the concentration of a pesticide that is judged legal for human use.
   a. residue; tolerance
   b. tolerance; residue
   c. reciprocity; toxicity
   d. toxicity; reciprocity

2. Immediate family members of the owner of the agricultural establishment are exempt from WPS requirements. (True or False?)

3. According to the WPS, workers:
   a. Are employed by an agricultural establishment.
   b. Mix, load or transfer pesticides.
   c. Clean, repair or adjust pesticide application equipment.
   d. Perform tasks such as harvesting and weeding.
   e. a and d only.

4. To ensure that employees will be informed about exposure to pesticides, the WPS requires a pesticide safety poster to be displayed for workers and handlers.(True or False?)

5. According to WPS, mitigating pesticide exposure requires:
   a. Legal assistance.
   b. Posting all fields that have been treated with a highly toxic pesticide.
   c. The employer to make transportation to a medical care facility available if an agricultural worker has potentially been poisoned by a pesticide.
   d. Workers to be supplied with gloves.

6. The Field Sanitation Standard is administered by:
   a. OSHA
   b. MDOL
   c. MDA
   d. USDA

7. What are three programs or regulations that require pesticide recordkeeping in Michigan?

8. According to the federal recordkeeping requirements, records on RUP applications must be made within _____days of the application and kept for___ years from the date of the application.

9. Direct supervision is:
   a. Required for all pesticide applications made by non-certified persons.
   b. Includes supervising equipment calibration when an RUP is used.
   c. Required when applications of RUPs are applied by non-certified persons.
   d. When a certified applicator is physically present when a non-certified applicator uses a particular RUP on an agricultural commodity.
   e. b, c and d

10. In some cases, the pesticide label will alert you to laws or regulations that the applicator must comply with. (True or False?)

PART B

CHAPTER 2

PESTS AND PEST MANAGEMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Explain the importance of correctly identifying pests.
- Explain the importance of understanding the life cycles and habits of pests.
- Explain the factors you should consider when deciding whether control of a pest is necessary.
- Demonstrate that you know some common ways that non-chemical control methods can be used to manage pests in agricultural situations.
- Define "persistent" and "nonpersistent" pesticides.

INSECTS

- Name the two physical characteristics that all insects have in common.
- List the four primary types of insect mouthparts and give an example of an insect that has each type.
- Define "metamorphosis."
- Recognize and understand the difference between gradual metamorphosis and complete metamorphosis.
- List other types of pests that resemble insects or cause similar types of damage.
- Identify the life cycle stage in which most insects are most vulnerable and easiest to manage.
- Describe the two main ways that pesticides act to poison insects and similar pests.

PLANT DISEASES

- Define "plant disease."
- List the three main types of pathogens that cause plant diseases.
- Describe the factors that are necessary before a plant disease can develop.
- Describe some ways that plants respond to diseases.
- List some ways that plant disease agents may be spread.
- Explain how symptoms and signs can help you diagnose a plant disease.
- Explain the difference between fungicides that are protectants and those that are eradicants.

WEEDS

- Name and describe the four developmental stages of weeds.
- Distinguish between the life cycle characteristics of annual, biennial and perennial weeds.
- Name several ways weeds reproduce.
- Demonstrate that you know the common categories of land and aquatic weeds and some of their identifying characteristics.
- List several factors that affect a plant's susceptibility to herbicides.
- Define "selective" and "nonselective" herbicides.
- Demonstrate your ability to select the correct combination of herbicide characteristics for a given weed control situation.
- Identify the uses of plant growth regulators, defoliants and desiccants.

VERTEBRATES

- Give some examples of vertebrate pests and the types of damage they cause.
- List some vertebrate management measures that may require approval from local or state authorities.

TERMS TO KNOW

Contact pesticide - A pesticide that kills pests simply by contacting them.

Eradication - Destroying an entire pest population in an area.

Foliar - Applied to the leaves of a plant.

Habitat - The places where a plant or animal lives, feeds and breeds.

Host - A plant or animal on or in which a pest lives.

Life cycle - The series of stages an organism passes through during its lifetime.

Metamorphosis - The series of changes in shape, form or size through which insects and insectlike organisms pass in their growth from immature stages to adult stage.

Nonpersistent pesticide - A pesticide that breaks down quickly after it is applied.

Nonselective pesticide - A pesticide that is toxic to most plants, insects or animals.

Parasite - An organism living on, in or with another living organism for the purpose of obtaining food.

Pathogen - Any disease-producing organism.

Persistent pesticide - A pesticide that remains active for a period of time after application, giving continued protection against the pest.

Plant disease - Any harmful condition that makes a plant different from a normal plant in its appearance or function.

Predator - An organism that attacks, kills and feeds on other organisms.

Prevention - Keeping a pest from becoming a problem.

Selective pesticide - A pesticide that is more toxic to some kinds of plants and animals than to others.

Stomach poison - A pesticide that kills when it is eaten by the pest.

Suppression - Reducing pest numbers or damage to an acceptable level.

Systemic pesticide - A pesticide that is taken into the blood of an animal or the sap of a plant.

Translocated herbicide - A pesticide that kills plants by being absorbed by leaves, stems or roots and moved throughout the plant.

Vertebrate - An animal with a jointed backbone.

Correct identification of pests and a knowledge of their development and behavior are keys to effective pest management. In this chapter, pests are grouped into four broad categories:

- Insects and insectlike pests.
- Weeds.
- Plant diseases.
- Vertebrates.

This chapter provides some basic facts about agricultural pests, their life cycles and how they commonly develop and spread, but it is not intended to make you an expert in pest identification. Accurate detection, identification and diagnosis of pest problems is a mixture of science and art – experience is important. When you find a pest or pest problem you cannot identify, ask an expert for assistance. The MSU diagnostic lab provides services to identify plant and pest-related problems.

When you have identified a pest, you must decide how to manage it. Remember that even though a pest is present, it may not be very harmful. Consider whether the cost of control would be more than the economic loss from the pest's damage.

If control is necessary, decide whether you need to **prevent** the pest from becoming a problem, **suppress** the numbers of pests or the level of their damage, or **eradicate** the entire pest population. Then, using what you have learned about integrated pest management, choose the methods that will do a cost-effective job of managing the pest while causing the least harm to people and the environment.

Pesticides are a valuable tool, but they should be used only when and where they are needed. Consider chemical control:

- When pest numbers or the damage the pests are causing are unacceptable and other pest management methods will not provide effective control.
- When the situation indicates that you need to use a pesticide preventively. For example, when temperature and humidity conditions make it likely that a plant disease will develop.

Never attempt to control a pest until you know what it is.

INSECTS AND INSECTLIKE PESTS

Insects

There are more kinds of insects on earth than all other living animals combined. They are found in soil, water, snow and air, and on or in plants and animals. They eat the choicest foods from our table. They can even eat the table!

Insects can be divided into three categories according to their importance to people:

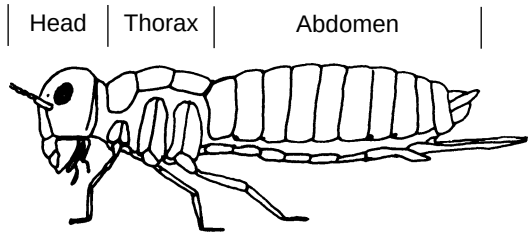
- **Species of ecological importance** — About 99 percent of all species are in this category. They do not directly help or harm people, but they are crucial in the food

web. They are food for birds, fish, mammals, reptiles, amphibians, aquatic life and other insects. Some degrade animal wastes and dead plants and animals, returning nutrients to the environment.

- **Beneficial insects** — In this small but important group are the predators and parasites that feed on harmful insects, mites and weeds. Examples are ladybird beetles, ground beetles, tachinid flies, praying mantids and many tiny parasitic wasps. Also in this category are the pollinating insects, such as bumblebees and honeybees, butterflies and beetles. Without pollinators, many kinds of plants could not grow. Useful products such as honey, dyes from secretions and silk come from insects.
- **Destructive insects** — Although this is the category that usually comes to mind when insects are mentioned, it includes the fewest species. These are the insects that feed on, injure or transmit disease to people, animals, plants, food, fiber and structures. This category includes aphids, beetles, fleas, mosquitoes, caterpillars and termites.

Physical Characteristics

All adult insects have two physical characteristics in common. They have three pairs of jointed legs (six legs) and three body regions – head, thorax and abdomen.



Head — The head has antennae, eyes and mouthparts. Antennae vary in size and shape and can help identify some insect pests. Insects have compound eyes made up of many individual eyes. These compound eyes enable insects to detect motion, but they probably cannot see clear images.

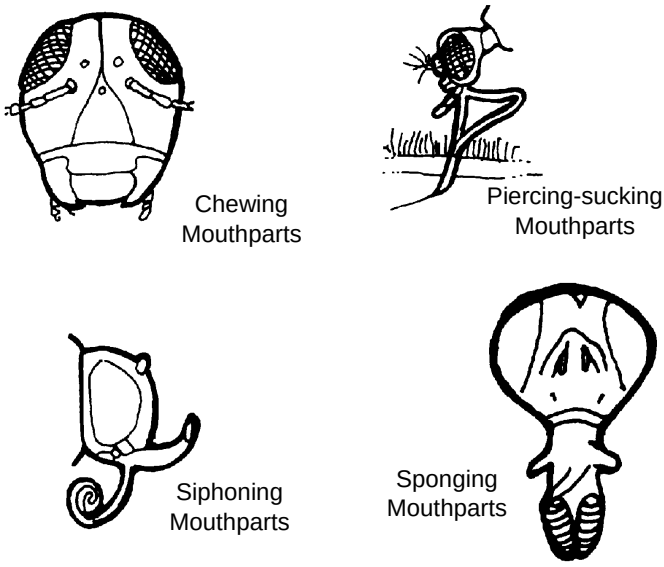
The four general types of insect mouthparts are chewing, piercing-sucking, sponging and siphoning. Understanding the type of mouth a pest has can help identify the damage caused by that pest or the pest that caused certain damage.

Chewing mouthparts contain toothed jaws that bite and tear. Cockroaches, ants, beetles, caterpillars and grasshoppers are in this group.

Piercing-sucking mouthparts consist of a long, slender tube that is inserted into plant or animal tissue to suck out fluids. Insects with these mouthparts include stable flies, sucking lice, mosquitoes, true bugs and aphids.

Sponging mouthparts are tubular, tongue-like structures with a spongy tip to suck up liquids or soluble food. This type of mouthpart is found in flesh flies, blow flies and house flies.

Siphoning mouthparts are formed into a long tube for sucking nectar. Butterflies and moths have this type.



Thorax — The thorax contains the three pairs of legs and (if present) the wings. The various sizes, shapes and textures of wings and the pattern of the veins can be used to identify insect species. The forewings take many forms. In beetles, the forewings are hard and shell-like; in the grasshoppers, they are leathery; in flies, they are membranous; and those of true bugs are part membranous and part hardened. Most insects have membranous hindwings. The wings of moths and butterflies are membranous but are covered with scales.

Abdomen — The abdomen is usually composed of 11 segments, but eight or fewer segments may be visible. Along each side of most of the segments are openings called spiracles through which the insect breathes. In some insects, the tip end of the abdomen has tail-like appendages.

Life Cycles of Insects

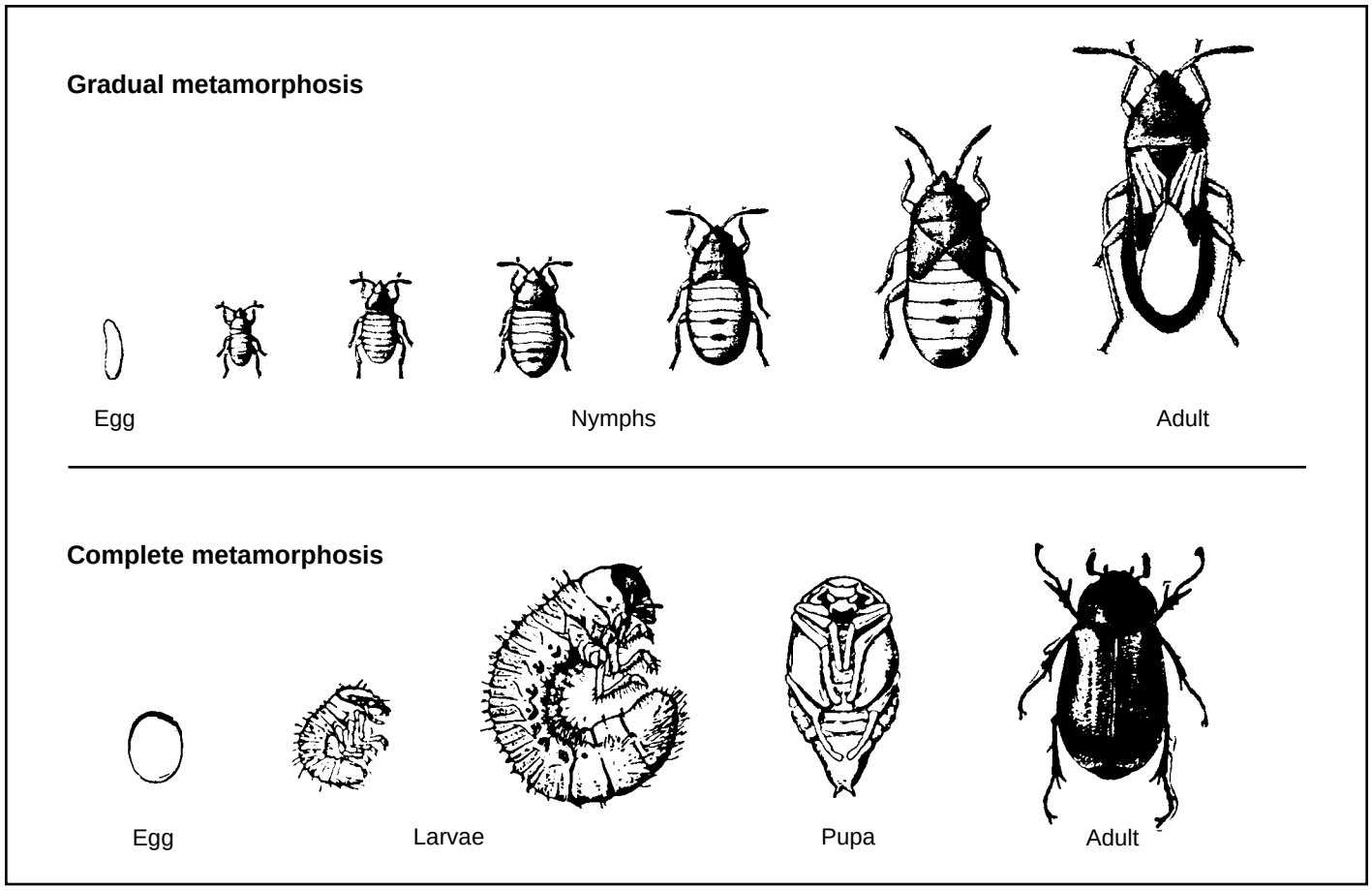
Most insect reproduction results from males fertilizing females. The females of some aphids and parasitic wasps produce eggs without mating. A few insects give birth to living young; however, life for most insects begins as an egg.

Temperature, humidity and light are some of the major factors influencing the time of hatching. Eggs come in various sizes and shapes: elongate, round, oval and flat. Eggs may be deposited singly or in masses on or near the host — in soil or water or on plants, animals or structures.

The series of changes through which an insect passes in its growth from egg to adult is called **metamorphosis**.

When the young first hatches from an egg, it is called either a larva, nymph or naiad. After feeding for a time, the young grows to a point where the skin cannot stretch further. The young sheds its skin (molts) and new skin is formed.

The number of these developmental stages (called instars) varies with the insect species and, in some cases, may vary with the temperature, humidity and food supply. The heaviest feeding generally occurs during the final two instars.



In the mature (adult) stage, the insect is capable of reproduction. Winged species develop their wings at maturity. In some species, mature insects do not feed or may not feed on the same material as the immature forms.

No metamorphosis — Between hatching and reaching the adult stage, some insects do not change except in size. The insect grows larger with each successive instar (molt) until it reaches maturity. Examples are silverfish, firebrats and garden springtails. The food and habitats of the young (called nymphs) are similar to those of the adult.

Gradual metamorphosis — Insects in this group pass through three stages of development before reaching maturity: egg, nymph and adult. The nymphs resemble the adult in form, eat the same food and live in the same environment. The change of the body is gradual, and the wings become fully developed only in the adult stage. Examples are potato leafhopper, boxelder bugs, lice, termites, aphids and scales.

Incomplete metamorphosis — The insects with incomplete metamorphosis also pass through three stages of development: egg, naiad and adult. The adult is similar to the young, but the naiads are aquatic. Examples are dragonflies, mayflies and stoneflies.

Complete metamorphosis — The insects with complete metamorphosis pass through four stages of development: egg, larva, pupa and adult. The young – which may be called larvae, caterpillars, maggots or grubs – are entirely different from the adults. They usually live in different situations and in many cases feed on different foods than adults. Examples are the European corn borer, beetles, butterflies, flies, mosquitoes, fleas, bees and ants.

Larvae hatch from the eggs. The larvae grow larger by molting and passing through one to several instar stages. Moth and butterfly larvae are called caterpillars; some beetle larvae are called grubs; most fly larvae are called maggots. Caterpillars have legs; maggots are legless. Weevil grubs (beetle family) are legless; other kinds of beetle larvae usually have three pairs of legs.

The pupa is a resting stage during which the larva changes into an adult with legs, wings, antennae and functional reproductive organs. Some insects form cocoons during this stage. Pupae do not cause damage and are typically not susceptible to chemical control methods because of their inactivity.

Insectlike Pests

Some other kinds of pest organisms — such as mites, ticks, spiders, sowbugs, pillbugs, centipedes, millipedes, nematodes and mollusks — are similar to insects in many ways. Most of these pests resemble insects and have similar life cycles; they can cause similar damage and usually can be managed with the same techniques. The materials used to manage insects may not control some of these insectlike pests, however, so proper identification is important.

Arachnids

Mites, ticks and spiders have eight legs and only two body regions. They are wingless and lack antennae. Metamorphosis is gradual and includes both larval and nymphal stages. Eggs hatch into larvae (six legs) that become nymphs (eight legs) and then adults. Ticks and mites have modified piercing-sucking mouthparts; spiders have chewing mouthparts.

Crustaceans

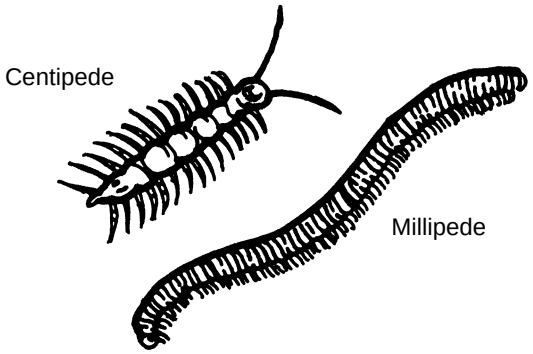
Sowbugs and pillbugs, water fleas and wood lice have 10 or more legs. They are wingless and have only one segmented body region. They have two pairs of antennae and chewing mouthparts. Sowbugs and pillbugs have a hard, protective, shell-like covering and are related to lobsters and crayfish. Metamorphosis is gradual, and they may pass through up to 20 instars before they reach adulthood.

Centipedes and Millipedes

Centipedes have one pair of legs per flattened segment. They have chewing mouthparts. Some species can inflict painful bites.

Millipedes have two pairs of legs per segment and are cylindrical like an earthworm. The antennae are short and mouthparts are comb-like. Millipedes feed on decaying organic matter, seeds, bulbs and roots.

There is no metamorphosis – centipedes and millipedes do not change except in size between hatching and reaching the adult stage.

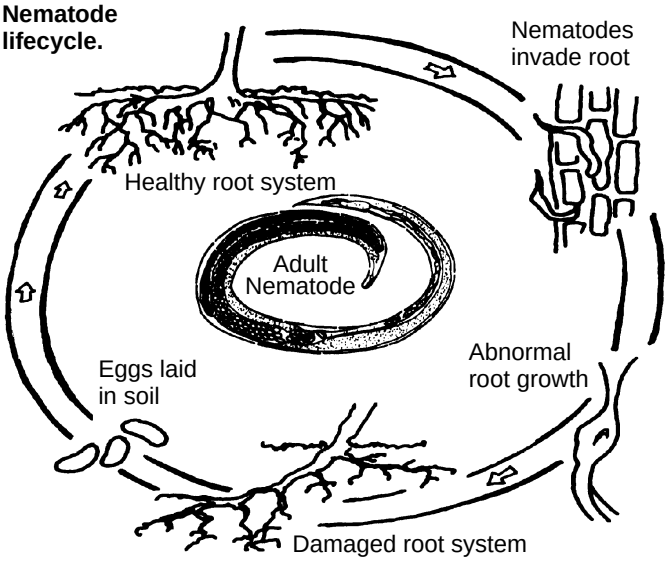


Nematodes

Nematodes are small, usually microscopic, roundworms. The mouthparts of those that feed on plants are like a hollow needle – they use them to puncture plant cells and feed on the contents. Nematodes may develop and feed either inside or outside of a plant. They move with an eel-like motion in water, even water as thin as the film of moisture around plant cells or soil particles. Because nematodes are not visible to the naked eye, it is easy for people to spread nematodes unknowingly on footwear, tools and equipment.

The life cycle of a nematode includes an egg, several larval stages and the adult. Most larvae look like adults but are smaller. In adverse conditions, the females of some species, such as root-knot and cyst nematodes, form an inactive, resistant form called a cyst. The cyst is the hard, leathery, egg-filled body of the dead female. It is difficult to penetrate with pesticides. A cyst may provide protection for several hundred eggs for as long as 10 years.

Nematode lifecycle.



Mollusks

Mollusks are a large group of land and water animals that includes slugs, oysters, clams, barnacles and snails. They have soft, unsegmented bodies and often are protected by hard shells.

Snails and slugs — Land snails and slugs are soft-bodied and have two pairs of antennae-like structures. Their bodies are smooth and elongated. Snails have spiral-shaped shells into which they can completely withdraw for protection when disturbed or when weather conditions are unfavorable. Slugs do not have shells and must seek protection in damp places.

Snails and slugs deposit eggs in moist, dark places. The young mature in a year or more, depending on the species. Adults may live for several years. They overwinter in sheltered areas in cold regions but are active year round in warm regions and in greenhouses.

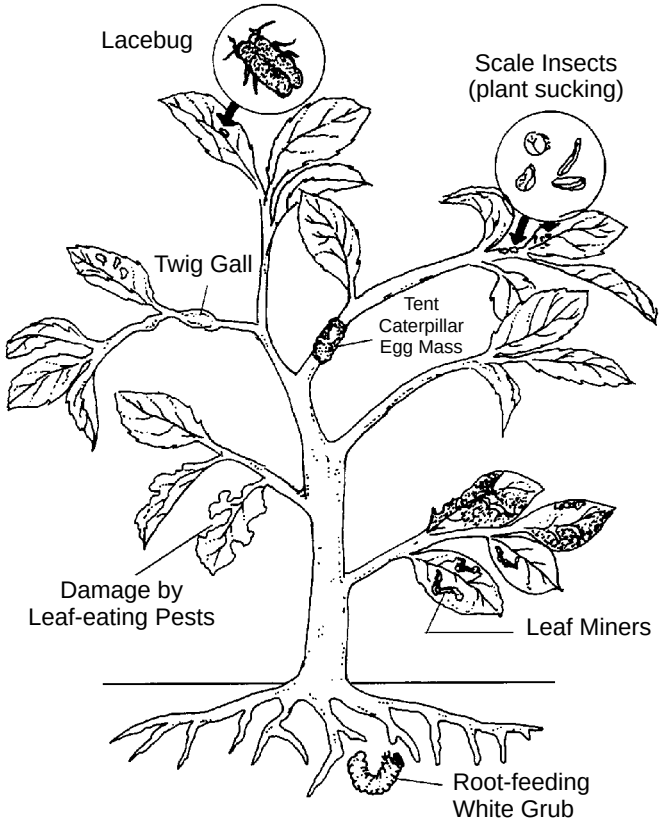
Damage Caused by Insects and Insectlike Pests

Insects, ticks, mites and similar pests damage plants, animals and structures in many ways. The damage often provides clues to the identity of the pest. Nematodes, for example, are too small to be seen, so their characteristic damage may be the only indication of their presence.

Even though pests are present, the level of damage they are causing may not be of enough economic importance to warrant control measures. The potential for

harm may be greater at some times than others. For example, insects that damage leaves in the spring are usually more harmful to a plant than insects that damage leaves in the late summer when the plant is about to lose its leaves.

Plant Pests



Leafeaters — Some insects and insectlike pests feed on plant leaves. For many plants, the loss of a few leaves will not cause reduced yield. But when pests remove most or all of the leaves from a plant, the plant may be killed or is left stunted and unproductive. The larval stage (caterpillars) of some butterflies and moths can cause costly damage. Examples include gypsy moths which feed on trees, and imported cabbageworms, which feed on cabbage leaves. Some beetles are also leaf-eating pests, such as the Colorado potato beetle.

Beetles can be leaf-eating pests.

Snails and slugs feed on plants at night. They tear holes in foliage, fruits and soft stems, using a rasp-like tongue. They may eat entire seedlings. As they move, snails and slugs leave a slime-like mucous trail that dries into silvery streaks. These streaks are undesirable on floral crops and on the parts of crops that are to be sold for human food.

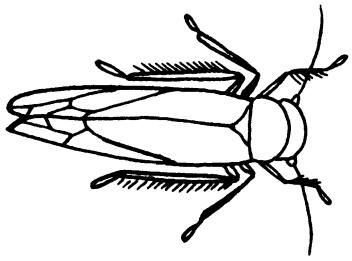
Internal feeders — Some insects and insectlike pests feed and develop inside fruit, grain or other plant parts. Usually the larval stage causes the damage during feeding. Some pests pupate inside their host. Because they are inside the plant, these pests often cause significant damage before they are detected. They are also more difficult to control when they are inside the plant. Internal feeders include birch leaf miners and codling moths.

Stalk or stem borers — The larval stage of some insects and insectlike pests bore into stalks or stems. This harms the plant by weakening the stalk or stem and by preventing water and food from flowing freely within the plant. Weakened plants may blow over or wilt as a result of the damage. Examples of these borers include European corn borers, squash vine borers and dogwood borers.

Plant-sucking pests — Some insects and insectlike pests have sucking mouthparts that allow them to suck juices from plants. The activity of these pests can lead to curling and stunting of leaves and stems, wilting caused by blockage of water-conducting tissues, and dead areas caused by toxins that the pest injects during feeding.

As they feed, plant-sucking pests may also spread plant disease organisms. Some plant diseases may be controlled by controlling the insect pests that cause their spread.

While they suck on the plants, aphids and similar insects excrete honeydew that drips onto the lower parts of the plant. A fungus that causes a black sooty mold often grows on this sticky material. Other examples of plant-sucking pests are leafhoppers and squash bugs.



Leafhoppers are sucking insects.

Cutworms — Most cutworm larvae cut off plants at the soil surface and are often hard to detect and control because they feed at night and stay under the ground during the day.

Underground feeders — Many insects and insectlike pests cause damage by feeding on plant roots. Root-feeding pests interfere with the plant's water and nutrient uptake. They can cause "goose-necking" in corn and poor color, stunting and loss of vigor in a wide range of crops.

Some underground feeders are the larval stage of insects. They include white grubs, corn rootworm, black

vine weevil and many kinds of fly maggots. Nematodes are another kind of underground feeder. Though some types of nematodes attack aboveground plant parts, most pest nematode species feed on or in the roots. They may feed in one location, or they may constantly move throughout the roots.

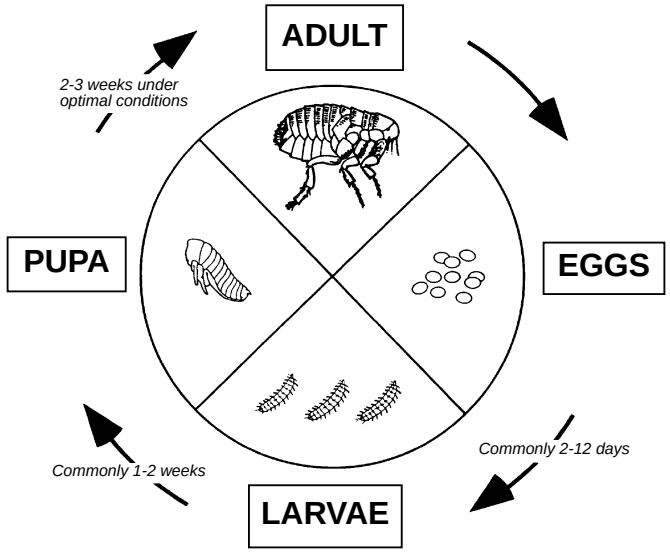
Underground pests are often difficult to identify because they cannot be seen without uprooting the plants. Nematodes are too small to see with the naked eye. Their presence is often deduced from the characteristic damage they cause or from experience with previous infestations. Confirmed identification of plant pest nematodes requires sending samples of the soil, roots and/or other affected plant parts to a diagnostic laboratory.

Pests of Animals

Insects, ticks, mites and similar pests that attack people and other animals have mouthparts similar to those of the plant feeders, but they suck blood and animal fluids rather than plant fluids.

Mosquitoes, fleas and ticks are bloodsucking pests. Cattle grubs, the ox warble of cows and the bot fly of horses are internal feeding insects. Face flies, house flies and gnats annoy and cause discomfort.

Some insects and insectlike pests inject disease-causing organisms such as bacteria, viruses and other parasites into the animals they are feeding on. In the United States, mosquitoes carry encephalitis and dog heartworm, and ticks carry Rocky Mountain spotted fever and Lyme disease.



Flea life cycle (complete metamorphosis).

Insect Pest Management Strategy

Control of insects and similar pests may involve any of the three basic pest management objectives. Management is usually aimed at suppression of pests to a point where their presence or damage level is acceptable. Prevention and eradication are useful only in relatively small, confined areas or in programs designed to keep foreign pests out of a new area.

To manage insects and insectlike pests successfully, you need a thorough knowledge of their habitats, feeding habits and life cycle stages.

Environmental conditions such as humidity, temperature and availability of food can affect the length of the life cycle by altering the growth rate of the insects. A favorable environment (usually warm and humid; mites prefer hot and dry) can shorten the time of development from egg to adult.

You must carefully monitor pest populations and take management action at a time when you are most likely to succeed. Timing may be essential, for example, when you need to control an internal feeder before it enters the plant. It is particularly useful to know the life cycle stages in which the pests are most vulnerable.

- In the egg and pupal stages, insects generally are difficult to control because these stages are inactive. The pests are not feeding, are immobile and often are in hard-to-reach areas such as under the ground, in cocoons or cases, and in cracks and crevices.
- In the late instar and adult stages, insects may be controlled with moderate success. Insects are easiest to see in these stages and usually are causing the most destruction. However, larger insects are often more resistant to pesticides, and adults may have already laid eggs for another generation.
- The early larval or nymphal stages, when the insects are small, active and vulnerable, is when you usually can achieve the best control.

Management methods used for insects and similar pests include host resistance, biological control, cultural control, mechanical control, sanitation and chemical control.

Host Resistance

Some crops, animals and structures resist insects and similar pests better than others. Use of resistant types helps keep pest populations below harmful levels by making the environment less favorable for the pests.

Biotechnologists and plant breeders are using genetic engineering to build pest resistance into plants. The protein crystal in *Bacillus thuringiensis* (Bt) that is toxic to many caterpillars, for example, has been incorporated into some plants. Leaf-feeding insects that feed on leaves containing the Bt protein often will die, making insecticide applications unnecessary.

Biological Control

Biological control measures for insects include:

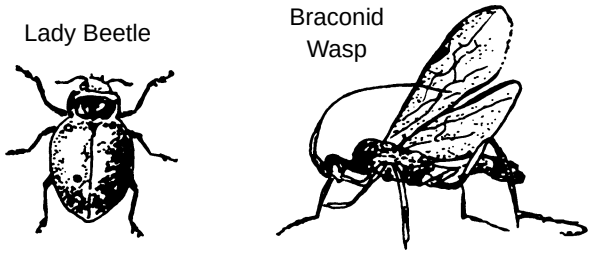
- Predators and parasites.
- Pheromones.
- Juvenile hormones.
- Microbials.

Predators and parasites — Most insect and insectlike pests have a variety of natural predators and parasites

that help keep their numbers in check. If you use pesticides, try to use ones that are not toxic to the predators and parasites you want to encourage, or apply the pesticides at a time when the beneficial organisms are not vulnerable.

For some pests, predators and parasites can be introduced into an area where they do not occur naturally or occur in low numbers. Several kinds of parasites and predators of the alfalfa weevil, for example, have been imported from Europe and Asia and released in infested areas in this country. Several species have become established and are helping to reduce pest numbers.

The use of predators and parasites can work well in enclosed areas such as greenhouses, but considerable knowledge and expertise is required to be successful with this method of pest management.



Pheromones — Some insects and insectlike organisms produce natural chemicals called pheromones that cause responses in other insects of the same or very closely related species. Once a particular insect pheromone is identified and the chemical is synthetically produced, it can be used to disrupt the behavior of that insect species.

Synthetic pheromones may be used to disrupt normal reproduction, or they may be used to attract the pests into a trap. Pheromone traps are often used in IPM monitoring – e.g., to monitor emergence and pinpoint timing of control measures for various orchard insect pests.

Juvenile hormones — Juvenile hormones, another type of species-specific chemical, interrupt the metamorphosis of insects and insectlike organisms. These chemicals prevent reproduction by keeping immature insects from maturing into adults. Each chemical acts against a single pest species.

Microbials — Microbial pesticides are microorganisms such as bacteria, fungi and viruses that have been formulated into pest control products. Microbial pesticides are introduced into infested areas to subject pests to disease. They almost always present an extremely low hazard to people and to nontarget organisms. Most microbial pesticides are naturally occurring organisms, but some are genetically altered specifically for this purpose.

The bacterium *Bacillus thuringiensis (Bt)* is one of the best known microbial pesticides. Different strains of Bt are used to control larvae of moths, mosquitoes and black flies. Other examples include a bacterium used to control crown gall in trees, shrubs and vines; an organism that causes disease in milkweed vine; a fungus to control certain mites; and a virus to control certain moth pests.

Microbials are usually applied as a broadcast spray to infect as many target pests as possible. Like pheromones, microbials may be costly to develop, produce and market because they are usually pest-specific.

Cultural Control

In general, plants that are grown under conditions that allow them to be healthy and stress-free are usually better able to resist insect attacks than are less hardy plants. Depending on the situation, several cultural techniques may help control insects and similar pests:

- Crop rotation.
- Trap crops.
- Delay of planting.
- Harvest timing.

Crop rotation — Taking infested fields out of production and leaving them fallow or planting an alternate crop may deprive pests of host plants on which to feed and reproduce. Rotations work best against insects that have long life cycles and infest the crop during all stages of growth. Many traditional crop rotation schemes – corn-soybean rotation, for example – were developed to reduce pest problems.

Trap crops — Other crops attractive to pests may be planted early or nearby to draw pests away from the main crop. By destroying trap crops at the proper time, you can break the reproductive cycle of the pest before the desired crops are infested. To control the pickle worm in cucumbers, for example, you might also plant yellow squash, to which the pest is more attracted. The squash crop can be sprayed or destroyed before the pest can complete its development. The use of trap crops can also be effective against snails and slugs. Trap crops are expensive because of the land they occupy and the cost of their production.

Delay of planting — Delaying the planting date may reduce the population of certain pests by eliminating the plants they need for food and reproduction. For example, you can avoid Hessian fly damage in wheat by delaying planting until fly reproduction has ended for the year.

Harvest timing — Do not leave crops in the field after maturity if they are susceptible to pest attack. For example, wireworm damage to mature potatoes causes a serious quality reduction. Damage increases if the crop is left unharvested for even a short time after maturity.

Mechanical Control

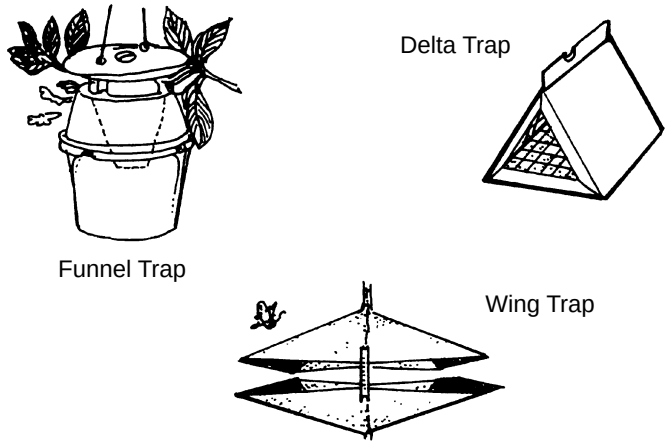
Mechanical controls used on insects and similar pests are:

- Screens and other barriers.
- Traps.
- Light.
- Heat and cold.

Screens and other barriers — Use of screens and other barriers is an important way to keep pests out of structures. The effective mesh size depends on the size of the

smallest flying insect pests in that environment. Screens or other barriers such as tightly sealed doors and windows also keep crawling insects outside. Barriers made of sticky substances sometimes can be used to stop crawling insects from entering an area.

Traps — Traps are sometimes used to control the target pest. More often, however, they are used to survey for the presence of insect pests and to determine when the pest population has increased to the point where control is needed.



Light — Insect pests may be attracted to artificial lights (bug zappers) at night that kill them upon contact. Because not all the pests are killed, the light attractant may actually help create infestations.

Heat and cold — In some cases, it is possible to expose insect pests to the killing effects of heat or cold. Insects that feed on stored grain and flour, for example, can sometimes be controlled by ventilating grain with cold winter air. Manipulation of temperature for pest management is also effective in some greenhouse situations.

Sanitation Control

Tilling fields and burning crop residues and culls soon after harvest greatly aid in controlling of some insect pests, as well as snails and slugs.

Removing litter from around buildings helps control pests that use it for breeding or shelter. Ants, termites and some other indoor pests may be suppressed by using this technique.

Sanitation is important in the control of animal parasites and filth flies. Proper manure management is a major part of fly control in and around barns, poultry houses and livestock pens, for example.

Indoors, sanitation is a major method of preventing insect pest problems. Keeping surfaces clean and dry is an important factor in suppressing ant, fly and cockroach infestations.

Chemical Control

Some problems with insects, mites, spiders and nematodes can best be managed with the use of chemicals. Chemicals such as insecticides, acaricides and nematicides are used to control these pests.

Mode of action — Most of these pesticides either repel the pests or poison them.

- **Repellents** keep pests away from an area or from a specific host. Products designed to keep mosquitoes, chiggers and ticks off people are an example.
- Poisons hinder one or more life systems in the pest. **Stomach poisons** must be eaten by the pest; **contact poisons** act when the pest touches them.

A few insecticides kill insects by interfering mechanically with their body functions. For example, mineral and refined petroleum oils suffocate insects; silica dusts destroy their body water balance by damaging their protective wax covering.

Persistence — Insecticides and related chemicals vary in the length of time they remain active after they are applied. Some kill the pests they contact at the time of application and then break down almost immediately. These are **nonpersistent** pesticides.

Others, known as **persistent** – or residual – pesticides, remain active for varying periods of time after they are applied. The residue that these products leave behind gives continued protection against pests that may enter the area after the application is completed.

Applying insecticides — Thorough knowledge of the target pest helps determine what chemicals to use and how often to apply them. One well timed application of an effective pesticide can provide the desired control. Sometimes repeated applications will be necessary as the infestation continues and pesticide residues break down.

Identifying when a pest is in a vulnerable life stage will help you time the application of an effective pesticide to provide the desired control.

The pesticide label, Extension Service recommendations and other sources, such as pesticide dealers, usually indicate a legal range of treatment intervals and dosages. By carefully observing the pest problem and applying chemicals when the pests are most vulnerable, you often will be able to use lower doses of pesticides and apply them less often. Over a long growing period, this can mean considerable savings in time, money and total pesticides applied.

The best management strategies take advantage of the natural controls provided by the pest's natural enemies. When you choose a pesticide, consider what effect it will have on these beneficial organisms.

Also think about how a pesticide treatment will affect other organisms in the area. If your treatment kills the predators and parasites of an insect that does not currently require control, that insect could quickly multiply to become a problem.

Ask your pesticide dealer, Extension agent or other experts for advice about the need for monitoring pest populations, delaying insecticide use and choosing pest-specific products.

PLANT DISEASES

A plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function. Some conditions that may induce disease include drought, lack of nutrients, high humidity, excessive moisture, and pathogens. Plant diseases caused by biological agents (pathogens) are the ones most important for you to know because pesticides are often used to control them. Pathogens include:

- Fungi.
- Bacteria.
- Viruses, viroids and mycoplasmas.

Parasitic seed plants (discussed in the section on weeds) and nematodes (discussed in the section on insectlike pests) are sometimes considered plant disease agents because of the types of injury they cause to the host plant.

Pathogenic Plant Diseases

Pathogens that cause plant disease live and feed on plant debris and on or in host plants. Many can be passed from one plant to another. Three factors are required before a pathogenic disease can develop _ a susceptible host plant, a pathogenic agent and an environment favorable for development of the pathogen.

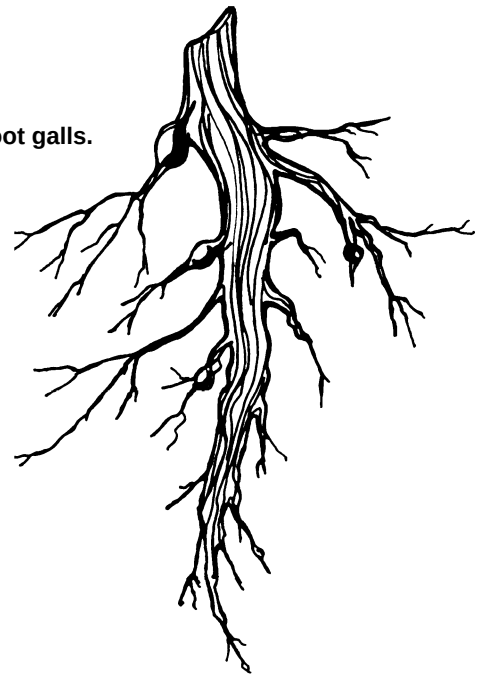
A pathogenic disease depends on the life cycle of the pathogen and on environmental conditions. Temperature and moisture, for example, affect the activity of the pathogen, the ease with which a plant becomes diseased and the way the disease develops.

The disease process starts when the pathogen contacts a part of a plant where infection can occur. If environmental conditions are favorable, the pathogen will begin to develop. If the pathogen enters the plant, infection starts. The plant is diseased when it responds to the pathogen.

The three main ways a plant responds are:

- **Overdevelopment of tissue,** such as galls, swellings and leaf curls.
- **Underdevelopment of tissue,** such as stunting, lack of chlorophyll and incomplete development of organs.
- **Death of tissue,** such as blights, leaf spots, wilting and cankers.

The pathogens that cause plant diseases may be spread by wind; rain; insects, birds, snails and earthworms; transplant soil; nursery grafts; vegetative propagation (especially in strawberries, potatoes, many flowers and ornamentals); contaminated equipment and tools; infected seed stock; pollen; irrigation water; and people.



Root galls.

Fungi

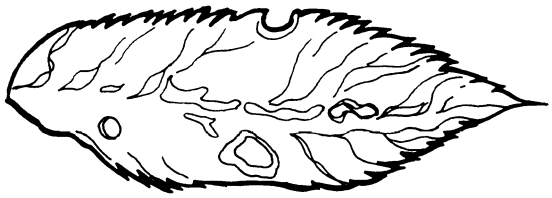
Fungi are plants that lack chlorophyll and cannot make their own food. They get food by living on other organisms. Some fungi live on dead or decaying organic matter.

Most fungi that cause plant diseases are parasites on living plants. They may attack plants both above and below the soil surface. Some fungus pathogens attack many plant species, but others are restricted to only one host species.

Most fungi reproduce by spores, which function about the same way seeds do. Fungus spores are often microscopic in size and are produced in tremendous numbers. Some spores can survive for weeks, months or even years without a host plant. Excessive water or high humidity are nearly always essential for spore germination and active fungal growth. Spores can spread from plant to plant and crop to crop through wind, rain, irrigation water, insects and insectlike pests, and by people through infected clothing and equipment.

Fungal infections frequently are identified by the vegetative body of the fungus (mycelium) and the fruiting bodies that produce the spores. These can usually be seen with the naked eye. Symptoms of fungal infections include soft rot of fruits, plant stunting, smuts,

rusts, leaf spots, wilting, and thickening or curling of leaves. Powdery and downy mildew, smuts, root and stem rots, and sooty and slime molds are examples of fungus diseases.



Leaf spot.

Bacteria

Bacteria are microscopic, one-celled organisms. They usually reproduce by single cell division. Each new cell is exactly like the parent cell. Bacteria can build up quickly under warm, humid weather conditions. Some can divide every 30 minutes. Bacteria may attack any part of a plant, either above or below the soil surface. Many leaf spots and rots are caused by bacteria.

Viruses, Viroids and Mycoplasmas

Viruses and mycoplasmas are so small that they cannot be seen with an ordinary microscope. They are generally recognized by their effects on plants. Often it is difficult to distinguish between diseases caused by viruses or mycoplasmas and those caused by other plant disease agents such as fungi and bacteria.

Usually, the best way to identify a virus is to compare the symptoms with pictures and descriptions of diseased plants for which a positive identification has been made. Other methods require more sophisticated testing, such as inoculating indicator plants and observing the results or using specifically identified antibodies to test for the presence of the organism.

Viruses depend on other living organisms for food and reproduction. They cannot exist separately from the host for very long. Viruses are commonly spread from plant to plant by mites and by aphids, leafhoppers, whiteflies and other plant-feeding insects. They may be carried along with nematodes, fungal spores and pollen, and may be spread by people through cultivation practices such as pruning and grafting. A few are spread in the seeds of the infected plant.

Viruses can induce a wide variety of responses in host plants. Most often, they stunt plant growth and/or alter the plant's color. Viruses can cause abnormal formation of many parts of an infected plant, including the roots, stems, leaves and fruit. Mosaic diseases, with their characteristic light and dark blotchy patterning, usually are caused by viruses.

Viroids are similar to viruses in many ways, but they are even smaller and lack the outer layer of protein that viruses have. Only a few plant diseases are known to be viroid-caused, but viroids are the suspected cause of many other plant and animal disorders. Viroids are spread mostly through infected plant stock. People can spread infected plant sap during plant propagation and other cultural practices. A few viroids are known to be transmitted with pollen and seeds.

Mycoplasmas are the smallest known independently living organisms. They can reproduce and exist apart from other living organisms. They obtain their food from plants. Yellows diseases and some stunts are caused by mycoplasmas. Most mycoplasmas are spread by insects, most commonly by leafhoppers. Mites may also spread them. Mycoplasmas are also readily spread among woody plants by grafting.

Diagnosis of Plant Disease

Trying to control a plant disease without having enough information about it usually will result in failure. The first step in disease management is to diagnose the disease correctly. This is not necessarily an easy task. Use references and people with expertise—Extension agents, diagnostic labs, etc.

You can recognize diseased plants by comparing them with healthy plants. To recognize a disease condition, you must know the plant's normal growth habits. When trying to identify the cause of a plant disease, you need to observe:

- **Symptoms** — the host plant's **reaction** to the disease agent.
- **Signs** — **visible presence** of the disease agent.

Many plant diseases cause similar symptoms in the host plants. Such things as leaf spots, wilts, galls or stunted growth may be caused by many different agents, including many that are not pathogens. For example, the symptoms may be a result of mechanical injury, improperly applied fertilizers and pesticides or frost.

Often the only way to pinpoint the cause is by finding the observable signs that the particular disease agent is present – such as fungal spores and mycelium or bacterial ooze.

Some pathogenic diseases occur regularly on specific agricultural, ornamental and forestry plantings. For these diseases, noticing specific symptoms may be enough to allow you to correctly identify the cause. But many less common pathogenic disease agents, including some fungi and bacteria, may have to be positively identified by laboratory procedures.

Managing Plant Disease

At present, plant disease control measures are mainly preventive. Once a plant or plant product is infected and symptoms appear, few control methods — including pesticides — are effective.

The main methods for control of plant diseases are:

- Host resistance.
- Cultural control.
- Mechanical control.
- Sanitation.
- Chemical control.

Host Resistance

The use of disease-resistant varieties is one of the most effective, long-lasting and economical ways to manage plant disease.

In some crop and greenhouse situations, resistant varieties are the only way to ensure continued production. For many diseases in low-value forage and field crops, for example, chemical controls are too costly. For other diseases, such as many soil-borne pathogens, no economical or effective chemical control method is available. Therefore, using resistant varieties is the most practical approach to disease management.

Cultural Control

For a plant disease to develop, a pathogen and its host must come together under the right environmental conditions. Cultural practices can prevent an infection by altering the environment, the condition of the host or the behavior of the pathogen.

Crop rotation — Pathogenic organisms can usually carry over from one growing season to the next in the soil or in plant debris. Producing the same or closely related crops on the same piece of land year after year leads to disease buildup. Crop rotation reduces the buildup of pathogens but seldom provides complete disease control.

Planting time — Cool-weather crops, such as spinach, peas and some turfgrass, are subject to attack by certain diseases if planted when the temperatures are warm. They often emerge and establish poorly under such conditions. Conversely, beans, melons and many flowers should be planted under warm conditions to avoid disease.

Seed aging — Some seed pathogens can be killed by holding the seed in storage. Proper storage conditions are essential to maintain seed viability.

Mechanical Control

Heat kills many pathogens. In greenhouses, sterilizing soil by heat helps control some plant diseases. Hot water treatments are effective in producing clean seed and planting materials. Seed and vegetative propagation materials such as roots, bulbs, corms and tubers may be treated before planting to control some fungal, bacterial and viral diseases.

In greenhouses and other enclosed growing areas, as well as in areas where food and feed are stored, temperature and humidity control may prevent pathogens from building up rapidly enough to cause damage.

Sanitation

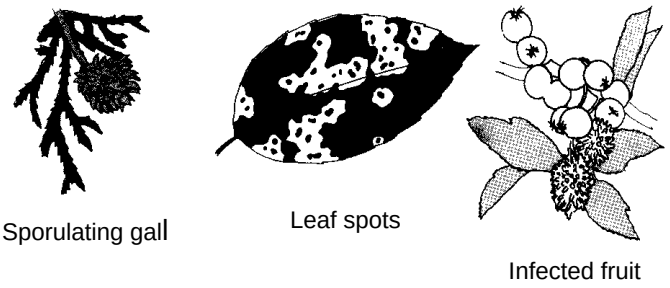
Sanitation practices help to prevent and suppress some plant diseases by removing the pathogens themselves or their sources of food and shelter.

Pathogen-free seed stock — Using clean seed stock is an important way to reduce the spread of plant disease. Pathogen-free propagation — Plant disease pathogens are frequently carried in or on vegetative propagation materials such as roots, bulbs, tubers, corms and cuttings. Use of clean planting stock is especially important in the culture of certain high-value agricultural and ornamental crops. When planning for isolation, consider how far the pathogen may spread, how the pathogen is spread and the distance between potential growing sites.

Pathogen-free storage — To control disease in food and feed storage areas, good sanitation in the facility before storage is a must. Then the crop should be relatively pathogen-free at the time it is put into storage.

Clean planting sites — In some crops, certain plant disease pathogens can be managed by eliminating other nearby plants that are hosts for the same disease organisms. These may be:

- Plants that harbor the pathogens or insects the transmit the pathogen, such as weeds around field borders, ditch banks and hedgerows.
- Plants the organism requires for one stage of its life cycle. An apple grower, for example, can manage cedar apple rust by eliminating nearby cedar (juniper) trees.



Cedar-apple rust.

Removing infected plants — Diseases can be managed by systematically removing infected plants or plant parts before the disease pathogen spreads to other "clean" plants. This method is especially important for the control of some viral and mycoplasma pathogens for which no other controls are available.

Crop residue management — Infected crop residues provide an ideal environment for carryover of many pathogens. Three basic techniques are used to manage crop residues:

- Deep plowing buries pathogen-infested residues and surface soil and replaces them with soil that is relatively free from pathogens.

- Fallowing reduces carryover of pathogens because their food source decays and is no longer available.
- Burning kills some pathogens and removes the residue they live on. Burning may not be legal in some areas.

Disinfecting equipment and tools — Some plant diseases can be spread from plant to plant, field to field and crop to crop by workers and their equipment. Disinfecting equipment, tools and clothing with a product or solution such as water and bleach (sodium hypochlorite) before moving from an infected area to a disease-free area can prevent or delay disease spread. This method of disease spread is especially important in high humidity and wet field conditions, because the pathogens are transported in the droplets of water that form on the equipment, tools and skin.

Chemical Controls

Chemicals used to manage plant disease pathogens include fungicides and bactericides (disinfectants). The general term "fungicide" is often used to describe pesticides that combat both fungi and bacteria.

Persistence — Fungicides vary in the length of time they remain active after they are applied. A **nonpersistent** fungicide controls the pathogen on contact or shortly after and then is no longer chemically active against the plant disease. A **persistent** fungicide can retain its chemical effectiveness for a period of time after application.

The pesticide label will tell how frequently to apply the product to achieve control. The interval will depend on the persistence of the pesticide, as well as:

- Environmental conditions (high humidity and warm temperatures may make more frequent applications necessary).
- Whether rainfall or irrigation washes the fungicide off plant surfaces.

Mode of action — Fungicides may be classified as protectants, eradicants or systemics.

Protectants must be applied before or during infection of the plant by the pathogen. To be effective, a protectant fungicide must either be persistent or be applied repeatedly. Most chemicals now available to combat plant diseases are protectants.

Eradicants are less common and are applied after infection has occurred. They act on contact by killing the organism or by preventing its further growth and reproduction.

Systemics are used to kill disease organisms on living plants. Systemic chemicals are transported in the sap stream from the application site to other plant parts. This type of chemical may act as both a protectant and an eradicant.

Timing — Successful chemical control of plant diseases requires proper timing. Usually plant disease management must begin *before* infection occurs. Apply the protectant chemical when environmental conditions are expected to be ideal for the development of plant disease organisms. If the protectant is not applied in time, major crop damage may result or you may need to use more expensive eradicant sprays to prevent significant injury.

Most fungicides prevent or inhibit disease growth for a period of time. Once the fungicide is no longer effective, the controlled disease may start to grow again or to produce spores and spread when conditions are favorable. For this reason, fungicides may need to be applied at regular intervals for continued disease management. For example, sprays that control late blight of potato must be applied every few days when cool, moist conditions favor disease infection.

Frequent applications are common during production of some fruit and vegetable crops. Different disease threats occur throughout the growing season and many of the disease-causing organisms are capable of causing repeated infections. Some crops, however, are vulnerable to disease only during a short time period and a single application of fungicide may provide adequate protection. Snow mold on turf is often controlled with a single fungicide application just before a snowfall.

Coverage — Almost all plant disease control chemicals are applied as cover sprays. The purpose is to reach and protect all potential sites of infection. Unlike insects and other pests, disease organisms do not move once they contact the plant. For good disease management, apply fungicides and bactericides evenly over the entire plant surface.

Secondary infections — A few fungicides prevent the plant disease organisms from reproducing in an infected plant. The fungicides prevent spore production in existing leaf infections and reduce the likelihood of spread. These fungicides are used, for example, against new apple scab infections, and they prevent spore production in existing leaf infections.

Seed treatment — Seeds are often treated with a fungicide to control disease-causing organisms in or on the seeds. Chemical seed treatment is also used to protect seeds from disease organisms that cause seed or seedling rots and to protect seedlings from infection by damping-off fungi in the soil.

Soil applications — In-row and spot applications of soil fungicides at the time of planting protect young seedlings from many disease organisms in the soil. Soil fungicides may also be used to protect the roots of established plants from infection by pathogens. These fungicides are applied as drenches and must move down through the soil into the root zone at a concentration adequate for control.

Other pesticides — Some pesticides that are not fungicides are used for indirect control of plant diseases. Insecticides and miticides may be used to control the insects and mites that spread plant disease organisms or that damage the plant in a way that makes it more vulnerable to plant disease. Sometimes herbicides are used to eliminate weeds that may harbor disease-causing organisms.

WEEDS

Any plant can be considered a weed when it is growing where it is not wanted. Weeds become a problem when they reduce crop yields, increase costs of production, and reduce the quality of crop and livestock products. In addition, some weeds cause allergic effects, such as skin irritation and hay fever, and some are poisonous to people and livestock.

Weeds harm desirable plants by:

- Competing for water, nutrients, light and space.
- Contaminating the product at harvest.
- Harboring pest insects, mites, vertebrates, or plant disease agents.
- Releasing toxins into the soil that inhibit growth of desirable plants.

Weeds may become pests in water by:

- Hindering fish growth and reproduction.
- Promoting mosquito production.
- Hindering boating, fishing and swimming.
- Clogging irrigation ditches, drainage ditches and channels.

Weeds can interfere in the production of grazing animals by:

- Poisoning the animals.
- Causing off-flavors in milk and meat.
- Competing with desirable plants and reducing forage quality and quantity.

In cultivated crops, the weeds usually found are those that are favored by the crop production practices. The size and kind of weed problem often depends more on the crop production method, especially the use or nonuse of cultivation, than on the crop species involved.

In non-crop areas, weed populations may be affected by factors such as:

- Natural selection.
- Weed control programs used in the past.
- Frequency of mowing or other traffic in the area.
- Susceptibility to herbicides.

Weed Classification

Land Plants

Most weeds on land are either grasses, sedges or broadleaf plants.

Grasses — Grass seedlings have only one leaf as they emerge from the seed. Their leaves are generally narrow and upright with parallel veins. Grass stems may be round or flat and either hollow or solid.

Grass plant.

Most grasses have fibrous root systems. The growing point on seedling grasses is sheathed and located below the soil surface. Some grass species are annuals; others are perennials.

Sedges — Sedges are similar to grasses except that they have triangular stems and three rows of leaves. They are often listed under grasses on the pesticide label. Most sedges are found in wet places, but principal pest species are found in fertile, well drained soils. Yellow and purple nutsedge are perennial weed species that produce rhizomes and tubers.

Broadleaf weeds — The seedlings of broadleaf weeds have two leaves as they emerge from the seed. Their leaves are generally broad with netlike veins. Broadleaf weeds usually have a taproot and a relatively coarse root system. All actively growing broadleaf plants have exposed growing points at the end of each stem and in each leaf axil. Perennial broadleaf plants may also have growing points on roots and stems above and below the surface of the soil. Broadleaves contain species with annual, biennial and perennial life cycles.

Aquatic Plants

Plants present in bodies of water may be pests in some agricultural situations. There are two types of aquatic plants — **vascular plants** and **algae.**

Vascular plants — Many aquatic plants are similar to land plants _ they have stems, leaves, flowers and roots. Most act as perennial plants, dying back and becoming dormant in the fall and beginning new growth in the spring.

Algae — Algae are aquatic plants without true stems, leaves or vascular systems. For control purposes, they may be classified as:

- **Planktonic algae** — microscopic plants floating in the water. They often multiply rapidly and cause "blooms" in which the water appears soupy green, brown or reddish brown, depending on the algal type.
- **Filamentous algae** — long, thin strands of algae that form floating mats or long strings extending from rocks, bottom sediment or other underwater surfaces.
- **Macroscopic freshwater algae** — large algae that look like vascular aquatic plants. The two should not be confused, because their control is different.

For more information on aquatic weed management, obtain MSU Extension bulletin E-2437, "Aquatic Pest Management."

Parasitic Seed Plants

Dodders, broomrape, witchweed and some mosses are important weeds on agricultural plants. They live on and obtain their food from the host plants. They can severely stunt and even kill the host plants by using the host plant's water, food and minerals. These plants reproduce by seeds and spread from plant to plant in close stands by vining and twining.

Dodder twined on a legume plant.

Development Stages

All crop plants and weeds have four stages of development:

- Seedling — small, delicate plantlets.
- Vegetative — fast growth; production of stems, roots and leaves. Uptake and movement of water and nutrients are fast and thorough.
- Seed production — energy directed to producing flowers and seed. Uptake of water and nutrients is slow and is directed mainly to flower, fruit and seed structures.
- Maturity — little or no energy production or movement of water and nutrients. Some plants begin to desiccate.

Life Cycles of Plants

Annuals

Plants with a one-year life cycle are annuals. They grow from seed, mature and produce seed for the next generation in one year or less. They are grasslike (crabgrass and foxtail) or have broad leaves (henbit and common cocklebur).

There are two types of annuals:

Summer annuals grow from seeds that germinate in the spring. They grow, mature, produce seed and die before winter. Examples: crabgrass, foxtail, common cocklebur, pigweed and common lambsquarter.

Cocklebur is a summer annual.

Henbit is a winter annual.

Winter annuals grow from seeds that germinate in the fall. They grow, mature, produce seed and die before summer. Examples: shepherd's purse, henbit and annual bluegrass.

Biennials

Plants with a two-year life cycle are **biennials**. They grow from seed and develop a heavy root and a compact cluster of leaves called a rosette the first year. In the second year, they mature, produce seed and die. Examples: mullein, wild carrot, burdock and bull thistle.

Bull thistle is a biennial.

Perennials

Plants that live more than two years are perennials. Some perennial plants mature and reproduce in the first year and then repeat the vegetative, seed production and maturity stages for several following years. In other perennials, the seed production and maturity stages may be delayed for several years. Some perennial plants die back each winter; others, such as deciduous trees, may lose their leaves but do not die back to the ground.

Johnsongrass (creeping perennial).

Most perennials grow from seed; many species also produce tubers, bulbs, rhizomes (belowground rootlike stems) or stolons (aboveground stems that produce roots). Examples: Johnsongrass, field bindweed, plantain and quackgrass.

Weed Management Strategy

Weed management is nearly always designed to **prevent** or **suppress** a weed infestation. Eradication usually is attempted only in regulatory weed programs and in relatively small, confined areas, such as greenhouses or plant beds.

To manage weeds that are growing among or close to desirable plants, you must take advantage of the differences between the weeds and the desired species. Generally, the more similar the desirable plant and the

weed species are to one another, the more difficult weed control becomes. For example, broadleaf weeds are usually more difficult to manage in broadleaf crops and grass weeds are often difficult to manage in grass crops.

A plan to manage weeds may include:

- Biological control.
- Cultural control.
- Sanitation.
- Chemical control.

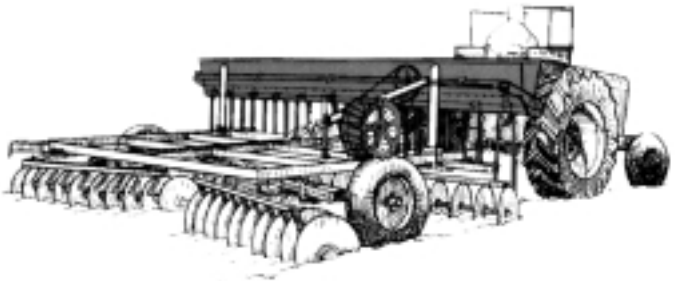
Biological Control

Biological weed control usually involves the use of insects and disease-causing agents that attack certain weed species. An example is the control of musk thistle with the thistle head weevil. Grazing is another form of biological control sometimes used to control plant growth along ditches and fencerows, and in non-cropland areas, forage crops and roadsides. Goats are commonly used, and geese are used for weeding some crops, such as strawberries and asparagus.

Cultural Control

Several kinds of practices can be used in cultivated plants to make it more difficult for weeds to survive. Most of these techniques work by disrupting the normal relationship between the weed and the crop.

Tillage — Tillage is an effective and often-used method to kill or control weeds in row crops, nurseries and forest plantings. However, tillage may bring buried seeds to the surface where they can germinate. Tillage can increase soil erosion and may help to spread established plant diseases to uninfected areas of the field. In some situations, weeds can be removed by hand weeding or hoeing.



Time of planting — Sometimes the planting date of crops can be delayed until after weeds have emerged and have been removed by cultivation or by herbicides.

Nurse crops — Plant species (usually annuals) that germinate quickly and grow rapidly are sometimes planted with a perennial crop to provide competition with weeds and allow the crop to become established. The nurse crop is then harvested or removed to allow the perennial crop to take over. For example, oats are sometimes used as a nurse crop to help establish alfalfa or clover.

Burning — Fire may be used to control limited infestations of annual or biennial weeds. Because fire destroys only the aboveground parts of plants, it is a good choice for control of woody plants in some situations, but it usually will not control other types of perennial weeds that have underground growing points. Contact local authorities for appropriate permits.

Mulching — By serving as a physical barrier and by keeping light from reaching weed seeds, mulching can reduce weed growth between rows and around individual plants.

Mowing — Mowing may reduce competition between weeds and crops and prevent flowering and seeding of annual, biennial and perennial weeds. Mowing is often used in pastures and orchards to control weeds and prevent soil erosion. The mower must be set at a height that will ensure control of weed plants without destroying desired plants.

Reduced tillage — This method can reduce both weed growth and soil erosion. With limited tillage, weed seeds are not brought near the soil surface. Those that do germinate do not have as much light or space to get started. However, the remaining debris may harbor insects and plant disease agents.

Shading — Aquatic weeds are sometimes controlled by using dyes to block out the sunlight. Land weeds can be shaded by planting crop plants so closely together that they keep the sunlight from reaching the emerging weeds.

Sanitation

Using "clean" seeds – those contaminated with few weed seeds – will reduce weed problems. If you buy seed, read the seed purity information on the label. It will indicate the approximate percent, by weight, of weed seeds and other crop seeds in the container. If you grow your own seed, pay particular attention to weed control in the crops grown for seed production, and consider having a representative sample tested for purity.

Chemical Control

Some weed problems can best be controlled with the use of herbicides. Several factors affect a plant's susceptibility to herbicides:

Growing points — Those that are sheathed or located below the soil surface are not reached by contact herbicide sprays.

Leaf shape — Herbicides tend to bounce or run off narrow, upright leaves. Broad, flat leaves tend to hold the herbicide longer.

Waxy cuticle — Sprays applied to leaves may be prevented from entering by a thick, waxy cuticle. The waxy surface also may cause a spray solution to form droplets and run off the leaves.

Leaf hairs — A dense layer of leaf hairs holds the herbicide droplets away from the leaf surface, allowing less chemical to be absorbed into the plant. A thin layer of leaf hairs causes the chemical to stay on the leaf surface longer than normal, allowing more chemical to be absorbed into the plant.

Stage in life cycle — Seedlings are susceptible to herbicides and to most other weed control practices. Plants in

the vegetative and early bud stages are generally very susceptible to translocated herbicides. Plants with seeds or in the maturity stage are the least susceptible to most chemical weed control practices.

Timing of stages in the life cycle — Plants that germinate and develop at different times than the crop species may be susceptible to carefully timed herbicide applications without risk of injury to the crop.

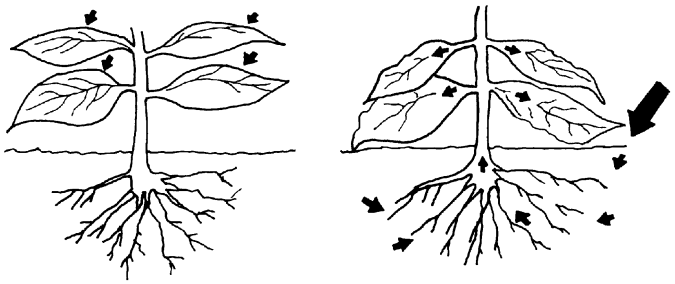
Herbicides

Just as there are many types of weeds, there also are many kinds of herbicides. They work in several ways to control weeds. Some herbicides are applied to the leaves and other aboveground parts of the plant (foliar applications) and others are applied to the soil.

Contact/Translocated

Some herbicides kill plants on contact; others work by translocation (moving throughout the plant's system).

Contact herbicides — Contact herbicides kill only the parts of the plant the chemical touches. They usually are used to control annuals and biennials and are characterized by quick browning and dieback of the weeds.



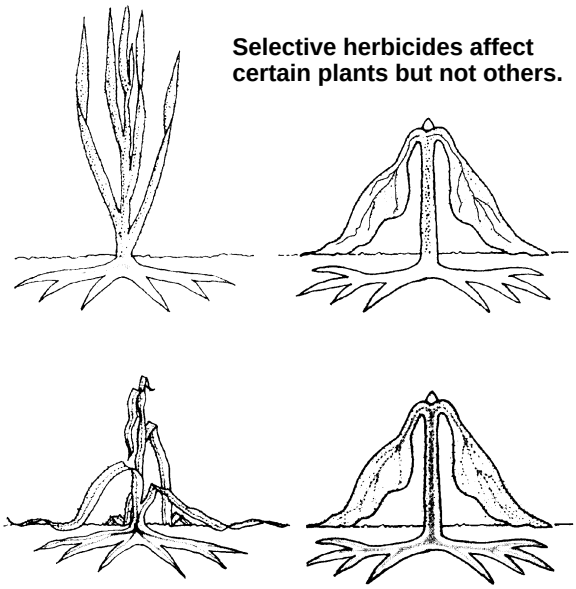
Translocated herbicides — Translocated herbicides are absorbed by roots or leaves and carried throughout the plant. Translocated herbicides are particularly effective against perennial weeds because the chemical reaches all parts of the plant, including deep roots and woody stems. Translocated herbicides may take longer than contact herbicides to provide the desired results. Control may take as long as two or three weeks — even longer for woody perennials.

Selective/Nonselective

Herbicide activity is either selective or nonselective.

Selective herbicides — Selective herbicides are used to kill weeds without causing significant damage to desirable plants nearby. They are used to reduce weed competition in crops, lawns and ornamental plantings.

Nonselective herbicides — Nonselective herbicides, if applied at an adequate rate, will kill all plants in the area. They are used where no plant growth is wanted, such as fencerows, irrigation and drainage ditch banks, and greenhouse floors and benches.



Selective herbicides affect certain plants but not others.

Nonselective herbicides, if applied at an adequate rate, will kill all plants in the area.

Factors affecting selectivity — Herbicide selectivity may vary according to the application rate. High rates of selective herbicides may injure all plants at the application site. Some nonselective herbicides can be used selectively by applying them at a lower rate.

Other factors that affect selectivity include the time and method of application, environmental conditions and the stage of plant growth.

Persistent/Nonpersistent

Herbicides vary in the length of time they remain active after they are applied.

Nonpersistent herbicides — Pesticides that quickly break down after application are called nonpersistent. These pesticides are often broken down easily by microorganisms or sunlight. A nonpersistent herbicide performs its control function soon after application and then is no longer active against weeds.

Persistent herbicides — The chemical structure of persistent herbicides does not change for a long time after application. Persistent herbicides may stay on or in the soil and give long-term weed control without repeated applications. If sensitive plants are later planted in the treated area, these herbicides may injure them. Persistent herbicides are sometimes called residual herbicides.

Choosing a Type of Herbicide

You need to choose the combination of herbicide type and application method (foliar or soil) that will provide the best control. In making the choice, use your knowledge of the weed, herbicide characteristics, and the crop or area to be treated. Follow the directions on the herbicide label carefully. Consider the terms above, how they describe the behavior of the pesticide and how, in combination, these characteristics will provide the type of weed management you desire. For instance:

Foliar contact nonpersistent nonselective — Some herbicides are applied to weed leaves either when the crop is not present or when the crop is taller than the weeds and the herbicide can be directed underneath it. These herbicides kill all foliage they touch but do not move readily to underground parts of the plant.

For example, paraquat applied before no-till corn or used as a directed spray underneath fruit trees will control seedling annual weeds. Diquat is used as a preharvest aid to kill potato vines and make harvest easier.

Foliar translocated nonpersistent nonselective — These herbicides are applied to the foliage and are absorbed and moved throughout the entire plant. Movement of the herbicide into the plant root system enables these compounds to control biennial and perennial weeds.

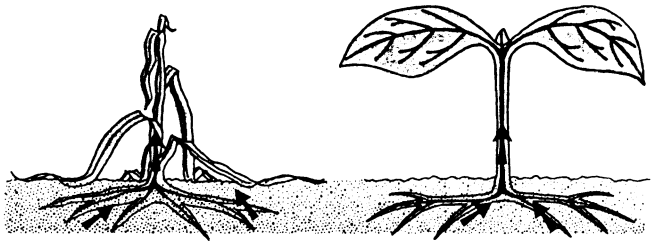
Because they are nonselective, most are used before planting and after harvesting. If the weeds are taller than the crop, such as volunteer corn in grain, special equipment can be used to wick the herbicide onto the weeds without harming the crop.

Glyphosate is an example of a foliar translocated nonpersistent nonselective herbicide.

Foliar translocated nonpersistent selective — These herbicides are some of the oldest and most widely used weed control chemicals. After they are applied to the foliage, they are absorbed and move throughout the plant. They are selective and can be applied to weeds while the crop is present with little or no harm to the desirable plants.

The best example of this type of herbicide is 2,4-D. It kills broadleaf weeds in grass crops, such as oats, wheat, barley, corn and turfgrass. Other herbicides in this group include brush killers used along fencerows and on pastures and rights-of-way. Selectively killing brushy plants without killing grass leaves less bare ground once the brush dies.

Soil translocated nonpersistent selective — These herbicides are applied to soil before, at or immediately after planting and are often referred to as preplant or preemergence herbicides. They typically persist for two to four months. Almost all soil-applied herbicides used for weed control in vegetable, agronomic (except small grain) crops, turfgrass and ornamental crops are this type. They are applied to the soil and are primarily root- or shoot-absorbed.



Soil translocated nonpersistent selective herbicides are soil-applied and control some plants and not others.

Soil translocated persistent nonselective — These herbicides are used to control all vegetation in an area for an extended period of time – potentially up to three to five years. They may be used around farm buildings.

There are other herbicides with various characteristics that may be best suited to obtain your weed management goals. If necessary, consult with an Extension agent, manufacturer's representative or other resource person for help in selecting the most appropriate herbicide for your situation.

Chemicals That Change Plant Processes

Plant growth regulators, defoliants and desiccants are classified as pesticides in federal laws. These chemicals are used on plants to alter normal plant processes in some way.

A plant growth regulator will speed up, stop, retard, prolong, promote or in some other way influence vegetative or reproductive growth of a plant. They are used to thin apples, control suckers on plants, control the height of floral potted plants, promote dense growth of ornamentals and stimulate rooting.

A defoliant causes the leaves to drop from plants without killing the plants. A desiccant speeds up the drying of plant leaves, stems or vines. Desiccants and defoliants are often called harvest aid chemicals. They are used to make harvesting a crop easier or to advance the time of harvest. They are often used on soybeans, tomatoes and potatoes.

VERTEBRATE PESTS

All vertebrate animals have jointed backbones. Mammals, birds, reptiles, amphibians and fish are vertebrates. Most vertebrate animals are not pests, but a few can be pests in some situations.

Vertebrates such as birds, rodents, raccoons or deer may eat or damage agricultural and ornamental crops. Birds and mammals may eat newly planted seed. Some prey on livestock and poultry, causing costly losses to producers each year. Birds and rodents consume stored food and often contaminate and ruin more than they eat.

Rodents, other mammals and some birds may carry serious diseases of humans and domestic animals such as rabies, plague and tularemia. Rodents are an annoyance and a health hazard when they get into buildings.

Burrowing and gnawing mammals may damage dams, drainage and irrigation tunnels, turf and outdoor wood products such as building foundations.

Undesirable fish species may crowd out desirable food and sport species. The few poisonous species of snakes become a problem when people, livestock or pets

are threatened. Amphibians occasionally clog water outlets, filters, pipes, hoses and other equipment associated with irrigation systems and drains.

Controlling Vertebrates

Techniques for control of vertebrate pests depend on whether the pest problem is indoors or outdoors.

Indoor vertebrate pest control usually is aimed at eradicating existing pest infestations and preventing new pests from getting in. Nearly all indoor vertebrate pests are rodents, but others, such as bats, birds and raccoons, also may require control.

Outdoors, the strategy usually is to suppress the vertebrate pest population to a level where the damage or injury is economically acceptable. Though difficult to achieve, long-term solutions require denying the pest refuge or habitat and food. Interfering with the animals' access to these areas and the travelways between the areas needing protection is part of successful long-term control.

Local and state laws may prohibit killing or trapping some animals such as birds, muskrats and beavers without special permits. Before you begin a control program, check with local authorities, including the Michigan Department of Natural Resources (MDNR).

Methods of vertebrate pest control include:

- Mechanical control.
- Biological control.
- Sanitation.
- Chemical control.

Mechanical Control

Mechanical control methods for vertebrate pests include traps, barriers, shooting, attractants and repellents.

Traps — Traps are sometimes a good choice for vertebrate pest control. Do not use leg-hold traps that cause the trapped animal to suffer and that may injure nontarget animals. Baited box traps (live traps) allow the captured animal to be relocated to another area or killed humanely. Check traps daily to maintain their effectiveness.

Barriers — Barriers are designed to prevent pests from passing through or entering into structures or damaging plants. These include fences, screens and other barriers that cover openings, stop tunneling and prevent gnawing on structures or plants.

Attractants — Many techniques, such as light and sound, are used to attract pests to a trap.

Repellents — Repellents are devices aimed at keeping pests from doing damage. They include such things as automatic exploders, noisemakers, recordings of scare calls, moving objects and lights. These devices do not always provide good control.

Shooting — Shooting is time-consuming but may be an effective way to achieve vertebrate control. Permits may be required. Contact the MDNR for permit information. Shooting works best in combination with other methods.

Biological Control

In some circumstances, vertebrate pests can be suppressed by increasing the presence of their predators. Developing habitats for birds or snakes that prey on rodents or using cats for rodent control is an example of this type of control.

Sanitation

Removing sources of food and shelter helps to suppress some vertebrate pests. Sanitation techniques are used widely to manage rodents in and around structures.

Chemical Control

Pesticides for rodent pest control usually are formulated in baits. Because the chemicals may be highly toxic to people, livestock and other animals, correct bait placement is important. To use baits effectively, you need a thorough knowledge of the pest's habits. Careful use of chemicals reduces the hazard to nontarget species. Factors to consider are:

- The bait on which a toxicant is used.
- The time of year.
- The method of chemical placement.
- The area of placement.

Few pesticides are available for control of vertebrate pests other than rodents, and most of them require special local permits for use. The chemicals used to control vertebrate pests include rodenticides, piscicides (fish) and avicides (birds).

CHAPTER PART B 2

Review Questions

Pests and Pest Management

Write the answers to the following questions and then check your answers with those found in the back of this manual.

INSECTS AND INSECTLIKE PESTS

1. Why is pest identification important?

2. Understanding the life cycle and habits of the pest you need to manage is important because knowing about a pest's life cycle helps to:

   a. Identify it in all its growth stages.
   b. Predict what kind of damage it is likely to cause in each stage.
   c. Use management measures at the times when the pest is most vulnerable.
   d. All of the above.

3. List some factors to consider when deciding whether control of a pest is necessary.

   1.

   2.

4. What are some non-chemical methods that can be used to control pests in some agricultural situations?
   a. Host resistance.
   b. Sanitation.
   c. Eradication.
   d. Nonpersistent.
   e. a and b

5. Explain what is meant by "persistent" pesticides and "nonpersistent" pesticides.

6. What physical characteristics do all mature insects have in common?
   a. Eight legs.
   b. Two main body parts.
   c. Six legs and four wings.
   d. Three body parts.
   e. None of the above.

7. What are the four main types of insect mouthparts? Give an example of each.

8. What is "metamorphosis"?
   a. Mature stage of an insect.
   b. Series of changes through which an insect passes in its development from egg to adult.
   c. An example of host resistance.
   d. transition into a sterile population.

9. What are the four stages of complete metamorphosis?

10. Which of the following are not insects but resemble insects or cause similar types of damage?
    a. Mites.
    b. Sowbugs.
    c. Aphids.
    d. Flies.
    e. a and b

11. During what stage in the life cycle are most insects most vulnerable and easiest to control?
    a. Early larval or nymphal stages.
    b. Egg.
    c. Adult.
    d. Reproductive stage.

PLANT DISEASE AGENTS

12. What is a plant disease?

13. What types of pathogens cause plant diseases?
    a. Fungi.
    b. Moisture.
    c. Viruses.
    d. Severe weather conditions.
    e. All of the above.
    f. a and c

14. What three factors are required before a pathogenic plant disease can develop?
    a. Resistant host, moisture and heat.
    b. Moisture, sunlight and a plant.
    c. A pathogenic agent, an environment favorable for development of the pathogen and a susceptible host.
    d. Susceptible host, favorable environment and moisture.
    e. None of the above.

15. What are the three main ways plants respond to diseases?
    1.
    2.
    3.

16. List several ways in which plant disease agents can be spread.

17. What are symptoms and signs of plant disease?

18. Match the type of fungicide with its action:

1. Eradicant	A. Applied before or during infection of the plant by the pathogen.
2. Systemic	B. Applied after infection occurs; kills disease organisms on contact or prevents further growth and reproduction.
3. Protectant	C. Moves in the sap from the application site to other plant parts, where it kills the disease organisms.

WEEDS

19. What are the four stages in the life cycle of a weed?

20. Match each stage of weed development with the correct description:

1. Seedling	A. Energy directed to producing flowers and seed.
2. Vegetative	B. Little or no energy production or movement of water and nutrients.
3. Seed production	C. Fast growth; production of stems, roots and leaves; fast uptake of water and nutrients.
4. Maturity	D. Small, delicate plantlets.

21. List several ways weeds reproduce.

22. Grass can be described as:
    a. Wide leaves with netlike veins: seedlings have two leaves.
    b. Large algae plants.
    c. Plants with narrow, upright leaves with parallel veins; seedlings have one leaf; round stems.
    d. Having triangular stems; three rows of leaves.

23. Sedges are:
    a. Aquatic plants that are similar to land plants; have stems, leaves, flowers and roots.
    b. Filamentous algae.
    c. Microscopic floating plants; may cause colored "blooms" in the water.
    d. Plants with triangular stems; three rows of leaves.

24. Explain the difference between selective and non-selective herbicides.

Which type of herbicide would you use in each of the following situations?

25. You need to control some weeds in an area that will be planted in about a month. The weeds are perennials, so you know that the herbicide must reach the roots to keep the weeds from growing back.
    a. Contact herbicide.
    b. Translocated herbicide.
    c. Defoliant.

26. You need to control a low-growing annual weed in a field where the corn crop is waist-high.
    a. Foliar contact nonpersistent nonselective herbicide, directed underneath the corn plants.
    b. Soil fumigant, injected around the corn plants.
    c. Soil translocated persistent nonselective herbicide, applied at a high rate.

27. You need to kill thistle plants in a pasture where the forage crop is already growing.
    a. Soil-translocated-persistent-nonselective herbicide, applied at low rates.
    b. Foliar-translocated-nonpersistent-selective herbicide, sprayed over entire field.
    c. Plant growth regulator, "wicked" onto the thistle plants.

VERTEBRATE PESTS

28. What are some vertebrate control measures that may require approval from the Michigan Department of Natural Resources?

PART B

CHAPTER 3

CALCULATING DILUTIONS AND SITE SIZE

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Identify factors you may need to consider when calculating how much pesticide you will need to use and how much to dilute the formulation.
- Use formulas to calculate dilutions.
- Use formulas to convert between square feet and acres.
- Use formulas to calculate the area of both regularly and irregularly shaped surfaces and the volume of enclosed spaces.

TERMS TO KNOW

Active ingredients - The chemicals in a pesticide product that control the target pest.

Calibration - The process of measuring and adjusting the amount of pesticide that application equipment will apply to the target area.

Carrier - A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its application. Also known as the material used to carry the pesticide to the target – e.g., water.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full strength but usually diluted before application.

Diluent - Anything used to dilute a pesticide; often referred to as the carrier.

Dilute - To make less concentrated.

Formulation - Pesticide product as sold; usually a mixture of active and inert ingredients.

Labeling - The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

Applying the correct amount of pesticide is a must for responsible, effective pest management. The pesticide label and other recommendations tell you how much to apply. It is your job to:

- Dilute the formulation correctly.
- Accurately calculate the size of the application site, if necessary.
- Calibrate your application equipment accurately.

This chapter, and the chapter on equipment calibration should help you acquire a basic understanding of how to be sure you are applying the right amount.

DILUTING PESTICIDES CORRECTLY

Unless you have the correct amount of pesticide in your tank mix, even a correctly calibrated sprayer will apply the wrong amount of pesticide to the target.

Formulations such as wettable and soluble powders, emulsifiable concentrates and flowables usually are sold as concentrates and must be diluted in the spray tank. Water is the most common diluent, but oil, liquid fertilizers and other liquids are sometimes used. Consult the labeling or other recommendations to find out what diluent to use, how much the formulation should be diluted and in what order the materials should be added.

You will need to do some simple calculations based on the capacity of your sprayer, how your equipment is calibrated, how much area you want to treat and the recommended application rate. This chapter gives you the formulas you need to figure dilutions in most ordinary situations, and it includes examples of how the formulas can be used.

But don't rely totally on the formulas plus your pencil or calculator — use your common sense, too. It is easy to make a mistake in calculation, so it is a good idea always to make a rough estimate of what you would expect the amount to be. Then you will be better able to judge whether the results of your calculations are reasonable. Many of the hints that accompany the examples in this chapter are designed to help make these kinds of estimates.

Try to calculate the amount of pesticide per tank by a second method to check your first answer. An error resulting in an over-application may result in crop injury, exceeding the label (legal) rate and wasted money. Under-applying may not control the target pest and also results in wasted resources. Calibration is absolutely necessary for achieving an economical application.

WEIGHTS AND MEASURES

Weights

16 ounces = 1 pound
1 gallon water = 8.34 pounds

Liquid Measure

1 fluid ounce = 2 tablespoons
16 fluid ounces = 1 pint
2 pints = 1 quart
8 pints = 4 quarts = 1 gallon = 128 fluid ounces

Length

3 feet = 1 yard
16 1/2 feet = 1 rod
5,280 feet = 320 rods = 1 mile

Area

9 square feet = 1 square yard
43,560 square feet = 160 square rods = 1 acre

Speed

1.466 feet per second = 88 feet per minute = 1 mph

Volume

27 cubic feet = 1 cubic yard

DILUTING DRY FORMULATIONS

Pounds Per 100 Gallons

Directions for dry formulations, such as wettable or soluble powders, may be given in pounds of pesticide formulation per 100 gallons of diluent. You must know how many gallons your sprayer tank holds (or the number of gallons you will be adding to the tank if the job requires only a partial tank load). Then use the following formula:

$$\frac{\text{Gallons in tank} \times \text{lbs. per 100 gal. recommended}}{\text{100 gallons}} = \text{Pounds of product needed in tank}$$

Example:

Your spray tank holds 500 gallons. The labeling calls for 2 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank to make a full tank load?

HINT: 100 gallons is one-fifth the volume of your tank, so you will need 5 times more than 2 pounds of formulation.

$$\frac{\textbf{Gallons in tank (500)} \times \textbf{lbs. per 100 gallons (2)}}{\textbf{100 gallons}} = \textbf{Pounds of product needed in tank}$$

(500 x 2) ÷ 100 = 10 pounds needed in tank

Example:

You need to spray only 1 acre, and your equipment is calibrated to spray 60 gallons per acre. The labeling calls for 2 pounds of formulation (product) per 100 gallons of water. How much formulation should you add to the tank to make 60 gallons of finished spray?

HINT: 60 gallons is slightly more than half of 100 gallons, so you will need slightly more than 1 pound (half of the recommended 2 pounds) of formulation.

$$\frac{\textbf{Gallons in tank (60)} \times \textbf{pounds per 100 gallons (2)}}{\textbf{100 gallons}} = \textbf{Amount of formulation needed in tank}$$

(60 x 2) ÷ 100 = 1.2 pounds needed in tank

1.2 pounds x 16 ounces per pound = 19.2 ounces needed in tank

Pounds of Formulation Per Acre

The label may list the recommended rate in terms of pounds of pesticide formulation per acre.

If the job requires a full tank, you must know how many gallons your equipment applies per acre and the spray tank capacity. Use these formulas:

$$\frac{\textbf{Gallons in tank}}{\textbf{Gallons applied per acre}} = \textbf{Acres sprayed per tankful}$$

Acres sprayed per tank x pounds of formulated product per acre = Pounds of formulated product needed in tank

Example:

Your sprayer applies 15 gallons per acre and your tank holds 400 gallons. The labeling rate is 3 pounds of formulation per acre. How much formulation should you add to the tank to make a full tank load?

HINT: 400 gallons is much more than 15 gallons, so you will be able to spray many acres with a tankful and will need to add many pounds of formulation to the tank.

$$\frac{\textbf{Gallons in tank (400)}}{\textbf{Gallons per acre (15)}} = \textbf{Acres sprayed per tankful}$$

400 ÷ 15 = 26.7 acres sprayed per tankful

Acres sprayed per tankful (26.7) x pounds formulation per acre (3) = Pounds needed in tank

26.7 x 3 = 80.1 pounds needed in tank

Add 80.1 pounds of pesticide formulation to the tank.

If the job requires less than a full tank, you must know how many acres you want to treat and how many gallons your sprayer is delivering per acre. You must figure both the number of gallons needed in the tank and the pounds of formulation to add. Use these formulas:

Gallons per acre x acres to be treated = Gallons needed in tank

Acres to be treated x pounds formulation per acre = Pounds formulation needed in tank

Example:

You want to spray 3½ acres. Your equipment holds up to 100 gallons and delivers 15 gallons per acre. The labeling rate is 3 pounds per acre. How much water do you need to add to the tank? How much pesticide should you add to the tank?

Gallons per acre (15) x acres to be treated (3½) = Gallons needed in tank

15 x 3.5 = 52.5 gallons of water needed in the tank

Acres to be treated (3 ½) x pounds formulation per acre (3) = Pounds formulation needed in tank

3.5 x 3 = 10.5 pounds formulation needed in tank

Pounds of Formulation Per 1,000 Square Feet

If the application rate is listed as pounds or ounces of formulation per 1,000 square feet, use the following formula:

$$\frac{\textbf{Amount in tank} \times \textbf{rate per 1,000 square feet}}{\textbf{Amount equipment applies per 1,000 square feet}} = \textbf{Amount formulation needed in tank}$$

Example:

Your sprayer tank holds 3 gallons and applies 2 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 4 ounces of formulation per 1,000 square feet. How much formulation do you need to make a tankful of spray?

HINT: Your sprayer holds 3 gallons, which is equal to 12 quarts. Also be aware that 16 ounces equal 1 pound.

$$\frac{\textbf{Amount in tank (3 gallons = 12 quarts)} \times \textbf{rate per 1,000 square feet (4 oz.)}}{\textbf{Amount equipment applies per 1,000 square feet (2 quarts)}} = \textbf{Amount form. needed in tank}$$

(12 x 4) ÷ 2 = 24 oz

24 oz. ÷ 16 oz. per pound = 1.5 pounds needed in tank

Be sure you are working with the appropriate units of measure. e.g., ounces or gallons, pints or quarts, etc.

Pounds of Active Ingredient Per Acre

If the recommended rate is given as **pounds of active ingredient** (a.i.) per acre, you must first convert that figure to **pounds of formulation** per acre. Use the following formula:

$$\frac{\textbf{Pounds of a.i. per acre} \times \textbf{100}}{\textbf{Percent of a.i. in formulation}} = \textbf{Pounds formulation per acre}$$

Then follow the formulas listed above under the heading "Pounds of formulation per acre" to find the pounds of formulation to add to your tank.

Example:

You want to apply 2 pounds of active ingredient per acre. Your formulation is 80 percent WP. How much formulation do you need per acre?

HINT: Because the formulation is less than 100 percent active ingredient, more than 2 pounds of the formulation will be needed.

$$\frac{\textbf{Pounds of a.i. per acre (2)} \times \textbf{100}}{\textbf{Percent a.i. in formulation (80\%)}} = \textbf{Pounds formulation per acre}$$

(2 x 100) ÷ 80 = 2.5 pounds of formulation per acre

Percent of Active Ingredient in Tank

If the recommended rate is a percentage of active ingredient in the tank, another formula is necessary. First find the number of gallons of spray in the spray tank (either the tank capacity or gallons needed for the job if that's less than tank capacity). Then:

$$\frac{\textbf{Gallons in tank} \times \textbf{percent a.i. wanted} \times \textbf{weight of carrier (lbs. per gal.)}}{\textbf{\% a.i. in formulation}} = \textbf{Pounds formulation to add to tank}$$

Example:

Your directions call for a spray containing 1.25 percent active ingredient. You need to mix 4 gallons of spray for the job. The pesticide is a 60 percent SP and you will use water as the diluent. How much formulation do you need to add to the tank?

HINT: Your product has 60 percent a.i. and your spray mixture is to be much less, only 1.25 percent. You will need to add only a small amount of formulation per gallon.

$$\frac{\textbf{Gallons in tank (4)} \times \textbf{percent a.i. needed (1.25)} \times \textbf{weight of water/gal (8.3)}}{\textbf{Percent a.i. in formulation (60)}} = \textbf{Pounds of formulation needed in tank}$$

(4 x 1.25 x 8.3) ÷ 60 = .69 pounds of formulation needed in tank

.69 pounds x 16 ounces per pound = 11 ounces of formulation needed in tank

Diluting Liquid Formulations

Application rates for liquid formulations (EC, F, S, etc.) are often listed as pints, quarts or gallons per 100 gallons of diluent (carrier) or per acre. To make these calculations, use the same formulas you use for calculating dilutions for dry formulations, but substitute the appropriate liquid measure for "pounds" in the formulas.

Pints/Quarts/Gallons Per 100 Gallons

Use the following formula:

$$\frac{\textbf{Gallons in tank} \times \textbf{amount per 100 gal. recommended}}{\textbf{100 gallons}} = \textbf{Amount formulation needed in tank}$$

Example:

The labeling rate is 2 pints of pesticide formulation per 100 gallons of water. Your spray tank holds 30 gallons. How much pesticide formulation do you need to add to the tank?

HINT: Since your tank holds about one-third of the 100 gallons, you will need about one-third of the 2 pints per 100 gallon rate.

$$\frac{\textbf{Gallons in tank (30)} \times \textbf{pints per 100 gal. (2)}}{\textbf{100 gallons}} = \textbf{Pints formulation needed in tank}$$

(30 x 2) ÷ 100 = .6 pints of formulation needed in tank

.6 pints x 16 ounces per pint = 9.6 ounces of formulation needed in tank

Pints/Quarts/Gallons of Formulation Per Acre

Use these formulas:

$$\frac{\textbf{Gallons in tank}}{\textbf{Gallons applied per acre}} = \textbf{Acres sprayed per tankful}$$

Acres sprayed per tank x amt. of formulation per acre = Amt. of formulation needed in tank

Example:

Your sprayer applies 22 gallons per acre and your tank holds 400 gallons. The labeling rate is 1 1/2 quarts per acre. How much *pesticide formulation* should you add to make up a full tank?

HINT: 22 gallons per acre will treat just under 5 acres with 100 gallons, so 400 gallons will treat just under 20 acres. Therefore, your answer should be less than 20 acres X 1 1/2 quarts per acre, or less than 30 quarts.

$$\frac{\textbf{Gallons in tank (400)}}{\textbf{Gallons per acre (22)}} = \textbf{Acres sprayed per tankful}$$

400 ÷ 22 = 18.2 acres sprayed per tankful

Acres per tankful (18.2) x amount of form. per acre (1.5 qts) = Amount form. needed in tank (27.3 qts.)

18.2 x 1.5 = 27.3 quarts (27 quarts plus 9.6 ounces of formulation) of formulation per tank

(1 qt. = 32 oz.; 32 oz. x .3 = 9.6 oz.)

Pints/Quarts of Formulation Per 1,000 Square Feet

If the application rate is listed as pints or quarts of formulation per 1,000 square feet, use the following formula:

$$\frac{\textbf{Gallons in tank} \times \textbf{rate per 1,000 square feet}}{\textbf{Amount equipment applies per 1,000 square feet}} = \textbf{Amount formulation needed in tank}$$

Example:

Your sprayer tank holds 10 gallons and applies 1 1/2 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 5 tablespoons per 1,000 square feet. How much formulation do you need to make a tankful of spray?

HINT: Your sprayer holds 10 gallons, which is 40 quarts, and 64 tablespoons = 1 quart.

$$\frac{\textbf{Gallons in tank (10 gallons = 40 quarts)} \times \textbf{rate per 1,000 square feet (5 Tbsp)}}{\textbf{Amount equipment applies per 1,000 square feet (1.5 quarts)}} = \textbf{Amount needed in tank}$$

(40 x 5) ÷ 1.5 = 133 Tbsp

133 Tbsp ÷ 64 Tbsp per quart = 2 quarts plus 5 Tbsp (2.08 quarts) needed in the tank

Pounds of Active Ingredient Per Acre

The recommendation for the liquid formulation may be listed as **pounds of active ingredient** per acre. You must first calculate how many **gallons of formulation** would be needed per acre to achieve that rate. The label of a liquid formulation always tells exactly how many pounds of active ingredient are in a gallon (4 EC has 4 pounds of active ingredient per gallon; 6 EC contains 6 pounds per gallon, etc.). Use the following formula:

$$\frac{\textbf{Pounds a.i. to apply per acre}}{\textbf{Pounds a.i. per gallon formulation}} = \textbf{Gallons of formulation per acre}$$

Then use the formulas above under "Pints / quarts / gallons per acre" to figure the dilution.

Example:

The recommendation is for 1 pound of active ingredient per acre. You purchased an 8 EC that contains 8 pounds of active ingredient per gallon. Your tank holds 500 gallons and is calibrated to apply 25 gallons per acre. How many acres per tankful can you treat? How much formulation would you need for a full tank?

$$\frac{\textbf{Pounds a.i. to apply per acre (1)}}{\textbf{Pounds a.i. per gallon (8)}} = \textbf{Amount per acre}$$

$1 \div 8 = .125$ (⅛) gallons per acre

$$\frac{\textbf{Gallons in tank (500)}}{\textbf{Gallons per acre (25)}} = \textbf{Acres per tankful}$$

$500 \div 25 = 20$ acres per tankful

Acres per tankful (20) x gallons per acre (⅛ or .125) = Gallons to add to tank

20 x .125 = 2.5 gallons to add to tank

Percentage of Active Ingredient in Tank

If the recommended rate is a percentage of active ingredient in the tank, use this formula:

$$\frac{\textbf{Gallons in tank} \times \textbf{\% a.i. wanted} \times \textbf{weight of water (8.3 pounds per gallon)}}{\textbf{Pounds a.i. per gallon of formulation} \times \textbf{100}} = \textbf{Gallons of formulation to add}$$

Example:

You want to make 100 gallons of a 1 percent spray, using water as the diluent. You have a 2 EC formulation (the pesticide label tells you that this is 2 pounds active ingredient per gallon). How many gallons of the 2 EC should you add to the 100 gallons of water in the tank?

$$\frac{\textbf{Gallons in tank (100)} \times \textbf{\% a.i. wanted (1\%)} \times \textbf{weight of water (8.3)}}{\textbf{Pounds a.i. per gallon of formulation (2)} \times \textbf{100}} = \textbf{Gallons of formulation to add}$$

$(100 \times 1 \times 8.3) \div 2 \times 100 = 4.15$ gallons of formulation to add to tank

Mixing Concentrates for Airblast Sprayers or Mist Blowers

Spray mixtures used in an airblast sprayer or mist blower usually are 2, 3, 4, 5 or 10 times more concentrated than those used in boom or hydraulic sprayers. If no recommended rate is listed for airblast or mist applications, simply figure the dilution as you would for a boom or hydraulic sprayer and then multiply the last answer by the concentration factor (2x, 3x, 4x, 5x or 10x).

The unit on calibration has additional information on choosing an appropriate concentration and adjusting the equipment to apply it correctly.

Pounds/gallons of form. per tank x concentration factor = Pounds/gallons form. per tank in concentrate form

Example:

The label lists the rate as 4 pounds formulation per 100 gallons of water for dilute application. Your airblast sprayer tank holds 600 gallons. You want to apply a 5x concentration.

$$\frac{\textbf{Gal. per tank (600)} \times \textbf{lbs. per 100 gallons recommended (4)}}{\textbf{100 gallons}} = \textbf{Lbs. needed in tank for hydraulic sprayer}$$

$$(600 \times 4) \div 100 = 24$$

Pounds form. per tank for hydraulic sprayer (24) x Concentration wanted (5x) = Lbs. of form. to add to airblast tank

24 pounds x 5 = 120 pounds to add to airblast tank

Converting Between Square Feet and Acres

If the application rate is given in pounds, pints, quarts or gallons per 1,000 square feet, and you have calibrated your equipment in terms of acres, you must convert the 1,000-square-foot rate to the rate per acre:

$$\frac{\textbf{43,560 (sq. ft. in acre)}}{\textbf{1,000 sq. ft.}} = \textbf{43.5}$$

Amount of formulation per 1,000 sq. ft. x 43.5 = Amount formulation to apply per acre

Or you may have calibrated your equipment in terms of 1,000 or 100 square feet when the application rate is given in pounds, pints, quarts or gallons per acre. To convert from the rate per acre to the rate per 1,000 square feet (or 100 square feet):

$$\frac{\textbf{Amount formulation recommended per acre}}{\textbf{43.5 (435 for 100 sq. ft.)}} = \textbf{Amount formulation per 1,000 sq. ft. (or 100 sq. ft.)}$$

CALCULATING SIZE OF TARGET SITES

To determine how much pesticide you need for a job, you must measure or calculate the size of the site to be treated. The following examples will help you to calculate the area of both regularly and irregularly shaped areas and the volume of some enclosed spaces.

Many farmers use maps generated by the Farm Service Agency (formerly the Agricultural Stabilization and Conservation Service [ASCS]) to determine the size of a treatment area. These maps are a plan-view perspective and do not take into account the added surface area when the terrain in a given map area is hilly or has a significant amount of sloping land. Farmers should use their knowledge and experience with the area to adjust for application amounts. For instance, you may know the actual surface area based on equipment performance or distance measured and records created during other applications – e.g., drill planters, GPS digitized mapping, etc.

Regularly Shaped Sites

Rectangles — The area of a rectangle is found by multiplying the length (L) by the width (W).

Area = Length x **Width**

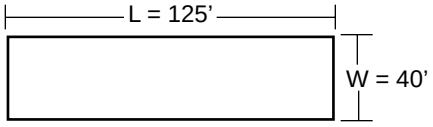
Example:

L = 125 feet

W = 40 feet

Area = 125 ft. x 40 ft.

Area = 5,000 sq. ft.



Circles — The area of a circle is the radius (half the diameter) times the radius times 3.14.

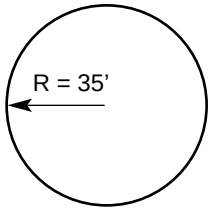
Area = radius x **radius** x **3.14**

Example:

r = 35 feet

Area = 35 ft. x 35 ft. x 3.14

Area = 3,846.5 sq. ft.



Triangles — To find the area of a triangle, multiply the width at the base (W) by the height (H), and divide by 2.

$$\textbf{Area} = \frac{\textbf{W} \times \textbf{H}}{\textbf{2}}$$

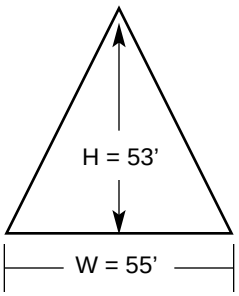
Example:

W = 55 ft.

H = 53 ft.

$$\text{Area} = \frac{55 \text{ ft.} \times 53 \text{ ft.}}{2}$$

Area = 1,457.5 square feet



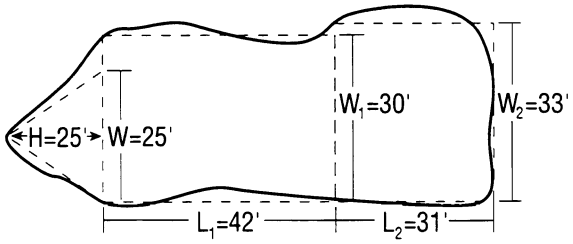
Irregularly Shaped Sites

Irregularly shaped sites often can be reduced to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.

$$\textbf{Area} = (W \times H \div 2) + (L_1 \times W_1) + (L_2 \times W_2)$$

Example:

W = 25 feet
H = 25 feet
L_1 = 30 feet
W_1 = 42 feet
L_2 = 33 feet
W_2 = 31 feet



Area = (25 feet x 25 feet ÷ 2) + (30 feet x 42 feet) + (31 feet x 33 feet)

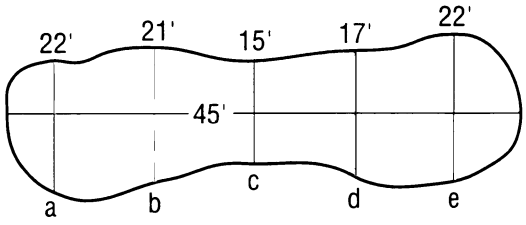
Area = 312.5 sq. feet + 1,260 sq. feet + 1,023 sq. feet

Total area = 2,595 square feet

Another way is to establish a line down the middle of the site for the length, and then measure from side to side at several points along this line. Sites with very irregular shapes require more side-to-side measurements. The average of the side measurements can be used as the width. The area is then calculated as a rectangle.

Example:

L = 45 feet
a = 22 feet
b = 21 feet
c = 15 feet
d = 17 feet
e = 22 feet



$$\text{Area} = L \times \frac{(a + b + c + d + e)}{\text{number of side-to-side measurements}}$$

$$\text{Area} = 45 \text{ feet} \times \frac{22 \text{ feet} + 21 \text{ feet} + 15 \text{ feet} + 17 \text{ feet} + 22 \text{ feet}}{5}$$

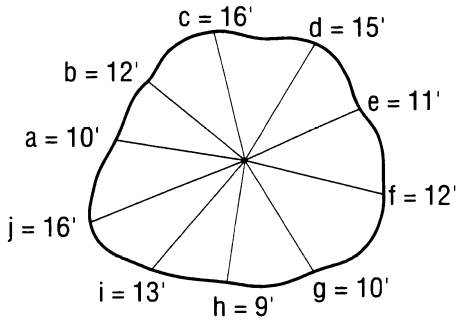
Area = 873 square feet

A third method is to convert the site into a circle. From a center point, measure distance to the edge of the area in 10 or more increments. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

Example:

$$\text{Average radius} = \frac{a + b + c + d + e + f + g + h + i + j}{\text{number of increments measured}}$$

$$\text{Average radius} = \frac{10 \text{ ft} + 12 \text{ ft} + 16 \text{ ft} + 15 \text{ ft} + 11 \text{ ft} + 12 \text{ ft} + 10 \text{ ft} + 9 \text{ ft} + 13 \text{ ft} + 16 \text{ ft}}{10 \text{ increments measured}}$$



Average radius = 12.4 feet

Area = 3.14 x radius x radius

Area = 3.14 x 12.4 feet x 12.4 feet

Area = 482.8 square feet

Volume of Enclosed Spaces

To treat an enclosed space, you must determine its volume. To treat bodies of water (other than surface areas), you must determine the volume of the water.

Spaces Shaped Like Cubes or Boxes

The volume of a cube or box is found by multiplying the length (L) by the width (W) by the height (H).

Volume = Length x **Width** x **Height**

Example:

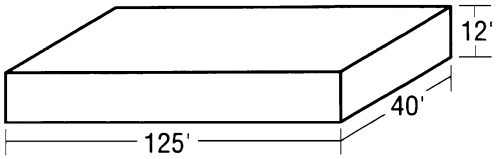
L = 125 feet

W = 40 feet

H = 12 feet

Volume = 125 feet x 40 feet x 12 feet

Volume = 60,000 cubic feet (feet^3)



Spaces Shaped Like Cylinders

The volume of a cylindrical structure is found by multiplying the height by the area of the circle at the base. The area of the circle is the radius (half the diameter) times the radius times 3.14.

Volume = Height x **radius** x **radius** x **3.14**

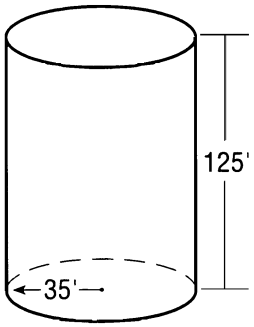
Example:

Height = 125 feet

Radius = 35 feet

Volume = 125 feet x 35 feet x 35 feet x 3.14

Volume = 480,812 cubic feet (feet^3)



Tent-shaped Spaces

The volume of a tent-shaped structure is found by multiplying the length (L) by the width (W) by the height (H) and dividing by 2.

$$\textbf{Volume} = \frac{\textbf{L} \times \textbf{W} \times \textbf{H}}{\textbf{2}}$$

Example:

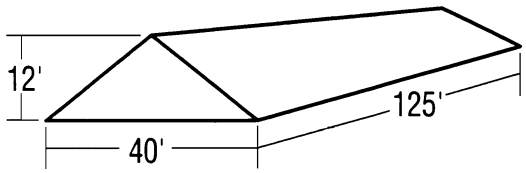
L = 125 feet

W = 40 feet

H = 12 feet

$$\text{Volume} = \frac{125 \text{ feet} \times 40 \text{ feet} \times 12 \text{ feet}}{2}$$

Volume = 30,000 cubic feet (feet^3)



Flat-topped Tent-shaped Spaces

The volume of a flat-topped tent-shaped structure is found by multiplying the length (L) by the height (H) by the average of the width at the top (W_1) and the width at the base (W_2).

$$\textbf{Volume} = \textbf{L} \times \textbf{H} \times \frac{(\textbf{W}_1 + \textbf{W}_2)}{\textbf{2}}$$

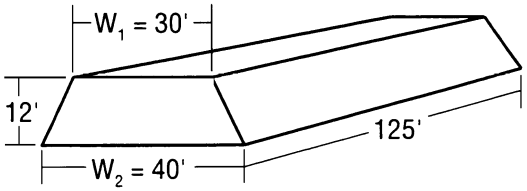
Example:

L = 125 feet

H = 12 feet

W_1 = 30 feet

W_2 = 40 feet



$$\text{Volume} = 125 \text{ feet} \times 12 \text{ feet} \times \frac{(30 \text{ feet} + 40 \text{ feet})}{2}$$

Volume = 52,500 cubic feet ($feet^3$)

Quonset-style Structures

The volume of quonset-style structures is found by figuring the area of the end and multiplying that by the length.

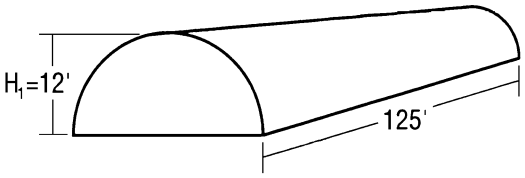
Half-circle ends: To figure the area of the half-circle- shaped end, treat it as a whole circle, using the height from the ground to the highest point as the radius (H_1). After you have figured the area of the whole circle ($H_1 \times H_1 \times 3.14$), divide by 2 to get the area of the half circle.

$$\frac{H_1 \times H_1 \times 3.14}{2} \times L = \text{Volume of half-circle quonset structure}$$

Example:

H_1 = 12 feet

L = 125 feet



$$\frac{12 \text{ ft.} \times 12 \text{ ft.} \times 3.14}{2} \times 125 \text{ ft.} = 28{,}260 \text{ cubic feet}$$

CHAPTER 3 PART B

Review Questions

Calculating Dilutions and Site Size

Write the answers to the following questions and then check your answers with those in the back of this manual. Use the formulas given with each question to calculate your solution. (In most cases, answers have been rounded to the nearest tenth.)

1. Your spray tank holds 300 gallons. The labeling calls for 3 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank to make a full tank load?

$$\frac{\textbf{Gallons in tank} \times \textbf{lbs. per 100 gallons}}{\textbf{100 gallons}} = \textbf{Pounds needed in tank}$$

2. You need to spray only 1 acre, and your equipment is calibrated to spray 50 gallons per acre. The labeling calls for 3 pounds of formulation per 100 gallons of water. How much formulation should you add to the tank to make 50 gallons of finished spray?

$$\frac{\textbf{Gallons in tank} \times \textbf{pounds per 100 gallons}}{\textbf{100 gallons}} = \textbf{Amount needed in tank}$$

3. Your sprayer applies 12 gallons per acre and your tank holds 500 gallons. The labeling rate is 2.5 pounds of formulation per acre. How much formulation should you add to the tank to make a full tank load?

$$\frac{\textbf{Gallons in tank}}{\textbf{Gallons per acre}} = \textbf{Acres sprayed per tankful}$$

AND

Acres sprayed per tankful × **pounds formulation per acre = Pounds needed in tank**

4. You want to spray 5 acres. Your equipment holds up to 300 gallons and delivers 18 gallons per acre. The labeling rate is 2 pounds per acre. How much water do you need to add to the tank? How much pesticide should you add to the tank?

Gallons per acre x **acres to be treated = Gallons of water needed in tank**

AND

Acres to be treated x **pounds formulation per acre = Pounds formulation needed in tank**

5. Your sprayer tank holds 5 gallons and applies 1.5 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 3 ounces of formulation per 1,000 square feet. How much formulation do you need to make a tankful of spray?

$$\frac{\textbf{Amount in tank (5 gallons = 20 quarts)} \times \textbf{rate per 1,000 square feet}}{\textbf{Amount equipment applies per 1,000 square feet}} = \textbf{Amount form. needed in tank}$$

6. You want to apply 3 pounds of active ingredient per acre. Your formulation is 60 percent WP. How much formulation do you need per acre?

$$\frac{\textbf{Pounds of a.i. per acre} \times \textbf{100}}{\textbf{Percent a.i. in formulation}} = \textbf{Pounds formulation per acre}$$

7. Your directions call for a spray containing 1.5 percent active ingredient. You need to mix 5 gallons of spray for the job. The pesticide is an 80 percent SP and you will use water as the diluent. How much formulation do you need to add to the tank?

$$\frac{\textbf{Gallons in tank} \times \textbf{percent a.i. needed} \times \textbf{weight of water/gal (8.3)}}{\textbf{Percent a.i. in formulation}} = \textbf{Pounds form. needed in tank}$$

8. The labeling rate is 1.5 pints of pesticide formulation per 100 gallons of water. Your spray tank holds 25 gallons. How much pesticide formulation do you need to add to the tank?

$$\frac{\textbf{Gallons in tank} \times \textbf{pints per 100 gal.}}{\textbf{100 gallons}} = \textbf{Pints formulation needed in tank}$$

9. Your sprayer tank holds 3 gallons and applies 1.5 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 6 tablespoons per 1,000 square feet. How much formulation do you need to make a tankful of spray?

$$\frac{\textbf{Amount in tank (3 gallons = 12 quarts)} \times \textbf{rate per 1,000 square feet}}{\textbf{Amount equipment applies per 1,000 square feet}} = \textbf{Amount needed in tank}$$

10. The recommendation is for 2 pounds of active ingredient per acre. You purchased a 6 EC that contains 6 pounds of active ingredient per gallon. Your tank holds 300 gallons and is calibrated to apply 30 gallons per acre. How many acres per tankful can you treat? How much formulation would you need for a full tank?

$$\frac{\textbf{Pounds a.i. to apply per acre}}{\textbf{Pounds a.i. per gallon}} = \textbf{Amount per acre}$$

AND

$$\frac{\textbf{Gallons in tank}}{\textbf{Gallons per acre}} = \textbf{Acres per tankful}$$

AND

Acres per tankful x **gallons per acre = Gallons to add to tank**

11. You want to make 200 gallons of a 2 percent spray, using water as the diluent. You have a 4 EC formulation (the pesticide label tells you that this is 4 pounds of active ingredient per gallon). How many gallons of the 4 EC should you add to the tank?

$$\frac{\textbf{Gallons in tank} \times \textbf{\% a.i. wanted} \times \textbf{weight of water (8.3)}}{\textbf{Pounds a.i. per gallon of formulation} \times \textbf{100}} = \textbf{Gallons of formulation to add to tank}$$

12. The label lists the rate as 3 pounds formulation per 100 gallons of water for dilute application. Your airblast sprayer tank holds 500 gallons. You want to apply a 3x concentration. How many pounds of formulation should you add for a full tank load?

$$\frac{\textbf{Gal. per tank} \times \textbf{lbs. per 100 gallons recommended}}{\textbf{100 gallons}} = \textbf{Lbs. needed in tank for hydraulic sprayer}$$

AND

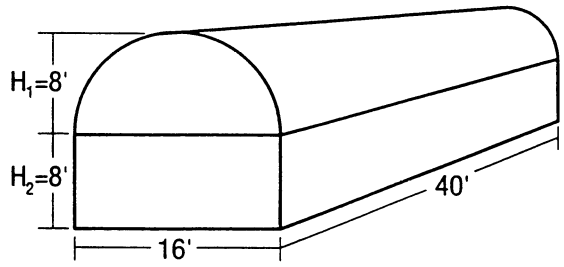
Pounds formulation per tank for hydraulic sprayer x **concentration wanted = Pounds of formulation to add to airblast tank**

13. How do you calculate the area of a rectangle? A circle? A triangle?

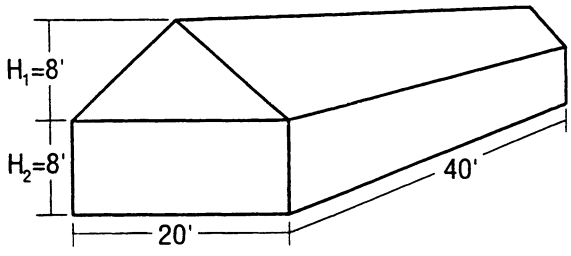
14. How do you calculate the area of an irregularly shaped site?

15. How do you calculate the volume of a space shaped like a cylinder?

16. What is the volume of space of the figure below (half-circle-over-rectangle ends)?



17. What is the volume of space of the figure below (triangle over rectangle ends)?



PART B

CHAPTER 4

APPLICATION EQUIPMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Select the right types of sprayers for various kinds of pest management situations.
- Recognize advantages and disadvantages of commonly used sprayer types.
- List some sprayer features that are important to consider when choosing equipment for a job.
- Show that you know the common types of sprayer pumps and some of their features.
- Explain the use of strainers in a sprayer system.
- Identify desirable features of common parts of a sprayer system — tanks, hoses, pressure gauges and regulators and valves.
- Name the three primary types of agitation used in sprayer systems and identify the formulations for which each is suitable.
- Identify the parts of a nozzle.
- Select the right nozzle pattern for various application situations.
- Explain how to clear a clogged nozzle.
- Explain some advantages and limitations of aerosol generators and foggers.
- Show that you know the basic features of equipment that applies dusts and granules.
- Show that you know the basic features of application equipment used in animal pest control.
- Identify the uses for some types of specialized application equipment.

TERMS TO KNOW

Abrasive - Capable of wearing away or grinding down another object.

Agitation - The process of stirring or mixing.

Calibrate - Measure and adjust the amount of pesticide the application equipment will release per unit of area.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full strength but usually diluted before application.

Corrosion - Process of being worn away gradually by chemical action.

Diluent - Anything used to dilute a pesticide.

Dilute pesticide - A pesticide that is not concentrated; one that does not have a high percentage of active ingredient.

Drift - Pesticide movement in air, away from the target site.

Emulsifiable concentrate (EC or E) - A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion (droplets of one liquid dispersed in another liquid).

Foliage - Primarily the leaves; may include stems of a plant.

Formulation - Pesticide product as sold, usually a mixture of active and inert ingredients.

Fumigant - Pesticide that is a vapor or gas or that forms a vapor or gas when applied and whose pesticidal action occurs in the gaseous state.

gpm - Gallons per minute.

Hydraulic - Operated by the pressure created by forcing liquid through a narrow opening.

Hydraulic agitation - Stirring or mixing provided by the high-pressure flow of surplus spray material from the pump.

Mechanical agitation - Stirring or mixing done by rotating paddles or propellers in the sprayer tank.

Mild steel - Steel that contains a very low percentage of carbon; also called "soft steel."

Nontarget - Any site or organism other than the site or pest at which the pesticide is being directed.

Personal protective equipment (PPE) - Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

psi - Pounds per square inch.

Soluble powder (SP) - Dry pesticide formulation that forms a true solution when mixed with water.

Solvent - A liquid, such as water, kerosene, xylene or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Suspension - A substance that consists of undissolved particles mixed throughout a liquid.

Target - The site or pest toward which control measures are being directed.

Volatile - Evaporating rapidly; turning easily into a gas or vapor.

Wettable powder (WP) - A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

The pesticide application equipment is important to the success of any pest management job. First, the right kind of application equipment must be selected then used correctly and maintained well.

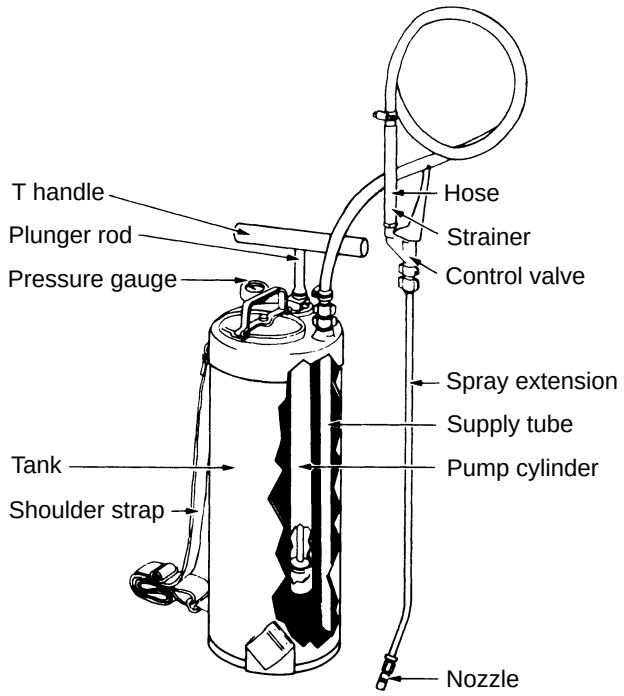
This chapter provides an overview of some things that should be known about choosing, using and caring for equipment. To use pesticide application equipment safely and effectively, **study the manufacturer's directions carefully.** Some pesticide applications – such as airblast spraying, fumigation, aerial application and chemigation – are highly specialized. Special training is necessary to use the equipment these applications require.

SPRAYERS

Sprayers are the most common pesticide application equipment. Sprayers range in size and complexity from simple, hand-held models to intricate machines weighing several tons.

Hand Sprayers

Hand sprayers are often used to apply small quantities of pesticides. They can be used in structures, and they can be used outside for spot treatments or in hard-to-reach areas. Most operate on compressed air supplied by a hand pump.



Compressed air sprayer — This is usually a hand-carried sprayer that operates under pressure created by a self-contained manual pump. The air in the tank is compressed by the pump. The compressed air forces liquid pesticide through the hose and nozzle whenever the control valve is opened. A few types of these sprayers use carbon dioxide cartridges instead of a hand pump for compression. Capacity is usually ½ gallon to 3 gallons.

Bucket or trombone sprayer — These sprayers involve a double-action hydraulic pump operated with a push-pull motion. The pesticide is sucked into the cylinder and pushed out through the hose and nozzle with the return stroke. Pressures up to 150 psi can be generated. The separate tank often consists of a bucket with a capacity of 5 gallons or less.

Backpack (knapsack) sprayer — One type of backpack sprayer is a compressed air sprayer with a harness that allows it to be carried on the operator's back.

Another type of backpack sprayer has a hand-operated hydraulic pump that forces liquid pesticide through a hose and one or more nozzles. The pump is usually activated by moving a lever. A mechanical agitator plate may be attached to the pump plunger. Some of these sprayers can generate pressures of 100 pounds per square inch (psi) or more.

Capacity of both these types of backpack sprayers is usually 5 gallons or less.

Wheelbarrow sprayer — Wheelbarrow sprayers are similar to backpack sprayers but have a larger tank and longer hose line. The tank is mounted on a wheeled cart for easy transport. The capacity of these sprayers is usually less than 25 gallons.

Small Motorized Sprayers

Some small sprayers have all the components of larger field sprayers but usually are not self-propelled. They may be mounted on wheels so they can be pulled manually, mounted on a small trailer for pulling behind a small tractor, or skid-mounted for carrying on a small truck. They may be low-pressure or high-pressure, according to the pump and other components with which they are equipped.

Standard equipment includes a hose and an adjustable nozzle on a handgun. Some models have multi-nozzle booms. These sprayers are suitable for relatively small outdoor areas.

Advantages:

- Larger capacity than hand sprayers.
- Low- and high-pressure capability.
- Built-in hydraulic agitation.
- Small enough for limited spaces.

Limitations:

- Not suitable for general field use.

Estate sprayers — These sprayers are mounted on a two-wheel cart with handles or pushing. Trailer hitches are available for towing the units. Spray material is hydraulically agitated. Some models have 15- to 30-gallon tanks. Pumps deliver 1½ to 3 gallons per minute at pressures up to 250 psi.

Larger models have 50-gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures up to 400 psi. Power is supplied by an air-cooled engine of up to 5 horsepower.

Power backpack sprayer — This backpack-type sprayer has a small gasoline-powered engine. The engine drives the pump, which forces the liquid pesticide from the tank through a hose and one or more nozzles. The engine also drives air blowers, which help propel the spray droplets. This model can generate high pressure and is best suited for low-volume applications of dilute or concentrated pesticide.

Power wheelbarrow sprayer — This sprayer, like the manually operated wheelbarrow sprayer, has a tank mounted on a wheel for easy transport. It may deliver up to 3 gallons per minute and can develop pressures up to 250 psi. The 1½ to 3 – horsepower engine is usually air-cooled. The tank size ranges from 12 to 18 gallons. The spray mixture may be either mechanically or hydraulically agitated.

Large Power-driven Sprayers (Low Pressure)

These sprayers are designed to distribute dilute liquid pesticides over large areas. They deliver a low to moderate volume of spray – 5 to 60 gallons per acre – at working pressures ranging from 10 to 80 psi.

These sprayers usually are mounted on tractors, trucks or boats, but some are self-propelled. Roller pumps and centrifugal pumps are most often used and provide outputs from 5 to more than 20 gallons per acre. Tank sizes range from less than 50 gallons to 1,000 gallons. The spray material usually is hydraulically agitated.

Advantages:

- Medium to large tanks permit relatively large area to be covered per fill.
- Versatility.

Limitations:

- Low pressure limits pesticide penetration and reach.

Boom sprayers — Low-pressure sprayers often are equipped with sprayer booms ranging from 10 to 60 feet in length and containing several nozzles. The height of the sprayer boom must be easily adjustable to meet the needs of the job. Boom supports should allow the boom to be set at any height from 12 to 72 inches above the surface being sprayed. Many nozzle arrangements are possible, and special-purpose booms are available.

Low-pressure sprayers often are equipped with booms ranging from 10 to 60 feet in length, containing several nozzles and that can be easily adjusted in height to meet the needs of the job.

Some booms are designed with sleeves, air curtains or shields to reduce drift.

Boomless sprayers — Low-pressure sprayers that are not equipped with booms generally have a central nozzle cluster that produces a horizontal spray pattern. The resulting swath is similar to the pattern made by a boom sprayer. These sprayers are useful in irregularly shaped areas because they can move through narrow places and avoid trees and other obstacles. Some low-pressure sprayers are equipped with a hose and handgun nozzle for applications in small or hard-to-reach areas.

Large Power-driven Sprayers (High Pressure)

These sprayers are used to spray through dense foliage or thick animal hair, to the tops of tall trees and into other areas where high-pressure sprays are necessary for adequate penetration and reach. Often called hydraulic sprayers, they are equipped to deliver large volumes of spray — usually 20 to 500 gallons per acre — under pressures ranging from 150 to 400 psi or more.

These sprayers usually are mounted on tractors, trailers, trucks or boats, or are self-propelled. Piston pumps are used and provide outputs up to 60 gallons or more per minute. Large tanks (500 to 1,000 gallons) are required because the application rate is usually 100 gallons per acre or more.

Mechanical agitators are usually standard equipment, but hydraulic agitators may be used. When fitted with correct pressure unloaders, these sprayers can be used at low pressures.

High-pressure sprayers may be equipped with a hose and single handgun nozzle for use in spraying trees and animals. These sprayers also may be fitted with a boom for broadcast applications.

Advantages:

- Provide good penetration and coverage of plant surfaces.
- Usually well built and long-lasting if properly cared for.

Limitations:

- Large amounts of water, power and fuel needed.
- High pressure may produce fine droplets that drift easily.

Airblast Sprayer

Airblast sprayers use a combination of air and liquid to deliver the pesticide to the surface being treated.

These sprayers usually include the same components as low-pressure or high-pressure sprayers, plus a high-speed fan. Nozzles operating under low pressure deliver spray droplets directly into the high-speed airstream. The air blast shatters the drops of pesticide into fine droplets and transports them to the target. The air blast is directed to one or both sides as the sprayer moves forward, or it may be delivered through a movable nozzle.

The trailer-mounted airblast sprayer uses a combination of air and liquid to deliver the pesticide to orchard trees.

Most airblast sprayers are trailer-mounted, but tractor-mounted models are available. Tank capacity ranges from 100 to 1,000 gallons. Most of these sprayers can be adapted to apply either high or low volumes of spray material as well as concentrates. Mechanical agitation of the spray mixture is the norm. An airblast sprayer may cover a swath up to 90 feet wide and reach trees up to 70 feet tall.

Advantages:

- Good coverage and penetration.
- Mechanical agitation.
- High capacity.
- Can spray high or low volumes.
- Low pump pressures.

Limitations:

- Drift hazards.
- Use of concentrated pesticides may increase chance of dosage errors.
- Hard to confine discharge to limited target area.
- Difficult to use in small areas.
- High power requirement and fuel use.

Other Sprayers

Ultra-low-volume (ULV) sprayers — These sprayers use special pesticide concentrates. ULV sprayers may be hand-held or mounted on either ground equipment or aircraft.

Advantage:

- No water is needed, so less time and labor are involved.

Limitations:

- Drift hazards.
- Coverage may not be thorough.
- High concentrates present safety hazards.
- Use of concentrated pesticides may increase chance of dosage errors.
- Few pesticides are labeled for ULV.

Controlled droplet applicators (CDA) — These applicators use a spinning disk (or cup) that breaks the liquid into uniform-sized droplets by centrifugal force. The droplets may be carried to the target by gravity or by an airstream created by a fan. Power to spin the disk or cup is provided by a small electric or hydraulic motor. Atomization is produced by the spinning disk rather than by pump pressure and nozzle. CDAs range in size from a small hand-held type to large tractor-mounted and trailer-mounted units.

Controlled droplet applicator.

Advantages:

- Requires a low volume of water.
- Produces a narrower range of droplet sizes than conventional nozzles and so reduces drift.
- Droplet size can be adjusted by speed of rotation.

Limitations:

- Droplets moving into the canopy by gravity may not penetrate well.
- Potential for drift may be high.

Electrostatic sprayers — Electrostatic sprayer systems give the pesticide a positive electric charge as it leaves the nozzles. Plants naturally have a negative charge, so the positively charged pesticide is attracted to the plants. The spray is directed horizontally through or above the crop, depending on the pesticide being applied.

Advantages:

- Pesticide adheres to foliage well, so less pesticide is needed per acre.
- Coverage is more even than with other types of equipment.
- Minimizes the likelihood of drift.

Limitation:

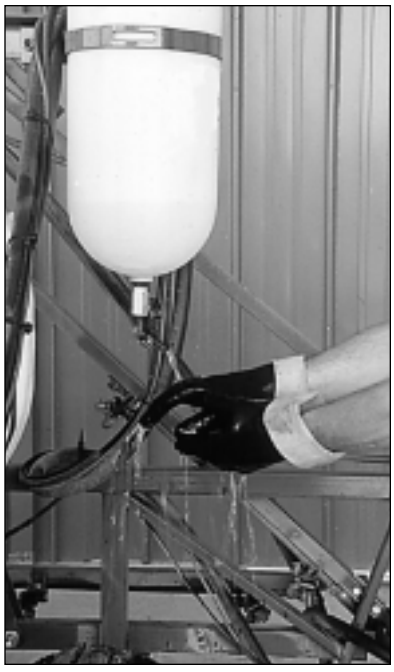
- Useful only for application to foliage.

SPRAYER PARTS

Large Tanks

Tanks should have large openings for easy filling and cleaning and be made of corrosion-resistant material such as stainless steel or fiberglass. Tanks should be designed to allow the use of strainers during filling and to allow mechanical or hydraulic agitation devices to be installed.

The tank should have a large drain, and other outlets should be sized to the pump capacity. If you use dual tanks, make sure the plumbing allows both tanks to have agitation and adequate withdrawal rates. Each tank should have a gauge to show the liquid level. All tanks should have shutoff valves for storing liquid pesticide temporarily while other sprayer parts are being serviced.



Many tractors or sprayers have the capacity to carry clean auxiliary water for personal decontamination and other purposes.

Pumps

The pump must have enough capacity to supply the needed volume to the nozzles and to the hydraulic agitator (if necessary) and to maintain the desired pressure. The pump parts should resist corrosion, and they should be abrasion-resistant if abrasive materials such as wettable powders will be used. Select gaskets, plunger caps and impellers that resist the swelling and chemical breakdown caused by many liquid pesticides. Consult your dealer for available options.

Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Some pumps will be damaged if operated when dry or with restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and for cooling the heat caused by friction and pressure.

Roller pumps — Roller pumps are the most widely used of all sprayer pumps. They provide moderate volumes (8 to 30 gpm) at low to moderate pressure (10 to 300 psi). Often used on low-pressure sprayers, roller pumps are self-priming. The pump case is usually cast iron or a nickel-iron alloy.

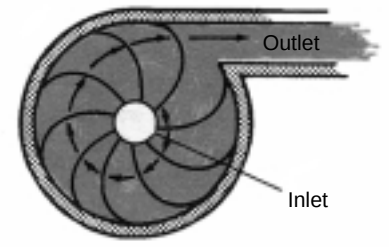
The rollers, made of nylon, Teflon or rubber, wear rapidly in wettable powders but are replaceable. A pump subjected to such wear should have a capacity about 50 percent greater than that needed to supply the nozzles and agitator. This reserve capacity will extend the life of the pump.

Roller pumps are usually the best choice for emulsifiable concentrates, soluble powders and other pesticide formulations that are not abrasive.

Gear pumps — Gear pumps are used on sprayers with low operating pressures. They provide low to moderate volume (5 to 65 gpm) at low to moderate pressures (20 to 100 psi). Gear pumps are self-priming, but the self-priming ability is rapidly lost as the pump wears.

Gear pumps are designed for use with formulations that use oil as a diluent. They wear rapidly when wettable powders are used. The parts are generally not replaceable. The pump is not affected by most solvents because all parts are metal. The pump case may be bronze with stainless steel impellers or it may be made entirely of bronze.

Centrifugal pumps — Centrifugal pumps are adaptable to a wide variety of spray applications. Generally, they deliver high volume (up to 200 gpm) at low pressures (5 to 70 psi); however, two-stage pumps develop high pressures (up to 200 psi). Pressure regulators and relief valves are not necessary.

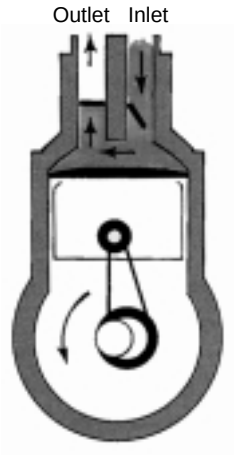


Centrifugal pump.

Centrifugal pumps are not self-priming and must be mounted below the tank outlet or provided with a built-in priming system. Centrifugal pumps are well adapted for spraying abrasive materials because the impeller does not contact the pump housing. Many models are easily repairable. The pump case is usually iron; the impeller is iron or bronze.

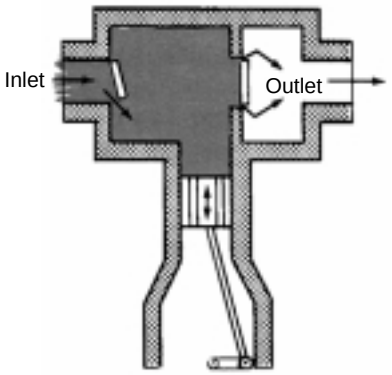
Diaphragm pumps — diaphragm pumps are generally used to deliver low volume (3 to 10 gpm) at low to moderate pressures (10 to 100 psi), but they also can be used for high-volume, high-pressure applications.

Diaphragm pumps withstand abrasion from wettable powder mixtures much better than gear, roller or piston pumps because the spray mixture does not contact any moving metal parts except the valves. Diaphragm pumps are self-priming. The rubber or neoprene diaphragm may be damaged by some solvents; the pump case is usually iron.



Diaphragm pump.

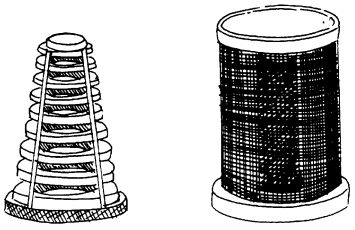
Piston pumps — Piston pumps deliver low to medium volumes (2 to 60 gpm) at low to high pressures (20 to 800 psi). Used for high-pressure sprayers or when both low and high pressures are needed, piston pumps are self-priming. They have replaceable piston cups made of leather, neoprene or nylon fabric, which make the pump abrasion-resistant and capable of handling wettable powders for many years. The cylinders are iron, stainless steel or porcelain-lined. The pump casing is usually iron.



Piston pump.

Strainers (Filters)

Pesticide mixtures should be filtered to remove dirt, rust flakes and other foreign materials from the tank mixture. Proper filtering protects the working parts of the sprayer from undue wear and avoids time loss and uneven application caused by clogged nozzle tips.



Filtering should be progressive, with the largest mesh screens in the filler opening and in the suction line between the tank and the pump. In general, strainers should be placed:

- On the filler opening (12 to 25 mesh).
- On the suction or supply line to the pump (15 to 40 mesh).
- Between the pressure relief valve and the boom (25 to 100 mesh).
- On the nozzle body (50 to 100 mesh).

A shutoff valve is needed between the tank and the suction strainer to allow the strainer to be cleaned without draining the tank. Replace damaged or deteriorated strainers. Strainers are your best defense against nozzle plugging and pump wear. Check nozzle catalogs for the proper screen size for each nozzle.

Hoses

Select neoprene, rubber or plastic hoses that:

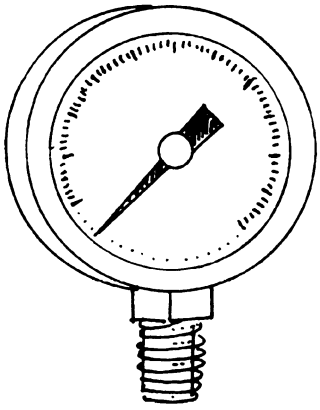
- Have a burst strength greater than the peak operating pressures.
- Have a working pressure at least equal to the maximum operating pressure.
- Resist oil and solvents present in pesticides.
- Are weather-resistant.

Suction hoses should be reinforced to resist collapse. They should be larger than pressure hoses, with an inside diameter equal to or larger than the inlet part of the pump. All fittings on suction lines should be as large as or larger than the inlet part of the pump.

Keep hoses from kinking or being rubbed. Flush hoses after use and wash them often to prolong life. Replace hoses at the first sign of surface deterioration (cracking or splitting).

Pressure Gauges

Pressure gauges should measure the pressure at the nozzle but usually are plumbed to monitor the line pressure of your spraying system. They must be accurate and have the range needed for your work. For example, a 0 to 100 psi gauge with 2-pound gradations would be adequate for most low-pressure sprayers.



Check frequently for accuracy against an accurate gauge. Excess pressure will destroy a gauge. If yours does not zero, replace it. An oil-filled gauge is recommended because it is highly accurate. Use gauge protectors to guard against corrosive pesticides and pressure surges.

Pressure Regulators

The pressure regulator controls the pressure and, therefore, the quantity of spray material delivered by the nozzles. It protects pump seals, hoses and other sprayer parts from damage caused by excessive pressure.

Keep the bypass line from the pressure regulator to the tank fully open and unrestricted. The bypass line should be large enough to carry the total pump output without excess pressure buildup. The pressure range and flow capacity of the regulator must match the pressure range you plan to use and the capacity of the pump. Never attach mechanical agitation devices to the bypass line discharge.

Pressure regulators are usually one of three types:

Throttling valves simply restrict pump output, depending on how much the valve is open. These valves are used with centrifugal pumps, whose output is very sensitive to the amount of restriction in the output line.

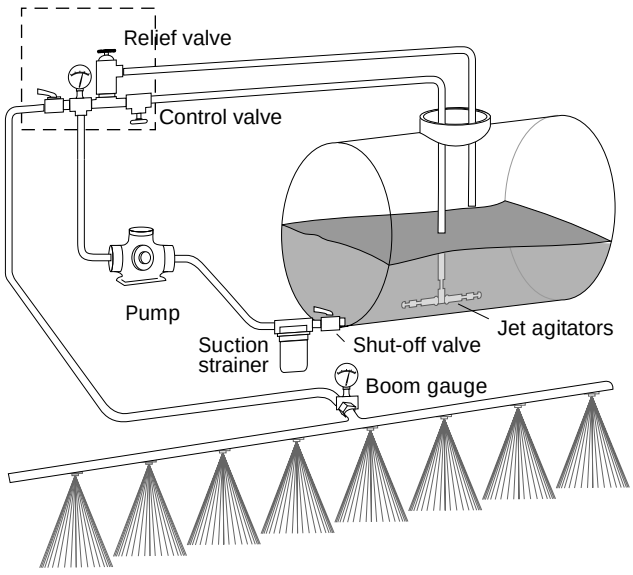
Spring-loaded bypass valves (with or without a diaphragm) open or close in response to changes in pressure, diverting more or less liquid back to the tank to keep pressure constant. These valves are used with roller, diaphragm, gear and small piston pumps.

Unloader valves work like a spring-loaded bypass valve when the sprayer is operating. However, when the nozzles are shut down, they reduce strain on the pump by moving the overflow back into the tank at low pressure. These valves should be used on larger piston and diaphragm pumps to avoid damage to the pump or other system components when the nozzles are cut off.

Agitators

Every sprayer must have agitation to keep the spray material uniformly mixed. The type of agitation needed depends on the pesticide formulation.

Bypass agitators — Bypass agitation uses the returning liquid from the pressure relief valve to agitate the tank. Bypass agitation is sufficient for soluble powders and for liquid formulations such as solutions and emulsifiable concentrates that do not require much agitation.



Do not use bypass agitation for wettable powders or in tanks larger than 55 gallons unless the system has a centrifugal pump. Centrifugal pumps usually have large enough outputs to make bypass agitation adequate in tanks smaller than 100 gallons.

Hydraulic (jet action) agitators — Hydraulic agitation is provided by the high-pressure flow of surplus spray material from the pump. Hydraulic agitation is required for wettable powder and flowable formulations in small tanks and for liquid formulations in 100-gallon or larger tanks with gear, roller, piston or diaphragm pumps.

The jet or jets for a hydraulic agitator are located at the bottom of the tank. The agitator is connected to the pressure side of the pump. Never place jet agitator nozzles in the bypass line.

Mechanical agitation — Wettable powder formulations are best mixed and kept in suspension with mechanical agitation. The mechanical agitator usually consists of flat blades or propellers mounted on a shaft that is placed lengthwise along the bottom of the tank.

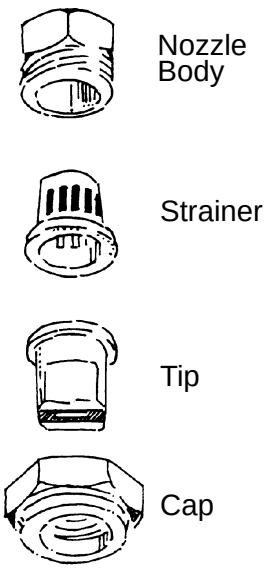
Control Valves

Quick-acting cutoff valves should be located between the pressure regulator and the nozzles to provide positive on-off action. These control valves should be rated for the pressures you intend to use and should be large enough not to restrict flow when open. Cutoff valves to stop all flow or flow to any section of the spraying system should be within easy reach of the sprayer operator.

There are many kinds of control valves. Mechanical valves must be accessible to the operator's hand; electrically operated valves permit remote control of flow. For tractors or self-propelled sprayers with enclosed cabs, remote-controlled valves permit all hoses carrying pesticides to be kept safely outside the cab.

Nozzles

Most nozzles have four major parts: the nozzle body, the cap, the strainer (screen), and the tip or orifice plate. They also may include a separate spinner plate. Successful spraying depends on the correct selection, assembly and maintenance of the nozzles.



The nozzle **body** holds the strainer and tip in proper position. Several types of tips that produce a variety of spray patterns may be interchanged on a single nozzle body made by the same manufacturer.

The **cap** is used to secure the strainer and the tip to the body. The cap should not be overtightened.

The nozzle **strainer** is placed in the nozzle body to screen out debris that may clog the nozzle opening. The type of nozzle strainer needed depends on the size of the nozzle opening and the chemical being sprayed.

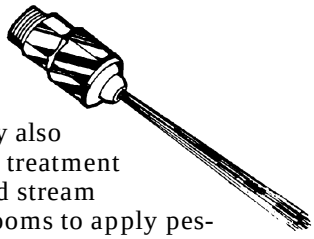
Special nozzle screens equipped with a check valve help prevent nozzle dripping. Check valves should be used in situations where a sprayer must be stopped and started frequently, such as in small target areas or near sensitive crops or areas. The operator must check these spring-loaded ball valves frequently to be sure they are working properly.

Nozzle tips break the liquid pesticide into droplets. They also distribute the spray in a predetermined pattern and are the principal element that controls the rate of application. Nozzle performance depends on:

- Nozzle design or type.
- Operating pressure.
- Size of the opening.
- Discharge angle.
- Distance of nozzle from the target.

Nozzle Paterns

Nozzle patterns are of three basic types: solid stream, fan and cone. Some special-purpose nozzle tips or devices produce special patterns. These include "raindrops," "flooding," and others that produce wide-angle fan- or cone-shaped patterns.



Solid stream nozzles — These nozzles are used in handgun sprayers to spray a distant or specific target such as livestock or tree pests. They also are used for crack and crevice treatment in and around buildings. Solid stream nozzles may be attached to booms to apply pesticides in a narrow band or inject them into the soil.

Fan pattern nozzles — At least three types of nozzle tips have fan patterns. They are used mostly for uniform spray coverage of surfaces _ for example, broadcast soil applications of herbicides or insecticides.

The **regular flat fan** nozzle tip makes a narrow oval pattern with tapered ends. It is used for broadcast herbicide and insecticide spraying at 15 to 60 psi. The pattern is designed to be used on a boom and to be overlapped 30 to 50 percent for even distribution. Spacing on the boom, spray angle and boom height determine proper overlap and should be carefully controlled.

The **even flat fan** nozzle makes a narrow oval pattern. Spray delivery is uniform across its width. It is used for band spraying and for treating walls and other surfaces. It is not useful for broadcast applications. Boom height and nozzle spray angle determine the width of the band sprayed.

The f**looding** (flat fan) nozzle delivers a wide-angle flat spray pattern. It operates at very low pressure and produces large spray droplets. Its pattern is fairly uniform across its width but not as even as the regular flat fan nozzle pattern. If used for broadcast spraying, it

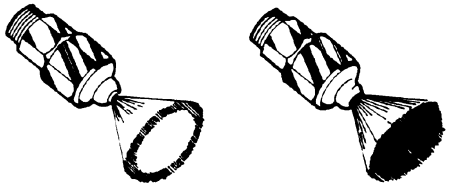
should be overlapped to provide double coverage. It is often used for applying liquid fertilizers or fertilizer-pesticide mixtures or for directing herbicide sprays under plant canopies.

Cluster nozzles are used either without a boom or at the ends of booms to extend the effective swath width. Cluster nozzles are a combination of a center-discharge and two or more off-center-discharge fan nozzles. Coverage may be variable because the spray pattern is not uniform.

Since no boom is required, these nozzles are particularly well suited for spraying hedgerows, fencerows and other hard-to-reach locations where uniform coverage is not critical.

Cone pattern nozzles — Hollow and solid cone patterns are produced by several types of nozzles. These patterns are used where penetration and coverage of plant foliage or other irregular targets are desired. They are most often used to apply fungicides and insecticides to foliage, although some types are used for broadcast soil applications of herbicides or fertilizers or combinations of the two.

When cone pattern nozzles are used for airblast sprayer broadcast application, they should be angled to spray between 15 and 30 degrees from the horizontal and should be spaced at the top of the manifold so the spray pattern will overlap up to 100 percent.



The **side-entry hollow** cone or **"whirl-chamber"** nozzle produces a very wide-angle hollow cone spray pattern at very low pressures. It has a large opening and resists clogging. Because of the wide spray angle, the boom can be operated low, reducing drift. These nozzles may be used in place of flat fan nozzle tips in broadcast applications.

Core-insert cone nozzles produce either a solid or hollow cone spray pattern. They operate at moderate pressures and give a finely atomized spray. They should not be used for wettable powders because their small passages clog easily and they wear rapidly because of abrasion.

Disk-core nozzles produce a cone-shaped spray pattern, that may be hollow or solid. The spray angle depends on the combination of disk and core used and also, to some extent, on the pressure. Disks made of very hard materials resist abrasion well, so these nozzles are recommended for spraying wettable powders at high pressures.

Adjustable cone nozzles change their spray angle from a wide cone pattern to a solid stream when the nozzle collar is turned. Many manual sprayers are equipped with this type of nozzle. Handguns for power sprayers have adjustable nozzles that usually use an internal core to vary the spray angle.

Nozzle Materials

Most nozzle parts are available in several materials. Here are the main features of each kind:

Brass:

- Resists corrosion from most pesticides.
- Wears quickly from abrasion.
- Probably the best material for general use.
- May be corroded by liquid fertilizers.

Plastic:

- Will not corrode.
- Resists abrasion better than brass.
- May swell when exposed to some solvents.
- Useful life about equal to that of brass nozzles.

Stainless steel:

- Resists abrasion, especially if hardened.
- Good corrosion resistance.
- Suited for high pressures, especially with wettable powders.
- Lasts longer than brass.

Aluminum:

- Resists some corrosive materials.
- Easily corroded by some fertilizers.
- Useful life much shorter than brass.

Tungsten carbide and ceramic:

- Highly resistant to abrasion and corrosion.
- Best material for high pressures and wettable powders.
- Last much longer than brass.

Sprayer Selection, Use and Care

Choosing the correct sprayer for each job is important. Your sprayer should be:

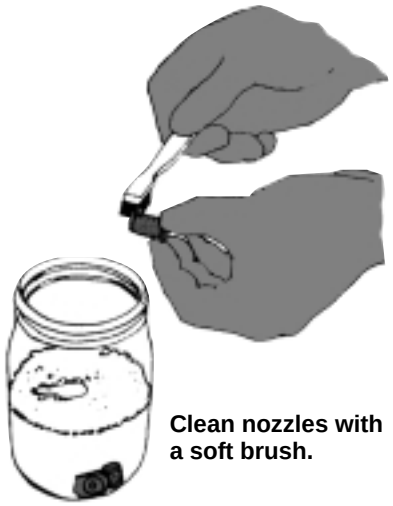
- Designed to do the job you want to do.
- Durable.
- Convenient to fill, operate and clean.

Always read and follow the operator's manual for proper use and care instructions. After each use, rinse the entire system. Check for leaks in lines, valves, seals and tank. Remove and clean nozzles, nozzle screens and strainers with an appropriate brush. Check the accuracy of the pressure gauges frequently.

Be alert for nozzle clogging and changes in nozzle patterns. If nozzles clog or other trouble occurs in the field, be careful not to contaminate yourself while correcting the problem. Shut off the sprayer before attempting any major repairs. Wear PPE while making repairs. Clean clogged nozzles only with a non-metal nozzle-cleaning tool such as a toothbrush. Sharp metal can change or ruin the nozzle orifice opening. Never use your mouth to blow out a nozzle.

It is important to clean and rinse the sprayer thoroughly when changing pesticides. This will minimize the chance for crop injury from residues in the tank.

To prepare spray equipment for storage, follow manufacturer's instructions. If there are no instructions, rinse and clean the system, then fill the tank almost full with clean water and add a small amount of new lightweight oil to the tank. Coat the system by pumping this mixture out through the nozzles or handgun. Drain the pump and plug its openings or fill the pump with lightweight oil or antifreeze. Remove nozzles and nozzle screens and store in lightweight oil or diesel fuel. Store the sprayer out of the sun.



Clean nozzles with a soft brush.

AEROSOL GENERATORS AND FOGGERS

Aerosol generators and foggers convert special formulations into very small, fine droplets (aerosols). Single droplets cannot be seen, but large numbers of droplets are visible as a fog or mist. Aerosol generators and foggers usually are used to completely fill a space with a pesticidal fog. Some insects in the treated area are killed when they come in contact with the poison. Other insects are simply repelled by the mist and return after it has settled.

Thermal foggers, also called thermal generators, use heat to vaporize a special oil formulation of a pesticide. As the pesticide vapor is released into the cooler air, it condenses into very fine droplets, producing a fog.

Other aerosol generators (cold foggers) break the pesticide into aerosols by using mechanical methods such as:

- Rapidly spinning disks.
- Extremely fine nozzles and high pressure (atomizing nozzles).
- Strong blasts of air.

Advantages:

- Penetration in dense foliage.
- Penetration of cracks and crevices.
- Some indoor devices are automatic and do not require presence of applicator.

Limitations:

- Aerosols and fogs drift easily from target area.
- No residual control — pests may return to the area as soon as fog dissipates,
- Risk of explosion in enclosed areas.

Selection, Use and Care

Choose an aerosol generator according to where you will use it – indoors or outdoors. There are truck- and trailer-mounted machines for use outdoors. Most hand-operated or permanently mounted automatic machines are for use indoors, such as in greenhouses.

In general, use and care for an aerosol generator as you would a sprayer. They do require several special precautions, however:

- Be sure that the pesticides used in the aerosol and fog generators are registered for that use.
- Keep the pesticides on the target.
- Because aerosol and fog formulations are easily affected by weather conditions during application, follow special use instructions.
- The operator, other people and animals should stay out of the fog or smoke cloud.

DUSTERS AND GRANULE APPLICATORS

Dusters

Dusters are used only occasionally in outdoor agricultural situations because of the high probability of drift. Dust applications are more common in greenhouses and other enclosed agricultural areas.

Hand dusters — Hand dusters may consist of a squeeze bulb, bellows, tube, shaker, sliding tube or a fan powered by a hand crank.

Advantages:

- Lightweight – do not require water.
- The pesticide is ready to apply without mixing.
- Good penetration in confined spaces.

Limitations:

- Dust may not stick to foliage.
- Dust is difficult to direct.
- Drift potential is high.

Power dusters — Power dusters use a powered fan or blower to propel the dust to the target. They include backpack types, units mounted on or pulled by tractors, and specialized equipment for treating seeds. Their capacity in area treated per hour compares favorably with some sprayers.

Advantages:

- Lightweight — no water required.
- Simply built.
- Easy to maintain.

Limitations:

- Drift hazards.
- Application may be less uniform than sprays.
- Dust may not stick to foliage.

Granule Applicators

Granule applicators distribute granular pesticides by several different methods, including:

- Forced air.
- Spinning or whirling disks (fertilizer spreaders).
- Multiple gravity-feed outlets (lawn spreaders, grain drills).
- Soil injectors (furrow treatments).
- Agricultural aircraft (ram-air).

Granule applicators may be designed to apply the pesticides:

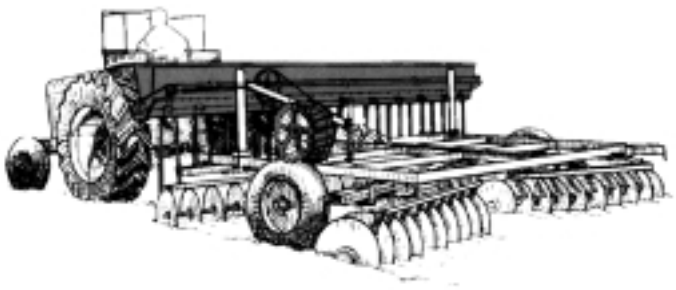
- Broadcast — even distribution over the entire area.
- To specific areas — banding, in-furrow, side-dress.
- By drilling — soil incorporation or soil injection.

Advantages:

- Simple in design.
- Eliminates mixing — no water needed.
- Minimal drift hazard.
- Low exposure hazard to applicator.

Limitations:

- Limited use against some pests because granules will not adhere to most foliage.
- Need to calibrate for each different granular formulation.
- Spinning disk types may give poor lateral distribution, especially on side slopes.
- Weather and ground conditions can affect the flow rate of granules.



Granular broadcast applicator on disc.

Selection, Use and Care

Look for a power duster that is easy to clean. It should give a uniform application rate as the hopper is emptied. Look for both hand and power dusters that direct the dust cloud away from the user.

Choose a granule applicator that is easy to clean and fill. It should have mechanical agitation over the outlet holes. This prevents clogging and helps keep the flow rate constant. Application should stop when drive stops even if outlets are still open.

Both dusters and granule applicators are speed-sensitive, so maintain uniform speed. Bouncing equipment will cause the application rate to vary. Stay out of any dust created by action of the equipment.

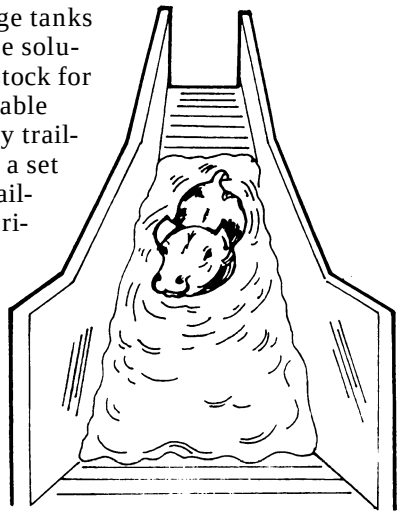
Watch band applicators to see that the band width stays the same. Small height changes due to changing soil conditions may cause rapid changes in band width.

Clean equipment as directed by the operator's manual.

ANIMAL APPLICATION EQUIPMENT

Dipping Vats

Dipping vats are large tanks (vats) of liquid pesticide solutions used to treat livestock for external parasites. Portable dipping vats are usually trailer-mounted tanks with a set of folding ramps and railings. The animals are driven up the ramp onto a platform and forced into the tank so they are completely immersed. Their heads may have to be pushed under the surface.



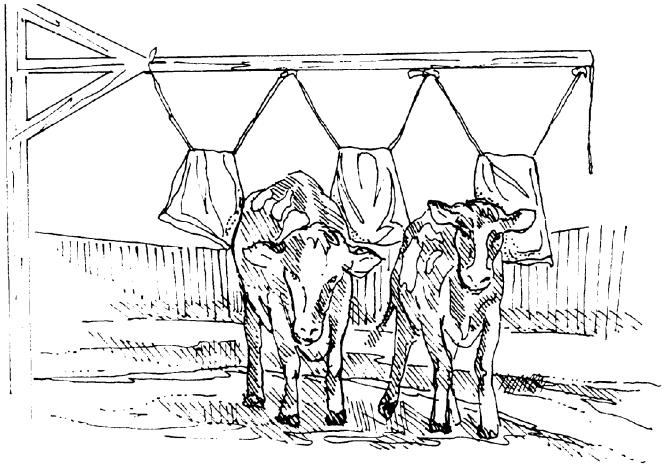
Spray-dip Machines

Spray-dip machines are used to treat livestock for external parasites. A spray-dip machine usually consists of a trailer-mounted chute with solid walls and gates at each end. The chute is located above a shallow tank and is equipped with several rows of large nozzles mounted so that they direct the spray mixture to thoroughly cover each animal. A large centrifugal pump supplies the pesticide to the nozzles. Surplus and runoff spray falls back into the tank, where it is filtered and recycled to the nozzles.

Face and Back Rubbers and Dust Bags

Face and back rubbers and dust bags are containers of dry or liquid pesticide formulations used to control external parasites of livestock. The devices are hung or mounted in areas adjacent to high livestock traffic areas,

such as feeding troughs, waterers and gate entrances. When the animal rubs against the device, the pesticide is transferred to the animal's face, back, sides or legs.



Dust Boxes

Dust boxes are used mainly in raised wire battery-type cages for laying hens or other poultry. These boxes contain a pesticide dust used to control poultry pests, usually mites. Birds wallow in the boxes and pick up the dust on their feathers and skin.

BAIT APPLICATION EQUIPMENT

Bait Stations

Bait stations hold pesticide-treated food that attracts target pests. They are used for insect control around poultry and livestock housing and for vertebrate control around crops, commodities and agricultural buildings.

Bait Applicators

Bait applicators are used to apply pesticides to control moles and other underground vertebrate pests. Some hand-operated models inject the poisoned bait directly into underground burrows. Mechanical models are tractor-mounted machines that form artificial burrows that intersect with natural burrows. When the pests use the artificial burrows, they feed on the bait.

SPECIALIZED APPLICATION EQUIPMENT

You may sometimes use other types of equipment designed for specialized or more precise applications. Some devices are used in conjunction with standard application equipment. Some specialized equipment is intended for application of herbicides. Other specialized application equipment is for applying pesticides through irrigation or watering systems.

Pesticide Injection Systems

With pesticide injection systems, instead of mixing the pesticide with water or other carrier in the sprayer tank, a control console electronically monitors and controls the chemical output of a metering pump. The pump meters the pesticide from its own holding tank and injects it into the line carrying the water to the boom. An in-line mixer device is located on the discharge side of the injector. It blends the carrier with the formulated pesticide before the mixture passes through the boom and is sprayed through the nozzles.

With pesticide injection systems, a control console electronically monitors and controls the chemical output of a metering pump instead of mixing the pesticide with water or other carrier in the sprayer tank.

If a carrier other than water is used, a flow meter and regulator valve are required to regulate the carrier. The carrier rate and flow are monitored and regulated from the same control console that monitors and regulates the rate of flow of the pesticide. The water (or other carrier) spraying pressure and volume are kept constant and the rate of chemical injection is regulated, thereby maintaining the same spray pattern regardless of speed or terrain.

Injection systems eliminate leftover tank solutions and large-tank rinsing. Unused pesticide in the injector tank can be drained back into its original container. The injector tank then requires proper rinsing.

Specialized Application Equipment for Herbicides

Some application equipment is designed to apply herbicides so that the herbicide contacts the weeds but does not contact desirable plants in the treated area. This equipment includes:

- Recirculating sprayers.
- Shielded applicators.
- Wiper applicators.
- Wax bar applicators.

Recirculating sprayers — These devices usually are used to apply contact herbicides to weeds that are taller than the crop in which they are growing. Solid streams of highly concentrated herbicides are directed across rows above the crop. The system prevents the herbicide from contacting the desirable plants. Spray material that is not intercepted by the weeds is caught in a box or sump on the opposite side of the row and is recirculated.

Advantages:

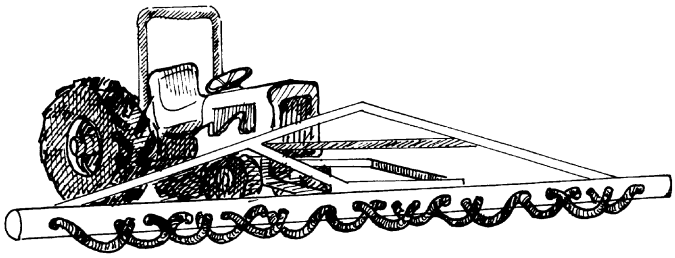
- Uses small quantities of pesticide.
- Less pesticide moves off target and into the environment.
- Permits treatment of weeds that have escaped other control measures.
- Protects susceptible nontarget plants from injury.

Limitations:

- Use is limited to special situations.

Shielded applicators — These applicators direct the herbicide onto the weeds while shielding desirable plants from the herbicide.

Wiper applicators — Sometimes called "wick" or "rope" applicators, these devices are used to apply herbicides selectively to weeds in crop areas. Wicks made of rope, rollers made of carpet or other material, or absorbent pads made of sponges or fabric are kept wet with a mixture of herbicide and water and brought into direct contact with weeds. The herbicide is wiped onto the weeds but does not come in contact with the crop.



Application may be to tall weeds growing above the crop or to lower weeds between rows, depending on the way the wiper elements are designed.

Advantages:

- Simple to operate.
- No drift.
- Uses small amount of pesticide.

Limitations:

- Useful only in special situations.
- Difficult to drain and clean.

Wax bars — Herbicides are sometimes applied with wax bars that are impregnated with herbicides. The bars are dragged slowly over the area to be treated.

Advantages:

- No drift.
- No calibration.

Limitations:

- Highly specialized, not readily available.

Irrigation Application Equipment

Irrigation or watering systems can be equipped to deliver pesticides to a target. Known as chemigation, this is a common method for applying pesticides in many irrigated areas. Accurate calibration and distribution are achieved by metering a large volume of dilute pesticide into the irrigation system. Anti-siphon check valves prevent contamination of the irrigation water source, and switch valves prevent overflow into the slurry feed tank.

Advantages:

- Convenient.
- Field access unnecessary.

Limitations:

- Constant agitation needed in slurry tank.
- Application of more water per acre than recommended on label will cause some pesticides to leach.
- Sprinkler distribution must have appropriate overlap pattern for uniform delivery.
- Injection of pesticides into flood and furrow irrigation systems may result in uneven concentrations of pesticides throughout the field, depending on soil permeability and field contours.

Extension bulletin E-2099, "Using Chemigation Safely and Effectively," provides additional information on applying agrichemicals through irrigation systems.

CHAPTER 4 PART B

Review Questions

Application Equipment

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. Match each sprayer type below with the pest control situation in which it would be most useful.

   1. Spot treatment of a few weeds in a small area. ____
   2. Broadcast application of herbicide to a 10-acre field. ____
   3. Broadcast application in an area where the equipment must move through narrow places and around trees. ____
   4. Application of herbicide to a stand of tall trees with dense foliage. ____

   A. Boomless sprayer
   B. High-pressure (hydraulic) sprayer
   C. Hand-operated sprayer
   D. Boom sprayer

2. Match the following types of sprayers with the correct statements about their advantages and limitations:

   1. Simple to operate; pressure and output not steady; little agitation. ____
   2. Larger capacity than hand sprayers; deliver both low and high pressures; not big enough for general field use. ____
   3. Cover large area with each tankful; limited penetration and reach. ____
   4. Good penetration and coverage; need large amounts of water, power and fuel; output drifts easily. ____
   5. Good coverage and penetration using low pump pressures; use of concentrates makes dosage errors more likely. ____
   6. No water needed; use of high concentrates presents safety hazards; few pesticides labeled for this use. ____
   7. Pesticide adheres to foliage well; little drift hazard; useful only for foliage applications. ____

   A. ULV sprayers
   B. Hand-operated sprayer
   C. Large High-pressure sprayers
   D. Large Low-pressure sprayers
   E. Electrostatic sprayers
   F. Airblast sprayers
   G. Small motorized sprayers

3. Match the following types of sprayer pumps with the correct statements about their features:

   1. Provide moderate volumes at low to moderate pressures; self-priming; best with non-abrasive formulations. ____
   2. Used with low-pressure sprayers to spray oil-based formulations; all parts are metal. ____
   3. High volume; not self-priming; good for abrasive formulations. ____
   4. Generally used to deliver low volumes, but also useful for high-volume, high-pressure applications; self-priming; good with abrasive formulations but may be damaged by some solvents. ____
   5. Used for high-pressure sprayers or when both low and high pressures are needed; self-priming; piston cups can be replaced when worn by abrasives. ____

   A. Centrifual pumps
   B. Diaphram pumps
   C. Gear pumps
   D. Piston pumps
   E. Roller pumps

4. Why are strainers used in a sprayer system?

Select the correct answers to complete the following statements about sprayer parts:

5. A good sprayer tank is easy to fill, easy to clean, and:
   a. Is corrosion-resistant.
   b. Has a large drain opening.
   c. Is equipped with a shutoff valve.
   d. Has a gauge to show the liquid level.
   e. All of the above

6. A pump should have enough capacity to supply the needed volume to the nozzles and to:
   a. Empty the tank in 5 minutes or less.
   b. Maintain the desired pressure at the nozzles.
   c. Deliver volume or pressure at least 15 percent greater than the manufacturer's recommendations.

7. The suction hoses on a sprayer system should be:
   a. Larger than the pressure hoses.
   b. Smaller than the pressure hoses.
   c. The same size as the pressure hoses.

8. Pressure gauges can be damaged by:
   a. Excess pressure.
   b. Pressure that is too low.
   c. Corrosive pesticides.
   d. a and c

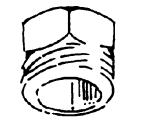
9. A quick-acting cutoff valve should be located between the:
   a. Pump and the pressure regulator.
   b. Pressure regulator and the nozzles.
   c. Bypass line and the agitator.

10. Match the following types of pressure regulators with the correct description:
   1. Valve is manually adjusted; restriction of pump output depends on how much the valve is open. ____
   2. Valve opens or closes in response to changes in pressure. ____
   3. Valve allows overflow to move back to tank when nozzles are shut down. ____

   A. Spring-loaded bypass valve
   B. Unloader valve
   C. Throttling valve

11 What are the three main types of agitation that can be used in spray tanks? Which type is best for wettable powders and other formulations that need a lot of agitation?

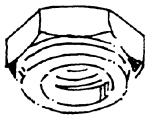
12. On the diagram below, label the four main parts of the nozzle.



A. _____

B. _____

C. _____



D. _____

13. What is the best way to clean a clogged nozzle?

14. Why are dusters not used often in outdoor agricultural pest control?

15. In which of the following situations would a granule applicator probably NOT be a good choice?
   a. Broadcast application of pesticide when drift may be a problem.
   b. Application of pesticide to plant foliage.
   c. Aerial application of pesticide.
   d. Soil incorporation of pesticide.

16. Which of the following types of equipment are left in place so that livestock or poultry will be self-treated when their normal activities bring them into contact with the devices?
   a. Spray-dip machines
   b. Dust boxes
   c. Face and back rubbers
   d. Dust bags
   e. Dipping vats

17. Match the following specialized application equipment with the correct descriptions of their functions:
   1. Recirculating sprayers ____
   2. Shielded applicators ____
   3. Wiper applicators ____
   4. Wax bars ____
   5. Chemigation equipment ____
   6. Pesticide injection systems ____

   A. Apply pesticides through irrigation systems.
   B. Directs pesticide above crop to treat taller weeds; collects excess spray material for reuse.
   C. Dragged slowly over area to be treated.
   D. Directs pesticide onto weeds but has a barrier that keeps the pesticide from contacting the crop.
   E. Ropes, rollers or pads soaked with pesticide rub against weeds but do not contact crop.
   F. No tank mixing required; a pump meters concentrated pesticide into the line carry ing water to the boom – mixing occurs before the solution is sprayed through the nozzles.

PART B

CHAPTER 5

CALIBRATION

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Define calibration.
- Calculate application rates.
- Check for uniform output from multiple nozzles or hoppers.
- Name some key factors you must consider when calibrating a sprayer.
- Explain the role of ground speed in the calibration of equipment.
- Use nozzle charts, along with facts about the application situation, to choose the correct nozzle tip for each job.
- Use formulas provided, to calibrate pesticide application equipment correctly.
- Identify the key factors you must consider when calibrating a granular applicator.

TERMS TO KNOW

Active ingredients – The chemicals in a pesticide product that control the target pest.

Band spraying – Application of a pesticide to a strip over or along a crop row.

Broadcast spraying – Uniform application of a pesticide over an entire area.

Calibration – The process of measuring and adjusting the amount of pesticide that a particular piece of equipment will apply to a given area.

Carrier – The primary material used to allow a pesticide to be applied effectively; for example, the talc in a dust formulation or the water mixed with a wettable powder before a spray application.

Diluent – Anything used to dilute a pesticide.

Dilute – To make less concentrated.

Directed spraying – Aiming a pesticide at a specific portion of a plant or target site.

Formulation – Pesticide product as sold, usually a mixture of active and inert ingredients; can be dry (solid), liquid or gas.

gpa – Gallons per acre.

gpm – Gallons per minute = $\frac{\text{GPA x MPH x W}}{5940}$

mph – Miles per hour. Speed (Mph) = $\frac{\text{distance (feet) x 60}}{\text{time (seconds) x 88}}$

Swath width – Side-to-side measurement of the band or strip of pesticide released by the application equipment.

Target – The site or pest toward which control measures are being directed.

Water-based pesticides – Pesticides that use water as the only diluent or carrier.

Calibration is the process of measuring and adjusting the amount of pesticide your equipment will apply to a specific area. Properly calibrated application equipment ensures that the applicator maximizes the value of a pesticide application within legal label rates and without crop injury or pest control failure.

Before you begin to calibrate the equipment, check it carefully to be sure that all components are clean and in good working order. Pay particular attention to the parts that regulate the amount of pesticide being released, such as nozzles or hopper openings.

Calibration does not have to be difficult. It can be as easy as 1-2-3; 1) nozzle flow rate, 2) ground speed, 3) width. Calibration requires some simple mathematics; this chapter provides some standard formulas to help you.

It is not necessary to memorize the formulas. Instead, make a list of the ones you will need in your work (including the steps to solution) and keep it handy. Review the formula each time you calibrate, just as you refer to the pesticide label each time you use a pesticide. As you work through the formula, use a calculator to reduce the chances of making an error. *Double check your calculations!*

The methods described in this chapter are not the only ways to calibrate equipment. Other equally acceptable methods may be used.

CALIBRATING FOR LIQUID PESTICIDE APPLICATIONS

Timed Flow Calibration Method

The following information will take you step by step through the decisions and calculations required to calibrate a pesticide sprayer. The six steps below describe the *Timed Flow Calibration method.*

Nozzle Selection – Two aspects of the nozzle – type (e.g., flat fan, hollow cone) and tip (size) – influence the amount of pesticide applied. The nozzle type is selected first. You choose the nozzle type based on the particular spray job you need to accomplish and to compliment the field conditions. The label may suggest a type of nozzle for best performance with the pesticide product. Table 1. Nozzle guide for broadcast spraying and Table 2. Nozzle guide for banding and directed spraying, suggest which nozzles are best suited for various applications.

> *The nozzle charts that accompany this unit are typical of those that manufacturers commonly distribute, but the nozzles named are not actual products.*

Nozzle Tip (size) – After the type of nozzle has been selected, you're next decision is to choose the nozzle tip (size) based on **gallons per minute (gpm).** To determine the gpm we want from a nozzle tip will require us to solve our first equation in the calibration process. To calculate gpm use the following equation:

$$\textbf{gpm} = \frac{\textbf{gpa x mph x w}}{\textbf{5940}}$$

Where:

gpm = gallons per minute, the nozzle flow rate.

gpa = gallons per acre, a management decision that you make based on pesticide label recommendations.

mph = miles per hour, the ground speed you select.

w = spacing between nozzles in inches or band width in inches.

5940 = a constant number, used as a conversion factor for units of gallons per acre, miles per hour and nozzle spacing in inches.

Calculating gpm – Each of the values in the gallons per minute (gpm) equation are determined by you. The gpa is based on pesticide label recommendations, field conditions, spray equipment and water supply. You select the mph to meet field and equipment conditions. The width (w) is expressed in inches and is determined by your nozzle arrangement or the row width.

For an example, let's assume you have determined the following:

Step one: Nozzle type selected = flat fan, 65° angle.

Step two: You have determined these parameters –

- Gallons per acre (gpa) = 12 gpa.
- Miles per hour (speed) = 5 mph.
- Nozzle spacing (w) = 20 inches.

Step three: Solve the gpm equation.

$$\text{gpm} = \frac{12\ (\text{gpa}) \times 5\ (\text{mph}) \times 20\ (\text{inches})}{5940} = \frac{1200}{5940} = 0.2\ \text{gpm}$$

Step four: Refer to a manufacturer's table for flat fan nozzles and select one that delivers the gpm (0.2 in our example) you calculated in step 3. Table 3. represents a nozzle selection chart. Table 3. shows that:

- The nozzle tip number 503, will deliver 0.2 gpm at 40 psi with a 50-mesh strainer on that nozzle.
- At 5 mph it will deliver 11.8 gpa.

Note, fine tuning can best be accomplished by adjusting the pressure slightly. It is usually more economical to purchase tips that allow you to operate your equipment at its optimum pressure and speed. Large deviations from the recommended pressure rating may cause changes in the nozzle spray pattern.

Uniform Release – Once you have determined the proper nozzle type and size tip, put these nozzles on the sprayer and operate it with water. (Water is usually used for calibration tests because testing then does not waste chemicals and it is safer for the operator.) Test for leaks, general sprayer problems and uniformity.

Table 1. Nozzle guide for broadcast spraying. (From NCR-520)

	Herbicides				Fungicides		Insecticides	
	Soil-incorporated	Pre-emerge	Post-emerge					
			Contact	Systemic	Contact	Systemic	Contact	Systemic
Extended range flat fan	Good	Very Good (at low pressure)	Good	Very Good (at low pressure)	Very Good	Very Good (at low pressure)	Good	Very Good (at low pressure)
Standard flat fan		Good		Good	Good		Good	
Drift guard flat fan	Very Good	Very Good		Very Good		Very Good		Very Good
Twin flat fan			Very Good				Very Good	
Turbo flood wide angle	Very Good	Very Good		Very Good		Very Good		Very Good
Wide angle full cone	Very Good	Very Good						
Flood nozzle wide angle	Good							
Rainbow™ hollow cone	Good	Good		Good				

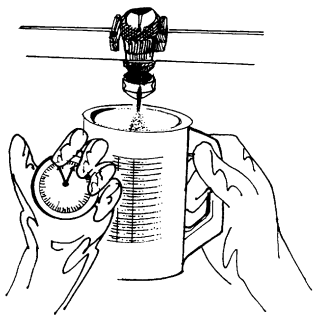
Table 2. Nozzle guide for banding and directed spraying. (From NCR-520)

	Herbicides			Fungicides		Insecticides		Growth Regulator
	Pre-emerge	Post-emerge						
		Contact	Systemic	Contact	Systemic	Contact	Systemic	
Even flat fan	Very Good	Good	Very Good	Good	Very Good		Very Good	Good
Twin even flat fan	Good	Very Good	Good			Very Good		
Hollow cone		Very Good		Good		Very Good		
Full cone	Good							Very Good
Disc and core cone				Very Good	Good	Very Good	Good	

Step five: We must test for uniform flow rate from each nozzle. To test nozzles, operate the tractor at the same throttle setting you use when spraying and when making your speed check (speed check described below). This assures that the pump is delivering the same volume as when you're actually spraying.

Catch the spray material from each nozzle in a jar or plastic container for one minute—sometimes referred to as the catch test. Carefully measure the discharge from each nozzle. Is the amount equal to the desired gpm? If the discharge is collected in a container marked with *ounces*, how can we tell if it equals the appropriate amount of *gallons* (gpm)?

We convert the gallons per minute (gpm) flow rate into ounces per minute by multiplying the number of gallons by 128.



1 gallon = 128 ounces

To convert from gallons to ounces, multiply the number of gallons by 128. In most cases it is practical to round to the nearest whole number.

Table 3. Flat Fan Nozzle Tips

Flat Spray Tip No. and strainer screen size	Pressure in psi	65° Series (For Boom Heights of 21-23 inches) Capacity 1 Nozzle in gpm	Gallons Per Acre (20" Nozzle Spacing) 4 mph	5 mph	7.5 mph	10 mph
501 (100 Mesh)	20	.07	5.3	4.3	2.8	2.2
	25	.08	5.9	4.7	3.1	2.4
	30	.09	6.4	5.1	3.4	2.6
	40	.10	7.4	6.0	4.0	3.0
	50	.11	8.3	6.7	4.5	3.4
	60	.12	9.1	7.4	4.9	3.7
502 (100 Mesh)	20	.11	7.8	6.3	4.3	3.2
	25	.12	8.8	7.1	4.7	3.6
	30	.13	9.7	7.7	5.2	3.9
	40	.14	11.1	8.9	6.0	4.5
	50	.15	12.4	10.0	6.7	5.0
	60	.16	13.6	10.9	7.4	5.5
503 (50 Mesh)	20	.14	10.5	8.4	5.6	4.2
	25	.16	11.8	9.4	6.3	4.7
	30	.17	12.9	10.3	6.9	5.2
	40	.20	14.8	11.8	7.9	5.9
	50	.23	16.5	13.2	8.8	6.6
	60	.25	18.1	14.4	9.7	7.2
504 (50 Mesh)	20	.21	15.7	12.6	8.4	6.3
	25	.24	17.6	14.1	9.4	7.1
	30	.26	19	15.4	10.3	7.7
	40	.30	22	17.8	11.8	8.9
	50	.34	25	20	13.2	10.0
	60	.37	27	22	14.4	10.9
505 (50 Mesh)	20	.28	21	16.8	11.2	8.4
	25	.32	24	18.7	12.5	9.4
	30	.35	26	21	13.7	10.3
	40	.40	30	24	15.8	11.9
	50	.45	33	27	17.7	13.3
	60	.49	36	29	19.4	14.6
506 (50 Mesh)	20	.35	26	21	14	10.5
	25	.40	29	23	15.7	11.7
	30	.43	32	26	17.2	12.9
	40	.50	37	30	19.8	14.9
	50	.56	42	33	22	16.6
	60	.61	45	36	24	18.2
507 (50 Mesh)	20	.42	31	25	16.9	12.6
	25	.47	35	28	18.7	14.1
	30	.52	39	31	21	15.5
	40	.60	45	36	24	17.8
	50	.67	50	40	27	20
	60	.73	55	44	29	22

In our example we want a 0.2 gpm flow rate. So, if we use a container marked in ounces, when collecting our nozzle discharge for one minute we will expect:

0.2 gpm x 128 oz./gal. = 26 oz./min (26 oz. collected in the container)

Compare this calculated number of ounces (26 oz/min.) with the amount actually collected in the container. Any nozzles that are not within ± 5 percent of the average output should be cleaned if they're plugged or replaced if worn or do not meet manufacturer's specifications. New nozzles should also be checked.

For our example, ± 5 percent of our desired flow rate (25.6 oz./min.) is determined as follows:

26 oz./min. x .05 = 1.3 oz./min.

26 oz./min. + 1.3 oz./min. = 27 oz./min.

26 oz./min. – 1.3 oz./min. = 25 oz./min.

If the average discharge is not what you anticipated from the calculations, you can adjust the output a bit by raising or lowering the pressure slightly.

Step 5a (this step is used only if a diluent other than water is used): Flow rates of materials other than water will be different than the nozzle flow rate with water. Your spray situation, based on pesticide label directions, may require the use of a diluent other than water. Because most nozzle selection charts provided by manufacturers are based on spraying with water, the figures will not be correct if you are using another diluent. A table such as Table 4 is often provided to adjust the figures to fit your situation.

Adjust the values on the nozzle charts by the conversion factor from the table to determine the correct value for the solution being sprayed.

Example: You have determined from label directions that you would be applying 12 gallons per acre if water were the diluent. The formulation you are using, which is not water-based, weighs 16 pounds per gallon:

12 gpa ÷ .72 (conversion factor from Table 4) = 16.67 gpa.

A nozzle that will pass 16.67 gpa of water will be needed to pass 12 gpa of the heavier, more viscous spray material.

So far, in this timed flow calibration process we have:

- Selected a nozzle type.
- Determined from label directions the gallons per acre (gpa) we want to apply.
- Chosen our desired sprayer speed in mph based on equipment and field conditions.
- Measured our nozzle spacing (width) in inches.
- Calculated the gpm we want to achieve using the equation:

$$gpm = \frac{gpa \times mph \times w}{5940}$$

- Selected a nozzle tip from a manufacturer's catalog that provides the calculated gpm.
- Confirmed that our flow rate from each nozzle is within ± 5 percent of the anticipated flow rate.

Table 4. Diluent Conversion Factors

Weight of Solution	Factors
6.6 lbs per gallon - KEROSENE	1.26
7.0 lbs per gallon	1.09
8.0 lbs per gallon	1.02
8.34 lbs per gallon-WATER	1.00
9.0 lbs per gallon	.96
10.0 lbs pergallon	.91
11.0 lbs per gallon	.87
12.0 lbs per gallon	.83
14.0 lbs per gallon	.77
16.0 lbs per gallon	.72
18.0 lbs per gallon	.68
20.0 lbs per gallon	.65

- Made adjustments for diluents other than water (if necessary).

Measuring Actual Speed: The final step in this calibration process is confirmation of the actual speed of your equipment. The timed flow calibration process eliminates the guesswork and enables you to accurately set up a sprayer to deliver the gpa that you require for an effective application.

Step six: To calibrate accurately, you must know your *actual* speed because tractor speedometers or tachometers may not be precise.

For accurate calibration, operate the equipment at the target site or on similar ground with the tank half full of water. Whether the equipment is hand-carried or mounted on a vehicle, the condition of the ground (surface) is important. A rough and uneven surface generally causes the equipment to be operated at a slower speed.

The equipment manufacturer's directions may offer a range of appropriate speeds. Your knowledge of conditions at the target site (including the drift hazard), plus your experience with the equipment, will help you determine an appropriate speed.

To measure actual speed (step six), mark off measured distances of 100, 200 or 300 feet in the field where the application is to be done. Then run the equipment over this distance at the operating speed, carefully marking the throttle setting or speedometer reading. Record the time required to cover the marked course. Be sure the equipment is moving at full operating speed before you reach the starting point. Make at least two runs; use the average time to do your calculations.

$$Speed\ (mph) = \frac{Distance\ (feet) \times 60}{time\ (seconds) \times 88}$$

The above equation will calculate your mph, but you also may find Table 5 useful. Table 5 converts the time measured to speed in miles per hour.

In summary, steps one through six are called the *timed flow calibration* method. If you know your speed and throttle setting, steps one through five permits you to set up and calibrate the sprayer without going into the field. This calibration method assures that the nozzles will provide the uniform output that is needed. Let's go through one more example of the timed flow calibration method.

Example two – Timed Flow Calibration Method.

Step one: We select a flat fan nozzle for our application.

Step two: We determine the following parameters –

- Gpa = 10 gallons, based on the pesticide label directions.
- Mph = 10 mph, based on our equipment and field conditions.
- Nozzle spacing = 20".

Step three: Solve the following equation to determine the gpm. We calculate gpm so we can select the appropriate size nozzle tip.

$$gpm = \frac{gpa\ (10) \times mph\ (10) \times w\ (20)}{5940} = 0.34 \text{ gallons per minute}$$

Step four: Knowing our desired gpm (0.34), refer to the manufacturer's nozzle chart to select a tip that will deliver this rate. See Table 3. Flat Fan Nozzle Tips. The chart tells us that nozzle 504 delivers 0.34 gpm at 50 psi and requires a 50 mesh screen. Travelling at 10 mph will achieve an application rate of 10 gpa.

Step five: Put the flat fan 504 nozzles with 50 mesh screens on your sprayer and confirm that they release the 0.34 gpm flow rate desired by doing a catch test. Remember that ± 5 percent of our desired flow rate is acceptable. If our catch containers are labeled with ounces, let's convert our gpm to ounces per minute so its more convenient to determine if our discharge is what we need.

0.34 gal / min. x 128 oz / gal. = 43.5 oz. / min.

Now determine what ± 5 percent of our desired flow rate is by calculating the following:

43.5 oz. / min. x .05 = 2 oz. / min.

43.5 oz. / min. + 2 oz / min. = 45.5 oz. / min.

43.5 oz. / min. – 2 oz. / min. = 41.5 oz. / min.

If the nozzles we have selected do not meet the ± 5 percent of our desired flow rate (41.5 – 45.5 oz. / min.) replace them.

Step six: We must confirm the actual speed that our equipment is travelling. Mark off measured distances of 100, 200 or 300 feet in the field where the application is to be done. Then run the equipment over this distance at the operating speed, marking the throttle setting or speedometer reading and recording run times. Be sure the equipment is moving at full operating speed before

Table 5. Time-Distance-Speed

Ground speed in miles per hour	Time required in **seconds** to travel a distance of: 100 feet	200 feet	300 feet		Ground speed in miles per hour	Feet traveled per minute
0.5	136	272	408		0.5	44
1.0	68	136	204		1.0	88
1.5	45	91	136		1.5	132
2.0	34	68	192		2.0	176
2.5	27	54	82		2.5	220
3.0	23	45	68		3.0	264
3.5	20	39	58		3.5	308
4.0	17	34	51		4 0	352
4.5	15	30	45			
5.0	14	27	41	OR		
6.0	11	23	34			
7.0	9.7	19	29			
8.0	8.5	17	26			
9.0	7.6	15	23			
10.0	6.8	14	20			
12.0	5.7	11	17			
15.0	4.5	9	13.6			
20.0	3.4	6.8	10.2			

you reach the starting point. Make at least two runs; use the average time to do your calculations.

$$\text{Speed (mph)} = \frac{\text{Distance (feet) x 60}}{\text{time (seconds) X 88}}$$

Ounces = Gallons Calibration Method

This method of calibration is very easy to use and can be used to check and fine-tune a sprayer quickly but does require driving a distance in the field. Before calibrating the sprayer with any method, you must check nozzle output for uniformity. Correct any nozzles that vary in flow rate by more than ± 5 percent, as described above. Also check that pressure gauges are reliable and the pressure is properly set. Pressure at the nozzle may be different than the pressure at the tractor cab. Be sure you are operating the sprayer so that the nozzle has the manufacturer's recommended pressure. Then proceed as follows:

Step one: For broadcast applications, determine the distance, in inches, between nozzles. For banded applications, determine the band width in inches.

Step two: Locate this width in Table 6. Calibration Distances and read off the corresponding course distance.

Step three: In the field to be sprayed, mark off a course of the proper distance. You may set permanent markers in the field or paint fence posts to make this step easier next time.

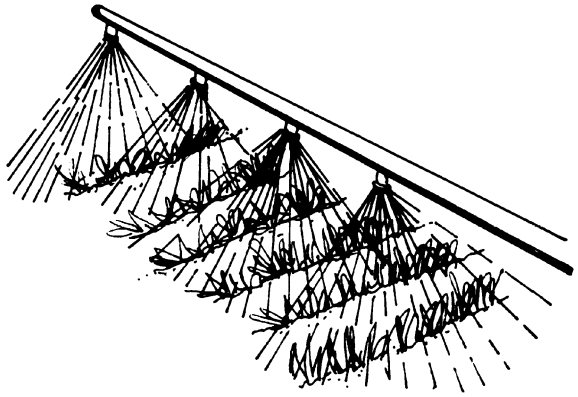
Step four: Fasten a 1-quart container to one nozzle on the sprayer so that it will catch all of the discharge from that nozzle. This assumes that all the nozzles are uniform in their discharge, as described above.

Step five: Start a distance back from the beginning of the course to get up to operating speed, then turn the sprayer ON at the beginning of the course and OFF at the end of the course.

Step six: Measure the volume collected in the container in ounces. Do this several times to be sure the results are reliable. You may average the output from several nozzles to get a more reliable reading.

Step seven: *OUNCES COLLECTED = GALLONS PER ACRE.* The total discharge measured in ounces is equal to gallons per acre (gpa) applied. With either broadcast boom or band sprayer, the gpa is equal to the output from one nozzle. When more than one nozzle is used per row, the combined amount collected from all nozzles directed at the row is equal to the gpa.

If it is not practical to fasten a container to the nozzle (step four) and drive a test course follow steps one through three as above, then follow these alternative steps four through six:



Step four: Select the gear and throttle setting, bring the sprayer up to speed, and measure the time needed to cover the test course. Time the course at least twice, once up and once back.

Step five: If it required 20 seconds to travel the test course, set the throttle at the pressure you will be using while spraying and catch one nozzle's output for 20 seconds (collect nozzle output for time equal to what it was required to cover the test course).

Step six: Measure the amount collected in ounces. The output in ounces is the amount applied in gallons per acre, i.e., if the nozzle output is 15 ounces, the sprayer applied 15 gallons per acre. Repeat steps 5 and 6 for each nozzle.

Example: Ounces = Gallons per acre for broadcast or band application:

The pressure you have selected is 30 psi. The nozzles are spaced 30 inches apart on the boom.

1. The distance to mark off for 30-inch nozzle spacing is 136 feet (from chart).
2. Fasten a 1-quart container to one nozzle on the sprayer so that it will catch all of the discharge from one nozzle.

Table 6. Calibration Distances

Row or Nozzle Spacing (inches)	Calibration Distance (feet)
40	102
38	107
36	113
34	120
32	127
30	136
28	146
26	157
24	170
22	185
20	204
18	227

3. Start a distance back from the beginning of the course to get up to operating speed, then turn the sprayer on at the beginning of the course and off at the end of the course.
4. Measure the amount collected in the container in ounces. The output in ounces is the amount applied in gallons per acre. If the nozzle output is 15 ounces, the sprayer applied 15 gallons per acre.
5. Repeat steps 3 and 4 for each nozzle.

Calibration Considerations

When a nozzle flow rate check (catch test) is done and the amount is not within the ± 5 percent, clean the nozzle, and clean or change the screen. If it still does not meet the discharge range, if it has a ball check valve, check this to be sure it is functioning properly and not restricting or allowing for excessive flow. Replace the nozzle if the problem cannot be corrected.

If you are confident in your calibration, but you end up with too much or too little material applied in the field, consider the accuracy of your acreage. Some operators use aerial photos generated by the Consolidated Farm Services Agency (CFSA, formerly ASCS). These maps only account for elevation changes every 400' and measurements may be higher or lower than the actual acreage that you are treating. If using land surveys, ask whether it was accurate and whether the site has changed, such as new road installations. Was the actual farming acreage measured? Or, did the total acreage include borders, ditches and hedgerows, which would make the actual treatment area less than the reported acreage. These are a few things to consider when the volume of your application is different than what you anticipated after careful calibration. Keep pesticide spray volume records per field to help you mix the correct amount the next time.

CALIBRATING GRANULE APPLICATORS

In all types of granular equipment, the amount of granules applied per unit of area depends on the size of the adjustable opening, the speed at which the equipment travels (or the speed of the hopper agitator), the roughness of the surface of the application site (except for aerial application), and the granular formulation chosen.

Different formulations have different flow rates depending on the size, weight, shape and texture of the granules. Environmental factors such as temperature and humidity also alter granular flow rates. (The flow rate slows as temperature and humidity rise.) Because so many variables can affect the delivery rate, calibrate your equipment for each formulation of product and for different field conditions.

Granular equipment that is wheel-driven delivers granules at a rate geared to the revolutions of the ground wheels. The faster the equipment is moved, the faster the release of granules. As a result, minor changes in equipment speed do not affect the amount of granules deposited per unit area. The only way to change the application rate in this type of equipment is by changing the feed gate settings. Confirm the appropriate tire size with the equipment manual.

Granular equipment with powered dispersal or gravity-flow dispersal distributes the granules at a rate independent of the ground speed of the equipment. The application rate per acre (or other unit area) depends on *both* the metered opening and the equipment speed. Adjustments in flow rates can be made by altering the rate of speed – faster speed means fewer granules delivered per area – or by altering the equipment settings.

Consult the equipment manual for manufacturer's recommended settings to deliver approximate rates of the granules being applied. If the equipment is motorized, select the speed by using manufacturer's suggestions and taking into consideration the condition of the application site. Soft, muddy or uneven surfaces and small areas with many obstacles require slower speeds or may have some wheel slippage.

Calibrate your equipment using the method described below. If the application rate differs more than 5 percent from the desired rate, adjust the equipment and recalibrate.

Broadcast Granular Applicators

Run a precalibration check on the granular application equipment:

- First, fill the hopper to a predetermined height or weight. Settle the material by driving a short distance or by shaking or striking the hopper; then refill the hopper.
- Set the flow rate as recommended by the equipment manual.
- Turn on the applicator and operate on a hard surface to check for uniform distribution along the swath width. If you cover the surface with a tarp before making the test run, you can collect the granules for reuse.

Next, operate the equipment over a measured area to determine whether the equipment is metering granules at the rate per acre you need. Use the "calibration collection method" described in the next column.

Calibration Collection Method

Multiple-outlet broadcast spreaders, band applicators, and soil injection equipment often can be calibrated by collecting the granules in calibration containers graduated in ounces. If the application rate is given in ounces (or pounds) per 1,000 linear feet of row and your equipment is a *ground-driven applicator:*

- Mark off 1,000 feet in the field you wish to treat.
- If the equipment is motorized, bring it up to the speed you have selected before beginning the test run.
- Collect the granules discharged from one tube or opening during the 1,000-foot test run. Ideally, using more catch containers you can collect material from all the tubes at one time. This will save time and allow you to compare the output volumes.

If the application rate is given in pounds per 1,000 linear feet of row and your equipment is **not** a *ground-driven applicator:*

- Make the 1,000 foot test run at the speed you have selected, but do not operate the applicator. Note the time (in seconds) it takes to complete the test run. Then with the equipment standing still, collect the granules discharged for that measured time.
- The amount of granules collected (in ounces or pounds) is the rate per 1,000 linear feet. (If you wish to use only a 100-foot test run, the amount of granules collected multiplied by 10 is the rate per 1,000 linear feet.)

Band Granular Applicators

Use the method described above to calibrate band applicators. However, if the labeling directions give the rate in pounds per acre broadcast, you must use the following formula to determine the rate per acre in bands (just as in band spray applications). Band width and row spacing must be in the same units, i.e., inches:

$$\frac{\textbf{Band width x Pounds per acre (broadcast)}}{\textbf{Row spacing}} = \textbf{Pounds per acre (band) applied}$$

Example:

- Labeling rate = 12 pounds per acre (broadcast).
- Band width = 6 inches.
- Row spacing = 30 inches.

$$\frac{\text{Band width (6 in) x 12 pounds per acre (broadcast)}}{\text{Row spacing (30”)}} = \text{2.4 pounds per acre (band) applied}$$

If the labeling directions list **pounds to apply per 1,000 linear feet**, you must use this formula to determine your rate:

$$\frac{\textbf{Total pounds used in test run}}{\textbf{Number of rows in swath}} = \textbf{Pounds used per row in test run}$$

$$\frac{\text{Pounds used per row (in test run) x 1,000 ft.}}{\text{Distance traveled in test run}} = \text{Pounds per 1,000 linear feet}$$

Example:

- Number of bands or rows covered in test run = 8.
- Distance traveled in test = 3,000 feet.
- Pounds used in test = 2.3.

$$\frac{\text{Pounds used in test (2.3)}}{\text{Number of rows (8)}} = \text{Pounds used per row in test run (.288)}$$

$$\frac{\text{Pounds used per row (.288) x 1,000 ft.}}{\text{Distance traveled in test run (3,000 ft.)}} = \text{Pounds per 1,000 linear ft. (.096 or 1.5 oz.)}$$

CHAPTER 5 PART B

Review Questions

Calibration

Write the answers to the following questions and then check your answers with those in the back of this manual.

NOTE: For the Michigan Department of Agriculture certification exam, you will be provided with all the formulas necessary to solve calibration problems.

1. What is calibration?

2. Explain how to determine whether all the nozzles (or hoppers) on a piece of application equipment are releasing approximately the same amount of pesticide.

3. What factors should be considered when calibrating a sprayer?
   a. Equipment speed.
   b. Nozzle pressure.
   c. Spray volume to be delivered.
   d. Type of carrier.
   e. All of the above.

4. What type of nozzle would you select if you were making a directed systemic insecticide application?
   a. Extended range flat fan.
   b. Even flat fan.
   c. Hollow cone.
   d. Drift guard flat fan.

5. Calculate the gallons per minute (gpm) if you were making a broadcast application with a boom sprayer in the following situation:
   - Nozzle = Flat Fan
   - Nozzle spacing = 20 inches
   - Nozzle pressure = 50 psi
   - Speed = 5 mph
   - Spray volume = 20 gpa.

$$gpm = \frac{gpa \times mph \times w}{5940}$$

6. Using Table 3 in this unit, select the nozzle tips you would use if you were making a broadcast application with a boom sprayer in the following situation:
   - Nozzle spacing = 20 inches
   - Nozzle pressure = 20 psi
   - Speed = 7.5 mph
   - Spray volume = 14 gpa.

   a. Nozzle tip 503, with a 50 mesh strainer
   b. Nozzle tip 504, with a 50 mesh strainer
   c. Nozzle tip 501, with a 100 mesh strainer
   d. Nozzle tip 506, with a 50 mesh strainer

7. What is the gpm for the equipment and nozzle set-up in question 6?
   a. .28
   b. .32
   c. .35
   d. .40

8. List at least three factors that should be considered when calibrating a granule applicator?

9. You are calibrating a granule applicator to apply granules in six 12-inch bands spaced 30 inches apart. The pesticide labeling lists only a broadcast rate – 13 pounds per acre.

   Calculate the correct band application rate per acre.

$$\frac{\text{Band width x pounds per acre (broadcast)}}{\text{Row spacing}} = \text{pounds per acre (band) applied}$$

10. You are calibrating the same granule applicator as in number 9; to apply granules in six 12-inch bands spaced 30 inches apart. In this case your pesticide labeling lists the application rate in **pounds per 1,000 feet**.

    Determine your rate per 1,000 linear feet if after a 3,000-foot test run at the chosen speed, it took 2.1 pounds of formulation to refill the hopper.

$$\frac{\text{Pounds used in test run}}{\text{Number of rows in swath}} = \text{Pounds used per row in test run}$$

$$\frac{\text{Pounds used per row (in test run) x 1,000 ft.}}{\text{Distance traveled in test run}} = \text{Pounds per 1,000 linear feet}$$

GLOSSARY

Abiotic - Not relating to living organisms.

Abrasive - Capable of wearing away or grinding down another object.

Absorption - The uptake of a chemical into plants, animals or minerals. Compare with adsorption.

Acaracide - A pesticide used to control mites and ticks.

Acceptable daily intake - A reference dose for the health-based standard for chemicals in food. For non-carcinogenic pesticides, it is generally 1/100 of the NOEL; for carcinogenic risk, it is 1/1,000,000 of the NOEL.

Acidic - Having a pH less than 7. Any of various typically water-soluble and sour compounds that are capable of reacting with a base to form a salt, that are hydrogen containing molecules or ions able to give up a proton to a base or are substances able to accept an unshared pair of electrons.

Acre-foot - A volume of water equivalent to 1 acre of water 1 foot deep.

Active ingredient - The chemical(s) in a pesticide product that control the target pest.

Acute effect - Illness or injury that may appear immediately after exposure to a pesticide (usually within 24 hours).

Acute exposure - Exposure to a single dose of pesticide.

Acute toxicity - A measure of the capacity of a pesticide to cause injury as a result of a single or brief exposure.

Additive - A chemical added to a pesticide formulation to increase its effectiveness or safety; same as adjuvant.

Adherence - Sticking to a surface.

Adjuvant - A chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety.

Adsorption - The process by which a pesticide bonds with a surface; e.g., a soil surface.

Adulterated - (1) A pesticide whose strength or purity falls below that specified on the label. (2) A food, feed or product that contains illegal pesticide residues.

Aerobe - An organism that requires oxygen for growth.

Aerosol - A suspension of very small particles of a liquid or a solid in a gas.

Agitate - To stir or mix.

Agitation - The process of stirring or mixing.

Agitator - Device that stirs or mixes a pesticide in a tank or hopper.

Algae - Photosynthetic plants that contain chlorophyll, have simple reproductive structures, and have tissues that are not differentiated into true roots, stems or leaves.

Algaecide - A chemical compound that kills algae.

Alkaline - Having a pH greater than 7: the opposite of acidic.

Allelopathy - The production of growth inhibitors by one plant that retard the development of another plant.

Allergic effects - Harmful effects, such as skin rash or asthma, that some people develop in reaction to pesticides that do not cause the same reaction in most other people.

Allergic effects statement - a statement appearing on a pesticide label that states if tests or other data indicate that a pesticide product has the potential to cause allergic effects, such as skin irritation or asthma. Sometimes the labeling refers to allergic effects as "sensitization."

Anaerobe - An organism which does not require oxygen for its growth.

Annual - A plant that completes its life cycle in one year.

Antagonism - An interaction of two or more chemicals such that the effect, when combined, is less than the predicted effect based on the activity of each chemical applied separately.

Anti-siphoning device - An attachment designed to prevent backward flow into the water source.

Antibiotic - Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Antidote - (1) A chemical applied to prevent the phytotoxic effect of a specific pesticide on desirable plants. (2) A substance used as a medical treatment to counteract poisoning.

Aquatic plants - Plants that grow on, in or under water.

Aqueous - Indicating the presence of water in a solution or environment.

At emergence - Treatment applied during the visible, emerging phase of the specified crop or weed.

Attractants - Substances that lure insects to traps or to poison-bait stations; bait.

Avicide - A chemical used to control birds.

Back-siphoning - The movement of liquid pesticide mixture back through the filling hose and into the water source.

Bacteria - Extremely small, single-celled microorganisms that usually lack chlorophyll and reproduce by fission (splitting of the cell into two equal halves).

Bactericide - A pesticide used to control bacteria.

Band application - Placement of a pesticide in a narrow area either over or along the crop row.

Band spraying - Application of a pesticide to a strip over or along a crop row.

Beneficial insects - Insects that are useful to people — e.g. predators and parasites of pest species, bees and other pollinators.

Benthic - Of aquatic habitats; those organisms that live on or in the sediments; bottom-dwelling.

Biennials - Plants that require two growing seasons to complete their life cycle.

Bioaccumulation - The buildup of pesticides or other chemicals in the bodies of animals (including humans), particularly in fat tissue.

Biocide - A chemical able to kill microbial organisms.

Biological control - Control by predators and parasites, either naturally occurring or introduced.

Biological degradation - The breakdown of a pesticide due to the activities of living organisms, especially bacteria and fungi.

Biology - The science that deals with the structure, function, development, evolution, and ecology of living organisms.

Biomass - Volume of living plant material.

Biotic - Relating to living organisms.

Biotype - A population within a species that has distinct genetic variation.

Botanical pesticide - Organic pesticides derived or extracted directly from plants. Examples are nicotine, pyrethrin, strychnine and rotenone.

Brand name - The specific, registered name given by a manufacturer to a pesticide product; same as trade name or proprietary name.

Broad-spectrum pesticide - A pesticide that is effective against a wide range of pests or species.

Broadcast application - The uniform application of a pesticide to an entire field or area.

Calibrate - To measure and adjust the amount of pesticide the application equipment will release per unit of area.

Calibration - The process of measuring and adjusting the amount of pesticide that application equipment will apply to the target area.

Carbamate - A synthetic organic pesticide containing carbon, hydrogen, nitrogen and sulfur that are used as insecticide, fungicide and nematicides. They have similar effects on nerve function as organo- phosphates.

Carcinogen - A substance which has the ability to cause cancer.

Carcinogenic - Capable of causing cancer in animals or humans.

Carrier - A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its application. Also known as the material used to carry the pesticide to the target, e.g., water.

Caution - Signal word associated with pesticide products classified as either slightly toxic or relatively nontoxic.

Cell - The basic structural unit of all living organisms: An organism may be composed of a single cell (e.g. bacteria) or many cells working together (all "higher" organisms, including man).

Certified applicator - A person qualified to apply or supervise applications of restricted use pesticides.

Certified commercial applicator - Any person (other than private applicators) who is certified or registered to use or supervise the use of a restricted use pesticide and who is in the business of applying pesticides for others.

Chelate - A combination of a metal ion and an organic molecule. Combining the two makes the metal ion less reactive with other chemicals in water or in a soil solution.

Chemical name - Name applied to a pesticide active ingredient that describes its chemical structure according to rules prescribed by the American Chemical Society and published in the Chemical Abstracts Indexes.

Chemical degradation - The breakdown of a pesticide by oxidation, reduction, hydrolysis or other chemical means.

Chemical-resistant - Ability to prevent movement of pesticide through the material during the period of use.

Chemigation - The application of an agricultural chemical by injecting it into irrigation water.

Chlorophyll - The green photosynthetic substance in plants that allows them to capture solar energy and convert it to chemical energy.

Chlorosis - Loss of green color (chlorophyll) from foliage.

Cholinesterase - An enzyme that helps to control the transmission of nerve impulses in animals and humans.

Chronic effect - Illness or injury that appears a long time, up to several years, after exposure to a pesticide.

Chronic exposure - Exposure to repeated doses of a pesticide over a period of time.

Chronic toxicity - A measure of the capacity of a pesticide to cause injury as a result of repeated exposures over a period of time.

Closed mixing systems - Systems in which liquid pesticide concentrates are transferred from their original containers to mix or spray tanks through a closed series of hoses, pipes, etc. Such systems are designed to prevent or minimize human exposure to the concentrates.

Collection pad or tray - A safety system designed to contain and recover spills, leaks, rinsates and other pesticide-containing materials.

Commercial applicator - Any persons other than private applicators, certified to apply pesticides.

Common name - (1) When referring to a pesticide, an abbreviated name applied to a herbicide active ingredient; usually agreed upon by the American National Standards Institute and the International Organization for Standardization. (2) When referring to an organism, a name derived from local common usage that is agreed upon by some accepted authority but may not be unique.

Compatibility - Mixable in the formulation or in the spray tank for application in the same carrier without undesirable alterations in the characteristics or effects of the individual components.

Compatibility agents - Chemicals that enhance the effective mixing of two or more pesticide products.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full-strength, but usually diluted before application.

Concentration - The amount of active ingredient or equivalent in a quantity of diluent expressed as percent, pounds per gallon (lb/gal), kilograms per liter (kg/l), etc.

Contact herbicide - A herbicide that causes localized injury to plant tissue where contact occurs.

Contact pesticide - A pesticide that kills pests simply by contacting them.

Corrosion - Process of being worn away gradually by chemical action.

Cross contamination - When one pesticide gets into or mixes with another pesticide accidently; usually occurs in a pesticide container or in a poorly cleaned sprayer.

Cultural control - Control by changing management practices to reduce pest numbers without using pesticides.

Cuticle - Thin, fatty or waxy outer surface on the leaves of some plants.

CZMA - Coastal Zone Management Act.

Danger - Signal word associated with pesticide products that may cause skin irritation, or eye injury more severe than suggested by the acute toxicity (LD50) of the product.

Days to harvest - The minimum number of days allowed by law between the final application of a particular pesticide and the harvest date.

Decontamination - To rid of a polluting or harmful substance.

Deflocculating agent - A material added to a suspension to prevent settling.

Degradation - The breakdown of a pesticide into a simpler compound that is usually, but not always, non-toxic; may be either chemical, physical or biological or any combination of the three.

Delayed effects - Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides.

Dermal toxicity - Ability of a chemical to cause injury when absorbed through the skin.

Dermal - Of the skin; through or by the skin.

Diluent - Anything used to dilute a pesticide; often referred to as the carrier.

Dilute - To make less concentrated.

Dilute pesticide - A pesticide that is not concentrated; one that does not have a high percentage of active ingredient.

Directed application - Precise application to a specific area or plant organ, such as to a row or bed or to the lower leaves and stems of plants.

Direct supervision - When a certified applicator is supervising the application of a pesticide and is physically present at the time and the place the pesticide is being applied.

Directed spraying - Aiming a pesticide at a specific portion of a plant or target site.

Dispersible granule - A dry, granular formulation that will separate or disperse to form a suspension when added to water.

Dispersing agent - A material that reduces the attraction between particles.

Distributor products - Products that are produced and registered by a manufacturer or formulator and sold under a different name by a distributor.

Dormant - State in which growth stops temporarily. May refer to plants, plant parts, microorganisms and certain animals.

Dose - (1) Amount, quantity or portion of a pesticide which is applied to a target. (2) A measure of exposure used in animal testing to determine acute and chronic toxicities; usually expressed in milligrams per kilogram body weight.

DOT - U.S. Department of Transportation.

Drift - Pesticide movement in air, away from the target site.

Dust - A finely-ground, dry pesticide formulation in which the active ingredient is combined with an inert carrier such as talc, clay, powdered nut hulls or volcanic ash; dusts are applied in the dry form.

Early postemergence - Applied after emergence during the cotyledonous growth phase of crop or weed seedlings.

Ecology - The science that studies the interrelationships of living organisms and their environment.

Economic damage - The amount of injury that will justify the cost of applied control measures.

Economic injury level - The population density at which a pest causes a reduction in the value of the crop that is greater than the cost of control.

Economic threshold or action threshold - The population density at which management measures should be instituted to prevent an increasing pest population from reaching the economic injury level.

Ecosystem - A system formed by the interaction of a community of organisms with their environment.

Emergence - The event in seedling or perennial growth when a shoot becomes visible by pushing through the soil or water surface.

Emersed plant - A rooted or anchored aquatic plant adapted to grow with most of its leaf and stem tissue above the water surface and not lowering or rising with the water level.

Emulsifiable concentrate (EC or E) - A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion (droplets of one liquid dispersed in another liquid).

Emulsifier - Chemical that allows petroleum-based pesticides (EC's) to mix with water.

Emulsion - A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other.

Encapsulated pesticide - A pesticide formulation in which the active ingredient is encased in extremely small capsules made of inert synthetic polymers. The pesticide is released gradually over a period of time.

Endangered species - Organisms whose survival as a species has been designated by a Federal agency to be endangered or threatened; a group of organisms on the brink of extinction.

Endangered species - A plant or animal that is in danger of becoming extinct.

Entomology - The science that deals with the study of insects.

Environment - All of our physical, chemical, and biological surroundings such as climate, soil, water and air and all species of plants, animals and microorganisms.

Enzymes - Proteins that increase the rate of specific chemical reactions.

EPA - U.S. Environmental Protection Agency.

EPA establishment number - A number assigned to each pesticide production plant by EPA which must appear on all labels.

EPA Registration number - A number assigned to a pesticide product by EPA when the product is registered by the manufacturer which must appear on all labels for that product.

Epidemic - A temporary widespread outbreak of a disease.

Eradication - Destroying an entire pest population in an area.

Erosion - Movement of soil and associated materials, principally by water and wind.

Exotic - Native to other regions, countries or continents.

Exposure - Coming into contact with a pesticide; getting a pesticide on a surface or in or on an organism.

Eyewash dispenser - Commercially available system for flushing contaminants out of the eyes.

FAA - Federal Aviation Administration.

FDA - Food and Drug Administration.

FEPCA - The Federal Environmental Pesticide Control Act of 1972. This law, including its many amendments replaces and adds to FIFRA. FIFRA remains as the commonly used acronym.

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

Flowable (F or L) - A pesticide formulation in which the active ingredient is impregnated on a diluent such as clay that is then finely ground and suspended in a small amount of liquid; the resulting paste or cream-like formulation is added to water in the spray tank and forms a suspension.

Foaming agent - A material designed to reduce drift, which causes a pesticide mixture to form a thick foam.

Foliage - Primarily the leaves; may include stems of a plant.

Foliar - Applied to the leaves of a plant.

Foliar application - Application of a pesticide to the aerial portions of either a crop or weed.

Food chain - A group of plants, animals and/or microorganisms linked together as sources and consumers of food.

Formulation - Pesticide product as sold, usually a mixture of active and inert ingredients.

Fragmentation - Plant pieces that break off the parent plant and can develop new roots and become re-established.

Fry - Recently hatched fish.

Fumigant - Pesticide that is a vapor or gas or that forms a vapor or gas when applied and whose pesticidal action occurs in the gaseous state.

Fungi - A group of lower parasitic plants lacking chlorophyll.

Fungicide - A chemical used to control fungi.

General use pesticide - A pesticide that is not classified as a restricted use pesticide.

Germination - The process of initiating growth in seeds.

GPA - Gallons per acre.

GPM - Gallons per minute = $\frac{\text{GPA} \times \text{MPH} \times \text{W}}{5940}$

Granules (G) - A dry pesticide formulation made by applying a liquid formulation of the active ingredient to particles of clay or another porous material. Granules are applied in the dry form and have a particle size substantially larger than dusts.

GRAS - Generally Recognized As Safe. Commonly used for risk assessment and to describe tested inert ingredients.

Groundwater - Water beneath the earth's surface in soil or rock.

Growth regulator - A substance used for controlling or modifying plant growth processes without appreciable phytotoxic effect at the dosage applied.

Habitat - The places where a plant or animal lives, feeds and breeds.

Half life - The length of time required for the quantity of a chemical to be reduced by half under a specific set of conditions.

Hazard - The likelihood that an injury will occur as a result of a given level and duration of exposure.

Heat stress - Illness that occurs when the body is subjected to more heat than it can tolerate.

Herbaceous plant - A vascular plant that does not develop persistent woody tissue above ground.

Herbicide - A chemical used to control, suppress or kill plants or to severely interrupt their normal growth process.

Host - A plant or animal on or in which a pest lives or feeds.

Hydraulic - Operated by the pressure created by forcing liquid through a narrow opening.

Hydraulic agitation - Stirring or mixing provided by the high-pressure flow of surplus spray material from the pump.

Hydrolysis - Decomposition of a chemical compound by reaction with water.

Impermeable - Cannot be penetrated.

Incompatibility - When two or more pesticides cannot be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator or harm to the crop or the environment.

Inert ingredients - Inactive components of a pesticide formulation that are used to dilute the pesticide or to make it safer, more effective, easier to measure, mix and apply and more convenient to handle.

Ingredient name - The active ingredients and the amount of each ingredient (as a percentage of the total product) in a pesticide listed by the official chemical name and / or common name for each active ingredient.

Inhalation toxicity - A measure of the capacity of a pesticide to cause injury when absorbed through the lungs.

Inorganic - Of mineral origin; does not contain carbon.

Inorganic pesticides - Pesticides of mineral origin; they do not contain carbon.

Insecticide - A chemical used to control insects.

Insoluble - Does not dissolve in liquid.

Integrated pest management (IPM) - An ecological approach to pest management in which all available techniques are consolidated into a unified program so that pest populations can be managed to avoid economic damage and minimize adverse effects.

IPM - Integrated pest management.

Invert emulsion - An emulsion in which water is dispersed in oil -rather than oil in water; invert emulsions are normally quite thick and thus less susceptible to drift.

Invertebrates - A class of animals that lack spinal cords.

Juvenile hormones - Natural insect chemicals that keep the earlier stages of an insect from changing into normal adult form.

Label - The information printed on or attached to the pesticide container or wrapper.

Labeling - The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

Larvicide - A pesticide used to kill insect larvae.

Late postemergence - Applied after the specified crop or weeds are well established.

LC_{50} - The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor. It is generally expressed as micrograms per liter as a dust or mist but in the case of a gas vapor as parts per million (ppm).

LD_{50} - The dose (quantity) of chemical(s) calculated to be lethal to 50 percent of the organisms in a specific test situation. It is expressed in weight of the chemical (mg) per unit of body weight (kg) of the test organism. The toxicant may be fed (oral LD_{50}) or applied to the skin (dermal LD_{50}).

Leaching - The movement of pesticide in water or another liquid downward through soil or other medium.

Lethal - Causing or capable of causing death.

Liability - Legal responsibility.

Life cycles - The series of stages an organism passes through during its lifetime.

Local effects - Effects which occur at the site where the pesticide makes initial, direct contact with body (i.e. skin, eye, nose, mouth, trachea, esophagus, stomach, GI tract, etc.). Local effects may occur immediately or may take longer to appear. These may include such effects as: local (contact site) skin irritation (rash, irritation, ulceration) or local irritation of mucous membranes of eyes, nose, mouth, throat, etc.

Macrophyte - A large or macroscopic plant that is easily seen without the aid of a microscope.

Material Safety Data Sheets (MSDS) - These data sheets contain specific information on toxicity, first aid, personal protection equipment, storage and handling precautions, spill and leak cleanup and disposal practices, transportation, physical data, and reactivity data. MSDS are available from manufacturers.

Mechanical control - Pest control by physically altering the environment.

Mechanical agitation - Stirring or mixing done by rotating paddles or propellers in the sprayer tank.

Metabolite - A compound derived from metabolic transformation of a chemical by plants or other organisms.

Metamorphosis - The series of changes in shape, form or size through which insects and insect-like organisms pass in their growth from immature stages to adult stage.

MDA - Michigan Department of Agriculture.

MDNR - Michigan Department of Natural Resources.

Microbial pesticide - Bacteria, viruses and fungi used to cause disease in some pests.

Microbicide - A chemical able to kill microorganisms. Includes bactericides, algaecides, and fungicides.

Microorganism - An organism that is so small that it cannot be seen without the aid of a microscope.

Mild steel - Steel that contains a very low percentage of carbon; also called "soft steel."

MIOSHA - Michigan Occupational Safety and Health Administration.

Miscible liquids - Two or more liquids that can be mixed and will remain mixed under normal conditions.

Miticide - A chemical used to control mites.

Mitigate - To lessen, decrease or make less severe.

Mode of action - The way in which a pesticide exerts a toxic effect.

Mold - The vegetative phase in the growth of certain fungi displaying long filamentous extensions.

Molluscicide - A chemical used to control snails, slugs and other mollusks.

Mollusks - Group of animals with soft, unsegmented bodies that are usually, but not always, enclosed in shells.

Monitoring - The process of information gathering and collection through observation of a site or target organism.

Mph - Miles per hour. Speed (Mph) = $\frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$

MSHA - Mine Safety and Health Administration

Mutagenic - Capable of producing genetic change.

Mutation - A change, usually harmful, in inherited genetic material.

Mycoplasmas - The smallest known living organisms that can reproduce and exist apart form other living organisms. They obtain their food from plants.

Narrow-spectrum pesticide - A pesticide that is effective against only one or a few species; the term is usually applied to insecticides and fungicides.

Natural enemies - The predators and parasites that attack pest species.

Necrosis - Localized death of tissue usually characterized by browning and desiccation.

Necrotic - Showing varying degrees of dead areas or spots.

Nematicide - A chemical used to control nematodes.

Nematodes - Small, slender, colorless roundworms that live saprophytically in soil or water or as parasites of plants, animals or fungi; plant-parasitic nematodes are so small that they cannot be seen except through a microscope.

Neoprene - A synthetic rubber characterized by superior resistance to penetration by pesticides.

Neurotoxic - A pesticide which is harmful to nerve tissue.

NIOSH - National Institute for Occupational Safety and Health.

No observable effect level (NOEL) - The dose of substance which causes no observable effects.

NOAA - National Oceanic and Atmospheric Administration.

Nonpersistent pesticide - A pesticide that breaks down quickly after it is applied.

Nonselective herbicide - A herbicide that is generally toxic to all species of plants. This toxicity may be a function of dosage, method of application, timing of application or other such factor. Some selective herbicides may become nonselective if used at very high rates.

Nonselective pesticide - A pesticide that is toxic to most plants, insects or animals.

Nontarget - Any site or organism other than the site or pest toward which the control measures are being directed.

Nontarget organisms - All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Noxious weed - A weed specified by law as being especially undesirable, troublesome and difficult to control. Definition will vary according to legal interpretations.

Offsite - Outside the area where the pesticide is being released.

Oil solution - A liquid pesticide formulation in which the active ingredient is dissolved either in oil or some other organic solvent.

Oncogen - A substance having the ability to cause tumors; the tumor may or may not be cancerous.

Oncogenic - Capable of producing or inducing tumors in animals, either benign (non-cancerous) or malignant (cancerous).

Oncogenicity - The ability to cause tumors.

Oral toxicity - A measure of the capacity of a pesticide to cause injury when taken by mouth.

Oral - Of the mouth; through or by the mouth.

Organic - Containing carbon.

Organic matter - Materials and debris that originated as living plants or animals.

Organic pesticides - Pesticides that contain carbon. Most are synthetic; some are derived or extracted from plants.

Organophosphate - A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples used primarily as insecticides and act on nervous system.

OSHA - Occupational Safety and Health Administration in the United States Department of Labor.

Ovicide - A chemical that destroys eggs.

Parasite - An organism living on, in or with another living organism for the purpose of obtaining food.

Parts per million, weight (PPMW) - One part of a substance in one million parts of another substance, by weight; for example, approximately 2.72 lb of active ingredient applied to 1 acre-foot of water will give 1 PPMW.

Pathogen - An organism that causes disease in other organisms.

Pelleted formulation - A dry formulation of herbicide and other components in discrete particles, usually larger than 10 cubic millimeters, and designed to be applied without a liquid carrier.

Penetrant - Chemical that helps a pesticide get through a surface and into an object or organism.

Percolation - Downward seepage of water through the soil.

Perennials - Plants that live for more than two years.

Persistence - A measure of how long a pesticide remains in an active form at the site of application or in the environment.

Persistent pesticide - A pesticide that remains active for a period of time after application and gives continued protection against a pest.

Personal protective equipment (PPE) - Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Pest - An unwanted organism (plant, animal, bacteria, etc.); any organism that competes with people for food, feed or fiber, impacts aesthetic qualities, or impedes industrial or recreational activities.

Pesticide - A substance or mixtures of substances intended to prevent, destroy, repel or control undesirable organisms.

Pesticide concentrate - A pesticide formulation as it is sold before dilution.

Pesticide handler - Person who directly handles pesticides, such as during mixing, loading, transporting, storing, disposing and applying or working on pesticide equipment.

Pesticide handling - Directly working with pesticides, such as during mixing, loading, transporting, storing, disposing, and applying or working on pesticide equipment.

Pesticide interaction - The action or influence of one pesticide upon another and the combined effect of the pesticide on the pest(s) or crop system.

Pesticide registration - The status given to a product to allow for its sale and use as a pesticide by the Environmental Protection Agency or by the state to meet a special local need.

Petiole - Stalk of a leaf.

Petroleum-based - Made from petroleum products. Examples are: xylene, refined oil and kerosene.

pH - A measure of the acidity or alkalinity of a solution.

Pheromones - Chemicals emitted by an organism to influence the behavior of other organisms of the same species.

Phloem - The living tissue in plants that functions primarily to transport metabolic compounds from the site of synthesis or storage to the site of utilization.

Photic zone - Portion of a body of water in which enough light can penetrate to support aquatic plant growth.

Photodecomposition - Degradation of a pesticide by light.

Photosynthesis - The process in green plants of synthesizing carbohydrates from carbon dioxide and water, utilizing light energy captured by chlorophyll.

Physiology - The branch of biology that deals with the functions and activities of living organisms.

Phytotoxicity - Injury to plants due to chemical exposure.

Piscicide - A chemical used to kill or control fish.

Plant disease - Any harmful condition that makes a plant different from a normal plant in its appearance or function.

Plant growth regulator - A substance used for controlling or modifying plant growth processes.

Plant pathology - The science that deals with the nature and causes of plant disease.

Poison - A chemical that is very highly toxic acutely. Legally, a chemical with an oral LD50 of 50 mg/kg or less.

Porous surfaces - Surfaces that have tiny openings which allow liquid to be absorbed or to pass through.

Postemergence - Applied after emergence of the target weed or crop.

PPB - Parts per billion. One ppb equals 1 pound in 500,000 tons.

PPM - Parts per million. One ppm equals 1 pound in 500 tons.

PPT - Parts per trillion. One ppt equals 1 pound in 500,000,000 tons.

Pre-emergence - Applied to the soil prior to emergence of the target weed or crop. Control of weeds before or soon after they emerge.

Precautionary statements - Pesticide labeling statements that alert you to possible hazards from use of the pesticide product and that sometimes indicate specific actions to take to avoid the hazards.

Precipitate - A solid substance that no longer will remain dissolved in water because of some physical or chemical process.

Predator - An organism that attacks, kills and feeds on other organisms.

Prevention - Keeping a pest from becoming a problem.

Private applicators - Persons using or supervising the use of restricted use pesticides to produce an agricultural commodity on their own or their employer's land, or on lands rented by them.

Propagation - Reproduction by either sexual or asexual means.

Propriety name - Same as brand name.

Protectant - A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury.

Protectant pesticide - Pesticide applied to a target site to prevent pest establishment.

Protectant fungicide - Pesticide applied to prevent the development of some plant diseases caused by fungi.

psi - Pounds per square inch.

Rate - The amount of active ingredient or acid equivalent applied per unit area or other treatment unit.

RCRA - The Resource Conservation and Recovery Act – the federal law regulating the transport, storage, treatment and disposal of hazardous wastes.

Ready-to-use pesticide - A pesticide that is applied directly from its original container consistent with label directions, such as an aerosol insecticide or rodent bait box, which does not require mixing or loading prior to application.

Reciprocity - An agreement between states to allow certified applicators in one state to obtain certification credentials in the other state.

Registered pesticide - A pesticide approved by the Environmental Protection Agency for use as stated on the label or by the state to meet a special local need.

Registered technician - A classification of applicators in Michigan who are authorized to apply general use pesticides for a commercial or private purpose as a scheduled and required work assignment.

Registration - The regulatory process designated by FIFRA and conducted by the EPA through which a pesticide is legally approved for use.

Release - When a pesticide leaves its container or the equipment or system that is containing it and enters the environment. Release can be intentional, as in an application, or by accident, as in a spill or leak.

Reregistration - Requirement by recent legislation that older pesticides be reevaluated against current standards. A Special Review Process is used to evaluate specific questions or concerns about a pesticide and decide whether the registration should be adjusted in any way.

Residual pesticide - A pesticide that continues to be effective for an extended period of time after application.

Residue - The part of a pesticide that remains in the environment for a period of time following application or a spill.

Residue tolerance - The maximum amount of a pesticide that may legally remain in or on a raw farm product intended for consumption by people or livestock.

Resistance (pesticide) - The genetically acquired ability of an organism to tolerate the toxic effects of a pesticide.

Respiration - (1) The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms. (2) The act of breathing.

Restricted entry interval - The length of time that must elapse after a pesticide application before people who are not using personal protective equipment can enter the treated site.

Restricted-use pesticide (RUP)- Pesticides designated by the EPA or the State for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, could occur. A "restricted-use" pesticide may be used only by or under the direct supervision of a certified applicator.

Resurgence - A dramatic increase in the population level of a target pest some time after a pesticide application due to the destruction of its natural enemies by the pesticide; pest numbers may soon surpass pretreatment levels.

Risk - A combination of toxicity and exposure and is the possibility of loss or injury from exposure.

Risk/Benefit - A scientific approach in which the risk posed by a certain substance is weighed against the benefit of its use.

Rhizomes - Lateral roots.

Rinsate - Wash water that contains a small amount of pesticide.

Runoff - Pesticide movement across a surface away from the application site in water or another liquid.

Sanitizers - Chemical compounds that reduce microbial contamination.

Saprophyte - An organism that obtains its food from dead or decaying organic matter.

SARA - Superfund Amendments and Reauthorization Act — amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Scientific name - The Latin name for the genus and species of an organism, designated by taxonomists and universally accepted. Scientific names are often used to avoid confusion which can result from the use of common names which may vary from one area to another.

Scouting - Regular monitoring of a crop or site in a prescribed manner to determine the pest population levels and the extent of pest damage.

Selective pesticide - A pesticide that is more toxic to some kinds of plants and animals than to others.

Selectivity - the ability of a chemical to be more toxic to some species than to others; may be a function of dosage or mode of application.

Semipermeable - Some substances can pass through and others cannot.

Senesce - To decline or fade; to age.

Sensitive areas - Sites or organisms that are particularly vulnerable to harmful effects from pesticides.

Signal words and symbols - Standardized designations of relative levels of toxicity which must, by law, appear on pesticide labels. The signal words used are DANGER, or DANGER-POISON with skull and crossbones, or WARNING, or CAUTION.

Site - The crop, animal or area infested by a pest and to which a pesticide is applied.

Slurry - A thick suspension of a finely-divided pesticide in a liquid.

Soft and hard water - A water quality parameter where soft waters exhibit total hardness less than 50 mg calcium carbonate per liter (parts per million); hard waters have total hardness greater than 100 mg calcium carbonate per liter; moderately hard waters are those between 50 and 100 mg calcium carbonate per liter.

Solubility - The ability to dissolve; such as the capacity of a pesticide to dissolve in a specific solvent.

Soluble - Able to be dissolved in another substance, usually a liquid.

Soluble powder (SP) - Dry pesticide formulation that forms a true solution when mixed with water.

Solution - A homogeneous mixture of one or more substances (solutes) in another substance (solvent), which is usually a liquid. The solutes are completely dissolved and will not settle out or separate under normal conditions.

Solvent - A liquid, such as water, kerosene, xylene or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Special local need (SLN) - An existing or imminent pest problem within the state which cannot be adequately controlled by the use of any available federally registered pesticide product. The EPA can approve temporary use of a pesticide to alleviate the need.

Species - The basic unit of taxonomic classification, designating a group of closely related individuals that are capable of interbreeding.

Spot treatment - Application of pesticides applied to restricted area(s) of a whole unit; e.g., treatment of spots or patches of weeds within a larger field or water body.

Spray drift - Movement of airborne spray from the intended area of application.

Spreader - A chemical that increases the area that a given volume of liquid will cover on a solid or on another liquid.

State Management Plan - A written plan that establishes guidelines for activities that will protect groundwater from pesticide contamination. Required by the EPA so that states may register pesticides that pose a threat to groundwater quality.

Statement of practical treatment (first aid) - Instructions on how to respond to an emergency exposure involving a pesticide product.

Sterilant - A pesticide that renders a pest incapable of reproduction.

Sterility - The inability of a living organism to reproduce.

Sticker - An adjuvant that increases the ability of a pesticide to stick to treated plant surfaces.

Stomach poison - A pesticide that kills when it is eaten and swallowed by a pest.

Stomata - Minute openings on the surfaces of leaves and stems through which gases (oxygen, carbon dioxide, water vapor) and some dissolved materials pass into and out of plants.

Sublethal - Pertaining to a dose level that is less than an amount necessary to cause death.

Substrate - The surface on which an organism lives.

Supervise - The act or process of a certified applicator in directing the application of a pesticide by competent person under his or her instruction and control and for whose actions the certified applicator is responsible, even though the certified applicator is not physically present at the time and the place the pesticide applied.

Suppression - Reducing pest numbers or damage to an acceptable level.

Surface water - Water on top of the earth's surface, such as lakes, streams, rivers, irrigation ditches, or storm water drains.

Surfactant - A material that improves the emulsifying, dispersing, spreading, wetting or other surface modifying properties of liquids.

Susceptibility - The sensitivity to or degree to which an organism is injured by a pesticide treatment. (See tolerance.)

Susceptible - Capable of being diseased or poisoned; not immune.

Suspended registration - An emergency suspension of a pesticide registration stops all manufacture, distribution, sale and use of the pesticide until all court proceedings are concluded.

Suspension - A substance that consists of undissolved particles mixed throughout a liquid.

Swath width - Side-to-side measurement of the band or strip of pesticide released by the application equipment.

Symptom - (1) Any detectable change in an organism resulting from the activities of a pathogen or other pest. (2) An indication of pesticide poisoning.

Synergism - The combined activity of two or more pesticides that is greater than the sum of their activity when used alone.

Synthetic - Man-made; manufactured.

Systemic effects - Effects which occur at sites other than the point of entry into the body following absorption and distribution through the circulatory system, possible chemical reaction within the body or contact with critical targets sites, or organs.

Systemic pesticide - A pesticide that is taken into the blood of an animal or sap of a plant.

Tank mix - A mixture in the spray tank of two or more pesticide products for simultaneous application.

Tank-mix combination - Mixing two or more pesticides or agricultural chemicals in the spray tank at the time of application.

Target - The site or pest toward which control measures are being directed.

Target pest - The pest toward which management measures are being directed.

Taxonomy - The classification of living organisms into groups based on similarities and relationships.

Teratogen - Any substance which can cause the development of malformations such as in birth defects.

Terrestrial - Living or growing on land; not aquatic.

Thickeners - Drift control agents such as cellulose, gels, and swellable polymers which cause the formation of a greater proportion of large spray droplets.

Tip-and-pour - Built-in measuring device that fills with a given amount of pesticide when the container is tilted.

Tolerance - (1) Capacity to withstand pesticide treatment without marked deviation from normal growth or function. (See susceptibility.) (2) The concentration of pesticide residue that will be legally allowed in or on agricultural products.

Toxicity - Measure of a pesticide's ability to cause acute, delayed, or allergic effects.

Toxicology - The study of the principles or mechanism of toxicity.

Toxin - A poisonous substance produced by a living organism.

Trade name - A trademark applied to a pesticide formulation by its manufacturer.

Translocated herbicide - A pesticide that kills plants by being absorbed by leaves, stems or roots and moved throughout the plant. Translocated herbicides may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides that are applied to the foliage and move downward through the phloem to underground plant parts.

Translocation - The internal movement of food, water, minerals or other materials (e.g. pesticides) from one part of a plant to another.

Use site - The immediate environment where a pesticide is being mixed, loaded, applied, transported, stored, or disposed of, or where pesticide-contaminated equipment is being cleaned.

USDA - United States Department of Agriculture.

Vapor drift - The movement of chemical vapors from the area of application. Note: Vapor injury and injury from spray drift are often difficult to distinguish.

Vapor pressure - The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vascular plant - A plant (macrophyte) with specialized conductive tissue.

Vascular system - The conducting tissue of plants, composed principally of xylem and phloem.

Vector - Means through which a disease causing organism is transmitted from one place to another.

Vegetative reproduction - Production of new plants from vegetative plant parts such as rootstocks, rhizomes, stolons, tubers, cuttings, etc., rather than from seed.

Vertebrate - An animal with a jointed backbone.

Virus - An obligate parasite often consisting only of a piece of genetic material surrounded by a protein coat.

Volatile - Evaporating rapidly; turning easily into a gas or vapor.

Volatility - The degree to which a liquid or solid changes into a gas (vapor) at ordinary temperatures when exposed to air.

Warning - Signal word associated with pesticide products considered moderately toxic.

Water-based pesticides - Pesticides that use water as the only diluent or carrier.

Water-dispersible granules - A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water-soluble concentrate (WS) - A liquid pesticide formulation in which the active ingredient is soluble in water and is formulated either with water or another solvent such as alcohol which mixes readily with water.

Watershed - The area of land draining into a body of water.

Weed - A plant growing where it is not desired; any plant that is objectionable or interferes with the activities or welfare of humans.

Wettable powder (WP or W) - A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

Wetting agent - (1) Substance that serves to reduce interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces (See surfactant). (2) A substance in a wettable powder formulation that causes it to wet readily when added to water.

WPS - Worker Protection Standard for agricultural pesticides.

Xylem - The tissue in higher plants which transports water, dissolved salts, and other materials (e.g. pesticides) from the roots to aerial portions of the plant.

Answers to Review Questions

Part A
Chapter 1: Principles of Pest Management

1. c
2. Identifying the pest allows you to determine basic information about it, including its life cycle and the time that it is most susceptible to being controlled.
3. b
4. b
5. Use of threshold information can improve your pest control strategy by helping you make a decision about when to begin management strategies.
6. c
7. Monitoring is important to many pest control strate gies because it helps determine if the threshold has been reached and whether control measures have been effective.
8. Integrated pest management utilizes all appropriate economical strategies to manage pests and their damage to acceptable levels with the least disruption to the environment.
9. Pest management tactics may include: host resis tance, biological control, cultural control, mechanical control, sanitation and chemical (pesticide) control.
10. The failure of the pesticide to control the pest might have been caused by :
    1. Pest resistance.
    2. Choosing the wrong pesticide.
    3. Misidentifying the pest.
    4. Applying the wrong amount.
    5. Applying the pesticide incorrectly, including applying at the wrong time.
    6. Weather problems: too dry, wet, hot or cold.
11. Pest resistance can be reduced by using integrated pest management and rotating the types of pesticides used.

Part A
Chapter 2: Laws and Regulations

1. b
2. d
3. d
4. True
5. d
6. MDEQ SARA Title III office, (517) 373-8481. Also, partial lists are printed in Extension bulletin E-2575.
7. d
8. If the injury involves any of the following: medical treatment, loss of consciousness, restriction of work or motion, transfer to another job.
9. True
10. d
11. True
12. B
13. MDA
14. Private applicators, commercial applicators and registered technicians.
15. b
16. True
17. False
18. c and d
19. a
20. True
21. MDA investigates pesticide misuse and EPA investigates pesticide failures.
22. MDNR
23. True
24. MIOSHA
25. b
26. d
27. e
28. a
29. f
30. c

Part A
Chapter 3: Pesticides

1. e
2. 1) Type of pest managed: algaecides control algae; insecticides control insects; rodenticides control rodents, etc.

   2) Chemistry: inorganic or organic, botanical, microbial, organophosphate, carbamate, etc.

3) Mode of action: sterilant, stomach poison, root inhibitor, etc.

4) Formulation: emulsifiable concentrate, fumigant, ready-to-use aerosol, dust, etc.

3. Insects; weeds; slugs and snails.
4. False: sterilants render pests incapable of reproduction.
5. e
6. Contact pesticides kill pests simply by contacting them. Systemic pesticides are absorbed by the host and move in the sap or blood and can kill the pest without harming the host.
7. a
8. True
9. c
10. False
11. d
12. True
13. Think about the characteristics of each formulation and consider which of the formulation's advantages and disadvantages are important in your application situation. Also, consider if you have the right application equipment, if the formulation can be applied safely, and if the formulation can reach the target pest and remain active long enough for effective control.
14. c
15. Finely ground active ingredients mixed with a liquid, along with inert ingredients, to form a suspension.
16. The wettable powder would be the better choice in the first situation, because EC's are corrosive and may cause pitting, discoloration or other damage to treated surfaces. Wettable powders are difficult to mix in very hard or very alkaline water, so the EC formulation would be the better choice in the second situation.
17. To increase its effectiveness or safety.
18. Foaming agents and thickeners help to reduce drift. Spreaders help to coat the treated surface with an even layer of pesticide. Compatibility agents aid in combining pesticides effectively.

Part A
Chapter 4: Pesticide Labeling and Registration

1. The label is the information printed on or attached to the pesticide container. Labeling includes the label itself, plus all other information you receive from the manufacturer about the product when you buy it.
2. If a pesticide is classified as restricted use, the words "Restricted Use Pesticide" will appear on the front panel of the pesticide label.
3. D,A,B,C
4. Signal words and symbols indicate the likelihood that you will experience acute harmful effects if you are overexposed. Signal words do not tell you any thing about the risks of delayed harmful effects or allergic effects.
5. You should look for precautions about hazards to humans (and domestic animals), environmental hazards and physical/chemical hazards.
6. e, c, b, a, d
7. False
8. d
9. b
10. d
11. False. This statement is required on every pesticide label.
12. a
13. cholinesterase
14. c
15. e
16. e
17. False. This product label requires the entrances to treated areas to also be posted.
18. True

Part A
Chapter 5: Pesticides in the Environment

1. Environment is everything that surrounds us – indoors and outdoors – including natural elements, man-made objects, people and other living organisms.
2. e
3. Ways to avoid point-source pollution include, for example:

   a. Proper management of wash water and spills produced at equipment cleanup sites.

   b. Proper disposal of containers, water used to rinse containers and excess pesticides.

   c. Correctly cleaning up leaks and spills at pesticide storage sites.

   d. Preventing pesticide spills while mixing concentrates or loading pesticides into application equipment.

4. a. Whether there are sensitive areas in the environment at the pesticide use site that might be harmed by contact with the pesticide.

b. Whether there are sensitive off site areas near the use site that might be harmed by contact with the pesticide.

c. Whether there are conditions in the immediate environment that might cause the pesticide to move off site.

d. Whether you can change any factors in your application or in the pesticide use site to reduce the risk of environmental contamination.

5. e
6. a
7. c
8. a
9. a
10. c
11. a
12. b
13. c
14. a
15. d
16. b
17. Refer to pages 61-62.
18. a. Pesticides may be carried off site if they stick to such things as shoes or clothing, animal fur or blowing dust – anything that moves from the use site to another location.

    b. Pesticide residues may remain on treated sur faces, such as food or feed products, when they are taken from the use site to be sold or used.
19. Nontarget plants and animals may be harmed by the pesticide residues that stay in the environment for a period of time after the release. These can be residues that remain in soil or on surfaces, or they may be residues that build up in the bodies of animals, harming those animals themselves and sometimes other animals that feed on them.
20. a

Part A
Chapter 6: Pesticides and Human Health

1. Toxicity measures the capacity of a pesticides to cause injury. Hazard is the potential for injury.
2. True
3. False
4. Oral, dermal, eye and inhalation.
5. d
6. d
7. Chronic, acute.
8. c
9. False
10. b
11. b, c, e
12. e
13. e
14. Organophosphates: Chlorpyrifos, Diazinon, Malathion

    Carbamates: Aldicarb, Carbaryl, Propoxur. Other examples can be found on page 72.
15. e
16. pesticide label
17. 1-800-764-7661, 1-800-POISON 1
18. See page 70.
19. d
20. See page 70.
21. toxicity, exposure.
22. True
23. e
24. Drink lightly salted water or sports drinks.

Part A
Chapter 7: Personal Protective Equipment

1. Have I read the labeling?

    How can I avoid exposure to pesticides?

    What PPE is required?

    Is the application equipment ready and safe?
2. Long-sleeved shirt, long pants, protective footwear, and gloves.
3. Exposure.
4. Choose pesticides with lower toxicity, and wear the appropriate PPE.
5. False
6. Pesticide label, pesticide producers, PPE manufac-turers, MSDS and EPA Chemical Resistance Category Chart (can be found in Appendix B).
7. e
8. False
9. e
10. True

Part A
Chapter 8: Safe Pesticide Handling

1. e
2. e

3. Triple-rinse, power-rinse.
4. e
5. Apply them to a labeled site.
6. e
7. e
8. e
9. True
10. The containment pad must be made of an impermeable material, such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners or no-wax sheet flooring (other materials are acceptable, according to the MDA). The pad should be concave or should have curbs, berms or walls high enough to hold the largest amount of spill, leak or equipment wash water likely to be created at the site. It also must be equipped with a system for removing and recovering spilled, leaked or released material — either an automatic sump system or a manually operated pump.
11. Separate facility; containment for overall storage area; containment of individual containers; located a safe distance from water resources; fire resistant construction; materials; chemical fire extinguisher near door; well ventilated; temperature controlled; adequate lighting; metal shelving with containment; pesticides kept in original containers; legible pesticide labels on all containers; secured; posted as pesticides storage area; waste-handling system in place; spill clean-up kit readily available; decontamination kit/equipment; supply of clean water; first aid kit; emergency plan with emergency contact numbers.
12. e
13. Control; contain; clean-up
14. MDEQ PEAS hotline (800-292-4706) for all uncon-tained spills; National Response Center (800-424-8802) if reportable quantity; clean-up spill or contact private spill response company for assistance; Chemtrec hotline (800-424-9300) for additional assistance; MDEQ Waste Management Division (517-373-2730) for additional assistance; MDA (800-405-0101) Agriculture Pollution Emergency hotline for additional assistance.

Part B
Chapter 1: Laws and Regulations

1. a
2. False
3. e
4. True
5. c
6. a
7. WPS, Right-to-Farm and the federal recordkeeping requirements under the 1990 Farm Bill.
8. 14 days; 2 years
9. e
10. True

Part B
Chapter 2: Pests and Pest Management

1. You cannot make a good decision about how to manage a pest problem until you are sure what the pest is. Pests differ in their life cycles, habitats, behavior and susceptibility to various control methods.
2. d
3. 1. Is the pest causing any harm?
   2. Would the cost of control be more than the economic loss from the damage the pest is causing?
4. e
5. A persistent pesticide remains active for a period of time after application, giving continued protection against the pest.

   A non-persistent pesticide breaks down quickly after it is applied.
6. d
7. Four types of insect mouthparts are:
   1. Chewing (cockroaches, ants, beetles, caterpillars and grasshoppers).
   2. Piercing-sucking (stable flies, sucking lice, bed bugs, mosquitoes, true bugs and aphids).
   3. Sponging (flesh flies, blow flies and house flies).
   4. Siphoning (butterflies and moths).

   [The examples listed here are those cited in this chapter; you may know of others.]
8. b
9. The four stages of complete metamorphosis are egg, larva, pupa and adult.
10. e
11. a
12. A plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function.
13. f
14. c
15. 1. Overdevelopment of tissue.
    2. Underdevelopment of tissue.
    3. Death of tissue.

16. The parasites that cause plant diseases may be spread by wind; rain; insects, birds, snails, slugs and earthworms; transplant soil; nursery grafts; vegetative propagation (especially in strawberries, potatoes, and many flowers and ornamentals); contaminated equipment and tools; infected seed stock; pollen; dust storms; irrigation water; and people.
17. Symptoms — such as leaf spots, wilts, galls or stunted growth — are the host plant's reaction to the disease agent.

    Signs — such as fungal spores or bacterial ooze — are the visible presence of the disease agent on the plant.
18. 1 – B

    2 – C

    3 – A
19. Weeds have four developmental stages: seedling, vegetative, seed production and maturity.
20. 1 – D

    2 – C

    3 – A

    4 – B
21. Depending on the type, weeds may reproduce by seeds, tubers, bulbs, bulblets, rhizomes, stolons or from root pieces left by cultivation.
22. c
23. d
24. Selective herbicides kill some plants without harming others. They can be used to kill weeds without harming the desirable plants nearby.

    Nonselective herbicides kill all plants in the area where they are applied.
25. b
26. a
27. b
28. It may be necessary to get approval for:
    - Shooting or trapping some animals, such as birds, deer, muskrats and beavers.
    - Using pesticides to control vertebrate pests other than rodents (such as fish, birds and predators).

Part B
Chapter 3: Calculating Dilutions and Site Size

(In most cases, answers have been rounded to the nearest tenth.)

1. $\frac{\text{Gallons in tank (300) x lbs. per 100 gallons (3)}}{\text{100 gallons}}$ = Pounds needed in tank

   (300 x 3) ÷ 100 = 9 pounds needed in tank

2. $\frac{\text{Gallons in tank (50) x pounds per 100 gallons (3)}}{\text{100 gallons}}$ = Amt. needed in tank

   (50 x 3) ÷ 100 = 1.5 pounds needed in tank

   1.5 pounds x 16 ounces per pound = 24.0 ounces needed in tank

3. $\frac{\text{Gallons in tank (500)}}{\text{Gallons per acre (12)}}$ = Acres sprayed per tankful

   500 ÷ 12 = 41.7 acres sprayed per tankful

   Acres sprayed per tankful (41.7) x pounds formulation per acre (2.5) = Pounds needed in tank

   41.7 x 2.5 = 104.3 pounds needed in tank

4. Gallons per acre (18) x acres to be treated (5) = Gallons needed in tank

   18 x 5 = 90 gallons of water needed in the tank

   Acres to be treated (5) x pounds formulation per acre (2) = Pounds formulation needed in tank

   5 x 2 = 10 pounds formulation needed in tank

5. $\frac{\text{Amount in tank (5 gallons = 20 quarts) x rate per 1,000 square feet (3 oz.)}}{\text{Amount equipment applies per 1,000 square feet (1.5 quarts) in tank}}$ = Amount formulation needed

   20 quarts x 3 ounces ÷ 1.5 quarts = 40 oz

   40 oz. ÷ 16 oz. per pound = 2.5 pounds needed in tank

6. $\frac{\text{Pounds of a.i. per acre (3) x 100}}{\text{Percent a.i. in formulation (60\%)}}$ = Pounds formulation per acre

   (3 x 100) ÷ 60 = 5 pounds of formulation per acre

7. $\frac{\text{Gallons in tank (5) x percent a.i. needed (1.5) x weight of water per gal (8.3)}}{\text{Percent a.i. in formulation (80) tank}}$ = Pounds form. needed in tank

   (5 x 1.5 x 8.3) ÷ 80 = 0.78 lbs. of formulation needed in tank
   0.78 pounds x 16 ounces per pound = 12.5 ounces of formulation needed in tank

8. $\frac{\text{Gallons in tank (25) x pints per 100 gal. (1.5)}}{\text{100 gallons}}$ = Pints formulation needed in tank

   (25 x 1.5) ÷ 100 = 0.38 pints of formulation needed in tank
   0.38 pints x 16 ounces per pint = 6.1 ounces of formulation needed in tank

9. $\frac{\text{Amount in tank (3 gallons = 12 quarts) x rate per 1,000 square feet (6 Tbsp)}}{\text{Amount equipment applies per 1,000 square feet (1.5 quarts)}}$ = Amount needed in tank

   (12 x 6) ÷ 1.5 = 48 Tbsp

   48 Tbsp ÷ 64 Tbsp per quart = 0.75 quarts (1.5 pints) needed in the tank

10. $\frac{\text{Pounds a.i. to apply per acre (2)}}{\text{Pounds a.i. per gallon (6)}}$ = Amount per acre

    2 ÷ 6 = .33 gallon per acre or (⅓)

    $\frac{\text{Gallons in tank (300)}}{\text{Gallons per acre (30)}}$ = Acres per tankful

    300 ÷ 30 = 10 acres per tankful
    Acres per tankful (10) x gallons per acre (1 / 3 or 0.33) = Gallons to add to tank
    10 x 0.33 = 3.3 gallons to add to tank

11. $\frac{\text{Gallons in tank (200) x \% a.i. wanted (2\%) x weight of water (8.3)}}{\text{Pounds a.i. per gallon of formulation (4) x 100}}$ = Gallons of formulation to add to tank

    (200 x 2 x 8.3) ÷ 4 X 100 = 8.3 gals. of formulation to add to tank

12. $\frac{\text{Gal. per tank (500) x lbs. per 100 gallons recommended (3)}}{\text{100 gallons}}$ = Lbs. needed in tank for hydraulic sprayer

    (500 x 3) ÷ 100 = 15
    Lbs. form. per tank for hydraulic sprayer (15) x concentration wanted (3x) = Lbs. of form. to add to airblast tank
    15 pounds x 3 = 45 pounds of formulation to add to tank

13. **Rectangle**: Multiply the length (L) by the width (W).
    Area = L x W

    Circle: Radius (one-half the diameter) times the radius times 3.14.
    Area = radius x radius X 3.14

    Triangle: Multiply the width at the base (W) by the height (H), and divide by 2.

    Area = $\frac{\text{W x H}}{2}$

14. There are three ways:
    1. Reduce the site to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.
    2. Establish a line down the middle of the site for the length, and then measure from side to side at several points along this line. Use the average of the side measurements as the width. Then calculate the area as a rectangle.
    3. Convert the site into a circle. From a center point, measure distance to the edge of the area in 10 or more

increments. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

15. Multiply the height by the area of the circle at the base.

    Volume = height x radius x radius x 3.14

16. Figure the area of the half circle as above, and figure the area of the rectangle (W X H_2). Add these two areas together and multiply by the length of the structure to get the volume.

    $$\frac{[H_1 \times H_1 \times 3.14]}{2} + [H_2 \times W] \times L = \text{Volume}$$

    Example: H_1 = 8 feet
    H_2 = 8 feet
    W = 16 feet
    L = 40 feet

    $$\frac{[8 \text{ ft.} \times 8 \text{ ft.} \times 3.14] + [8 \text{ feet} \times 16 \text{ feet}] \times 40 \text{ ft.}}{2} = 9{,}139.2 \text{ cubic feet}$$

17. Triangle-over-rectangle ends: Figure the area of the rectangle (W x H_1) / 2, and figure the area of the triangle (W x H_2).

    Add these two areas together and multiply by the length of the structure to find the volume.

    $$\frac{[W \times H_1]}{2} + [W \times H_2] \times L = \text{Volume}$$

    Example: H_1 = 8 feet
    H_2 = 8 feet
    W = 20 feet
    L = 40 feet

    $$\frac{[20 \text{ ft.} \times 8 \text{ ft.}]}{2} + [20 \text{ ft.} \times 8 \text{ ft.}] \times 40 \text{ ft.} = 9{,}600 \text{ cubic feet}$$

Part B
Chapter 4: Application Equipment

1. 1 – C
   2 – D
   3 – A
   4 – B

2. 1 – B
   2 – G
   3 – D
   4 – C
   5 – F
   6 – A
   7 – E

3. 1 – E
   2 – C
   3 – A
   4 – B
   5 – D

4. Strainers remove dirt and other foreign materials from the tank mixture, protect the working parts of the sprayer system from wear and prevent nozzle clogging.

5. e

6. b

7. a

8. d

9. b

10. 1 – C
    2 – A
    3 – B

11. The three main types of agitation are:

    _ Bypass agitation.

    _ Hydraulic (jet action) agitation.

    _ Mechanical agitation (best method for keeping wettable powders in suspension).

12. A – body
    B – strainer (screen)
    C – tip
    D – cap
13. First, shut off the sprayer and move it out of the pesticide-treated area. Wear personal protective equipment to keep the pesticide from getting on your skin. Clean the clogged nozzle with a non-metal nozzle-cleaning tool.
14. Because pesticide dusts drift away from the target easily.
15. b
16. b, c and d
17. 1 – B
    2 – D
    3 – E
    4 – C
    5 – A
    6 – F

Part B
Chapter 5: Calibration

1. Calibration is the process of measuring and adjusting the amount of pesticide that a piece of equipment will apply to a given area.
2. Put a container under each nozzle or hopper to collect the output (1) while the equipment runs for 1 minute or (2) while the equipment operates over a measured area. Then check to see if all the containers contain the same amount (within 5 percent).
3. e
4. b
5. gpm = 0.34
6. d
7. c
8. 1. Size of the adjustable opening.
   2. Equipment speed.
   3. Roughness of the surface of the application site.
   4. Size, weight, shape and texture of the granules in the formulation.
   5. Temperature and humidity.

---

9. $$\frac{\text{Band width (12 in.) x 13 pounds per acre (broadcast)}}{\text{Row spacing (30”)}} = 5.2 \text{ pounds per acre (band) applied}$$

10. $$\frac{\text{Pounds used in test run (2.1)}}{\text{Number of rows in swath (6)}} = \text{Pounds used per row in test run (0.35)}$$

    $$\frac{\text{Pounds used per row (in test run) 0.35 x 1,000 ft.}}{\text{Distance traveled in test run (3,000)}} = \text{Pounds per 1,000 linear feet (.12 or almost 2 oz.)}$$

APPENDIX A
Convenient Conversion Factors

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

APPENDIX B

EPA CHEMICAL RESISTANCE CATEGORY CHART

For use when PPE section on pesticide label lists a chemical resistance category

The Worker Protection Standard requires that labels of pesticides used on farms, and in forests, nurseries and greenhouses list the type of personal protective equipment (PPE) that must be worn with each product. Labels will refer to chemical resistance categories (A-H) for PPE. Items in these categories are made of materials that the pesticide cannot pass through during the times indicated below the chart. Choose the category of resistance which best matches the handling task duration. The categories are based on the solvents used in the pesticides, NOT the pesticides themselves. Therefore, there will be instances where the same pesticide with two different formulations (WP and EC, for example) will require PPE from two different chemical resistance categories.

CATEGORY LISTED ON PESTICIDE LABEL	TYPE OF PERSONAL PROTECTIVE MATERIAL							
	Barrier Laminate	**Butyl Rubber ≥ 14 mils**	**Nitrile Rubber ≥ 14 mils**	**Neoprene Rubber ≥ 14 mils**	**Natural Rubber* ≥ 14 mils**	**Polyethylene**	**Polyvinyl Chloride (PVC) ≥ 14 mils**	**Viton ≥ 14 mils**
A dry and water-based formulations)	high	high	high	high	high	high	high	high
B	high	high	slight	slight	none	slight	slight	slight
C	high	high	high	high	moderate	moderate	high	high
D	high	high	moderate	moderate	none	none	none	slight
E	high	slight	high	high	slight	none	moderate	high
F	high	high	high	moderate	slight	none	slight	high
G	high	slight	slight	slight	none	none	none	high
H	high	slight	slight	slight	none	none	none	high

* includes natural rubber blends and laminates

HIGH: Highly chemical-resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticides at rest breaks.

MODERATE: Moderately chemical-resistant. Clean or replace PPE within an hour or two of contact.

SLIGHT: Slightly chemical-resistant. Clean or replace PPE within ten minutes of contact.

NONE: No chemical-resistance. Do not wear this type of material as PPE when contact is possible.

MICHIGAN STATE UNIVERSITY EXTENSION

MSU is an Affirmative-Action Equal-Opportunity Institution. Extension programs and materials are available to all without regard to race, color, national origin, sex, disability, age or religion. n Issued in furtherance of Extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gail L. Imig, extension director, Michigan State University, E. Lansing, MI 48824. **AM 106 SEPT. 1994**

APPENDIX C
Restricted-use Pesticide Recordkeeping Form

Farm or business name and address _____

Treated Area	Pesticide Information	Applicator Information
Date mo / day / yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo / day / yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo / day / yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo / day / yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Federal law requires that the above record information must be recorded no later than 14 days following the pesticide application and must be maintained for 2 years following the application.

FOR MORE INFORMATION, CALL THE USDA PESTICIDE RECORDS BRANCH
(703-330-7826)
http://www.ams.usda.gov/science/sdpr.htm

APPENDIX D

Compatibility Test for Pesticide Tank Mixes

Applying a tank mix of pesticides, or pesticide and a liquid fertilizer as a tank mix can save time, labor, energy and equipment costs. Pesticide labels MUST be read to determine if the products can be mixed together or with fertilizers and the order in which they should be mixed. A pesticide can be tank mixed if the label does not prohibit its application with the other products or fertilizer and as long as all other label provisions are followed – however, the applicator assumes all responsibility for the application.

Tank Mixing Problems

Problems with tank mixing are caused by the failure of the products to remain uniformly dispersed – *incompatibility*. This incompatibility can be caused by improper mixing, inadequate agitation, or a lack of stable emulsifiers in some emulsifiable concentrates (EC). Some labels specify that it is necessary to check for mixture stability. In many cases a compatibility agent (adjuvant) is needed to make a uniform dispersion of the two types of chemicals and to prevent them from separating out in the spray tank. Some pesticides will not mix with liquid fertilizer even when a compatibility agent is added.

A jar test method can determine if a pesticide will be compatible with liquid fertilizer. The following methods were developed for testing the adjuvant (compatibility agent) Unite, but should work for any compatibility agent with 75 percent or more active ingredients. Method I is applicable for most situations, while method II is suggested where compatibility problems arise because of application of two or more different pesticides with a single source of liquid fertilizer. Method II is also recommended for mixtures involving high phosphate grade fertilizer (6-18-6, 9-18-9, 7-23-5, 10-34-0) and flowable pesticide formulations. Wettable powders should be premixed or slurried in water or fertilizer before adding to the fertilizer tank.

Pesticide Mixing Sequence

If more than one pesticide is going to be added to a tank mix they must be added in the proper sequence. Always add WP formulations first; L or F formulations second; water-dispersable granules (WDG) or dry flowables (DF) third; and solutions (S), surfactants, and EC formulations last. Each product must be well mixed before the next is added. Before adding EC's to liquid fertilizers, premix them with water to form a slurry.

Procedure to Determine Pesticide and Fertilizer Compatibility

Method I

1. Add 1 pint of liquid fertilizer to each of two glass quart jars.
2. Add ¼ teaspoon of the adjuvant to one jar.
3. Add the required amount of pesticide (see tables 1 and 2) to each jar and replace the lid tightly. If more than one pesticide is to be used, follow the mixing sequence described above.
4. Invert the jars several times to mix the chemicals. Allow them to stand undisturbed for a minimum of 30 minutes, preferably 60 minutes.
5. Observe and compare the jars for the formation of large flakes, sludge, clumps, layering, gels, or other precipitates. Observe if the pesticide or pesticides cannot be physically mixed with the liquid fertilizer but remains as oily globules or as a layer on the top or as flakes in the solution or on the bottom of the jar. An emulsifiable concentrate normally will go to the top either as an oily layer or a creamy layer; wettable powder and flowable formulations will either settle to the bottom of the jar, float in the fertilizer column at varying concentrations, or go to the top of the fertilizer solution as a sludge or gel layer depending upon the density of the fertilizer and the pesticide formulation.

   If the jar without the compatibility agent remains dispersed, then no adjuvant is needed. If neither jar is sufficiently compatible, repeat the test using ⅜ teaspoon of adjuvant. If compatibility is not sufficient, then use Method II.

Method II

1. Fill a quart jar with 1 pint of liquid fertilizer.
2. Prepare a premix of adjuvant and herbicide. Add immediately to the liquid fertilizer, secure the lid and mix the contents by inverting the jar several times.

   If the chemicals do not sufficiently mix, repeat this method using ⅜ teaspoon of adjuvant. If compatibility is still not achieved assume the compounds are not compatible and do not use them as a tank mix.

Table 1. Guidelines for liquid pesticide rates for compatibility test.

Gallons of liquid fertilizer applied/A	Teaspoons of liquid pesticide per pint of liquid fertilizer		
	(1 qt/A)	(2 qt/A)	(4 qt/A)
10	2.4	4.8	9.6
20	1.2	2.4	4.8
40	0.6	1.2	2.4
80	0.3	0.6	1.2
100	0.2	0.5	1.0

1 teaspoon = 4.93 ml

Table 2. Guidelines for wettable powder pesticide rates for compatibility test.

Gallons of liquid fertilizer applied/A of liquid fertilizer	Teaspoons of wettable powder per pint of liquid fertilizer		
	(1 lb/A)	(2 lb/A)	(4 lb/A)
10	3.5	7.1	14.2
20	1.8	3.5	7.1
40	0.9	1.8	3.5
80	0.6	1.2	2.4
60	0.4	0.9	1.8
100	0.3	0.7	1.4

Table 3. Guidelines for compatibility agent (adjuvant) rates.

Pints of adjuvant per 100 gallons	Teaspoons per pint liquid fertilizer
1	⅛
2	¼
3	⅜
4	½

1 teaspoon = 4.93 ml

To minimize compatibility problems with tank mixes, follow correct mixing procedures. The usual method for tank mixing pesticides is to fill the tank at least one-half to two-thirds full with carrier before adding any pesticide or adjuvant. If a compatibility agent is necessary, always add it before adding the pesticides. The order of adding various formulations is very important and should be as follows: WP formulations first; L or F formulations second; water-dispersable granules (WDG) or dry flowables (DF) third; and solutions (S), surfactants, and EC formulations last. Each product must be well mixed before the next is added. Before adding EC's to liquid fertilizers, premix them with water to form a slurry.

To assure a uniform spray mixture at all times, keep the mixture agitated during application and do not allow it to stand overnight without agitation. If possible, apply all of a tank mixture in one day.

References:

Garber, Lester, H. *Mixing Agricultural Chemicals.* Crop Chronicle, 1984.

Jordan, T.M., *Compatibility Test for Herbicides and Liquid Fertilizer.* Weed Science, Purdue University Extension Service, Department of Botany and Plant Pathology, West Lafayette, Indiana 47907.

Devisetty, B. N., et al. *Compatibility Agents for Liquid Fertilizer-Pesticide Combinations.* Special Technical Publication, 764. American Society for Testing and Materials, Philadelphia, PA, 1982.

APPENDIX E
Michigan State University Extension Offices

COUNTY EXTENSION OFFICES

Alcona County
320 S. State,
Harrisville 48740-0800
989-724-6478

Alger County
101 Court Street,
Munising 49862-1103
906-387-2530

Allegan County
County Building Annex,
Allegan 49010-1349
616-673-0370

Alpena County
603 South 11th Avenue,
Alpena 49707-2645
989-354-3636

Antrim County
County Building,
Bellaire 49615-0427
231-533-8818

Arenac County
County Building,
Standish 48658-0745
989-846-4111

Baraga County
Courthouse Annex,
L'Anse 49946-1002
906-524-6300

Barry County,
220 West Court Street,
Hastings 49058-1824
616-945-1388

Bay County
515 Center Avenue,
Bay City 48708-5994
989-895-4026

Benzie County
Government Center,
Beulah 49617-0349
231-882-0025

Berrien County
1737 Hillandale Road,
Benton Harbor 49022-9230
616-944-4126

Branch County
Courthouse Annex,
Coldwater 49036-1990
517-279-4311

Calhoun County
County Building,
Marshall 49068-1518
616-781-0784

Cass County
201 East State Street,
Cassopolis 49031-1352
616-445-8661

Charlevoix County
319B North Lake Street,
Boyne City 49712-1101
231-582-6232

Cheboygan County
County Building,
Cheboygan 49721-0070
231-627-8815

Chippewa County
300 Court Street,
Sault Ste. Marie 49783-2139
906-635-6368

Clare County
County Building,
Harrison 48625-0439
989-539-7805

Clinton County
County Courthouse,
St. Johns 48879-2347
989-224-5240

Crawford County
County Building,
Grayling 49738-1743
989-344-3264

Delta County
2840 College Avenue,
Escanaba 49829-9591
906-786-3032

Dickinson County
Community Services Center,
Iron Mountain 49801-2765
906-774-0363

Eaton County
Suite One,
Charlotte 48813-1047
517-543-2310

Emmet County
3434 Harbor-Petoskey Road,
Harbor Springs 49740-9587
231-348-1770

Genesee County
County Building #2,
Flint 48504-2376
810-244-8500

Gladwin County
County Library Building,
Gladwin 48624-2025
989-426-7741

Gogebic County
104 South Lowell,
Ironwood 49938-2044
906-932-1420

Grand Traverse County
Suite A,
Traverse City 49684-2208
231-922-4620

Gratiot County
214 East Center Street,
Ithaca 48847-1446
989-875-5233

Hillsdale County
20 Care Drive,
Hillsdale 49242-5039
517-439-9301

Houghton\Keweenaw Counties
1500 Birch Street,
Hancock 49930-1062
906-482-5830

Huron County
Room 104, County Building,
Bad Axe 48413-1317
989-269-9949

Ingham County
121 East Maple Street,
Mason 48854-0319
517-676-7207

Ionia County
100 Library Street,
Ionia 48846-1605
616-527-5357

Iosco County
P.O. Box 599,
Tawas City 48764-0599
989-362-3449

Iron County
2 South 6th Street,
Crystal Falls 49920-1400
906-875-6642

Isabella County
County Annex Building,
Mt. Pleasant 48858-2306
989-772-0911-30**2**

Jackson County
1699 Lansing Avenue,
Jackson 49202-2296
517-788-4292

Kalamazoo County
Room 302,
Kalamazoo 49007-3777
616-383-8830

Kalkaska County
County Government Center,
Kalkaska 49646-9436
231-258-3320

Kent County
836 Fuller Avenue NE,
Grand Rapids 49503-1902
616-336-3265

Lake County
Route 3,
Baldwin 49304-2235
231-745-2732

Lapeer County
1575 Suncrest Drive,
Lapeer 48446-1138
810-667-0341

Leelanau County
116 East Philip Street,
Lake Leelanau 49653-9782
231-256-9888

Lenawee County
Suite 2020,
Adrian 49221-3867
517-264-5300

Livingston County
820 East Grand River Avenue,
Howell 48843-2432
517-546-3950

Luce County
County Building, Room 26,
Newberry 49868-1208
906-293-3203

APPENDIX E continued
Michigan State University Extension Offices

Mackinac County
Courthouse,
St. Ignace 49781-1495
906-643-7307

Macomb County
Verkuilen Building,
Clinton Township 48036-
810-469-5180

Manistee County
6433 Eight Mile Road,
Bear Lake 49614-9712
231-889-4277

Marquette County
200 West Spring Street,
Marquette 49855-4630
906-226-4370

Mason County
Suite 4,
Scottville 49454-1221
231-757-4789

Mecosta County
14485 Northland Drive,
Big Rapids 49307-2368
231-592-0792

Menominee County
S904 U.S. Highway 41,
Stephenson 49887-0157
906-753-2209

Midland County
220 West Ellsworth St.,
Midland 48640-5194
989-832-6640

Missaukee County
6180 West Sandborn Road,
Lake City 49651-9330
231-839-4667

Monroe County
963 S. Raisinville Road,
Monroe 48161-9754
734-240-3170

Montcalm County
617 North State Road,
Stanton 48888-0308
517-831-7500

Montmorency County
Courthouse Annex,
Atlanta 49709-0415
989-785-4177

Muskegon County
635 Ottawa Street,
Muskegon 49442-1016
231-724-6361

Newaygo County
817 South Stewart Avenue,
Fremont 49412-9201
231-924-0500

Oakland County
Dept 416,
Pontiac 48341-1032
248-858-0885

Oceana County
210 Johnson Street,
Hart 49420-0151
231-873-2129

Ogemaw County
205 S. Eighth,
West Branch 48661-1207
989-345-0692

Ontonagon County
Courthouse,
Ontonagon 49953
906-884-4386

Osceola County
301 W. Upton Avenue,
Reed City 49677-0208
231-832-6139

Oscoda County
Courthouse Annex,
Mio 48647-0069
989-826-1160

Otsego County
800 Livingston Boulevard,
Gaylord 49735-8321
989-731-0272

Ottawa County
333 Clinton Street,
Grand Haven 49417-1329
616-846-8250

Presque Isle County
151 East Huron Avenue,
Rogers City 49779-0110
989-734-2168

Roscommon County
Courthouse Annex,
Roscommon 48653-0507
989-275-5043

Saginaw County
One Tuscola Street,
Saginaw 48607
989-758-2500

Sanilac County
37 Austin Street,
Sandusky 48471-1244
810-648-2515

Schoolcraft County
Room 218,
Manistique 49854-1485
906-341-3688

Shiawassee County
701 South Norton,
Corunna 48817-1209
989-743-2251

St. Clair County
Room 102,
Port Huron 48060-4015
810-989-6935

St. Joseph County
612 E. Main St,
Centreville 49032
616-467-5511

Tuscola County
362 Green Street,
Caro 48723-1910
989-672-3870

Van Buren County
Suite A,
Paw Paw 49079-1077
616-657-7745

Washtenaw County
705 N. Zeeb Rd.,
Ann Arbor 48107-8645
734-997-1678

Wayne County
640 Temple Street,
Detroit 48201-2558
313-833-3412

Wexford County
401 N. Lake St.,
Cadillac 49601-1891
231-779-9480

MSU Outreach Regional Offices

East Central
2013 W. Wackerly St.,
Midland 48640-2592
989-839-8540

North
Suite 100,
Traverse City 49684-8895
231-929-3902

Southeast
28115 Meadowbrook Road,
Novi 48377-3128
248-380-9104

Southwest
3700 E. Gull Lake Drive,
Hickory Corners 49060
616-671-2444

Upper Peninsula
702 Chippewa Square,
Marquette 49855-4811
906-228-4830

West Central
110 Commerce Building,
Grand Rapids 49503-3117
616-458-6805

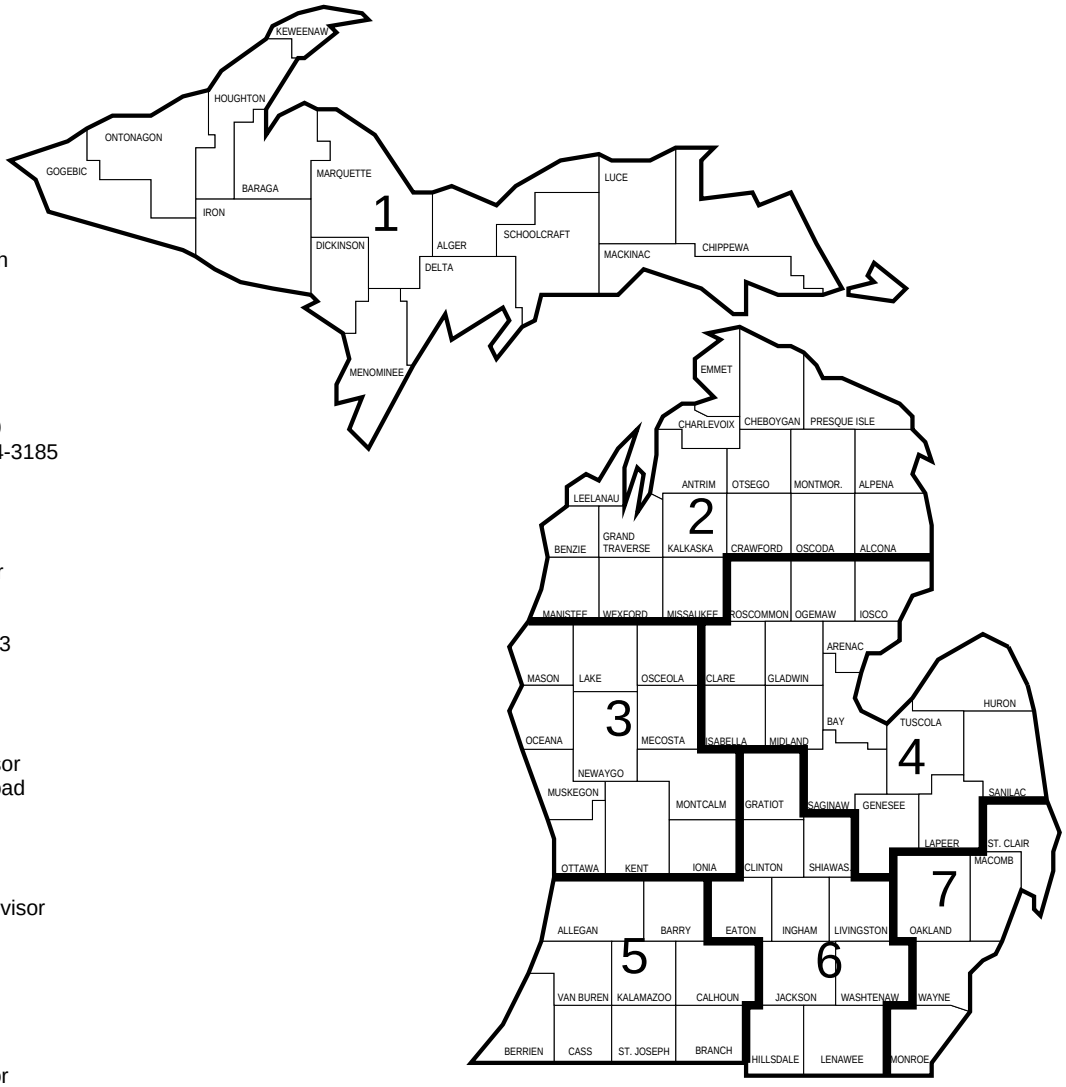
MSU Bulletin Office

10-B Agriculture Hall
Michigan State University
East Lansing, MI 48824-1039
517-355-0240
fax: 517-353-7168

APPENDIX E continued

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE & PLANT PEST MANAGEMENT DIVISION

525 W. ALLEGAN ST.
P.O. BOX 30017
LANSING, MICHIGAN 48909
517-373-1087
Web: www.mda.state.mi.us



REGION 1
Ernie Abel, Supervisor
UP State Fair
2401 12th Avenue North
Escanaba, MI 49829
231-786-4011
FAX 231-786-4196

REGION 2
Ernie Abel, Supervisor
701 S. Elmwood, Ste. 9
Traverse City, MI 49684-3185
231-922-5210
FAX 231-922-5236

REGION 3
Jeff Zimmer, Supervisor
State Office Bldg.
350 Ottawa NW
Grand Rapids, MI 49503
616-356-0600
FAX 616-356-0622

REGION 4
Daniel Keane, Supervisor
1585 Tittabawassee Road
Saginaw, MI 48604
989-758-1778

REGION 5
Michael Hansen, Supervisor
4032 M-139, Bldg. 116
St. Joseph, MI 48905
616-428-2575
FAX 616-429-1107

REGION 6
Jean Meiner, Supervisor
3001 Coolidge Rd.
East Lansing, MI 48823
517-324-3895

REGION 7
Kendra Anderson, Supervisor
One Lahser Center
26400 Lahser Road
Suite 415
Southfield, MI 48034
248-356-1701
FAX 248-356-0374

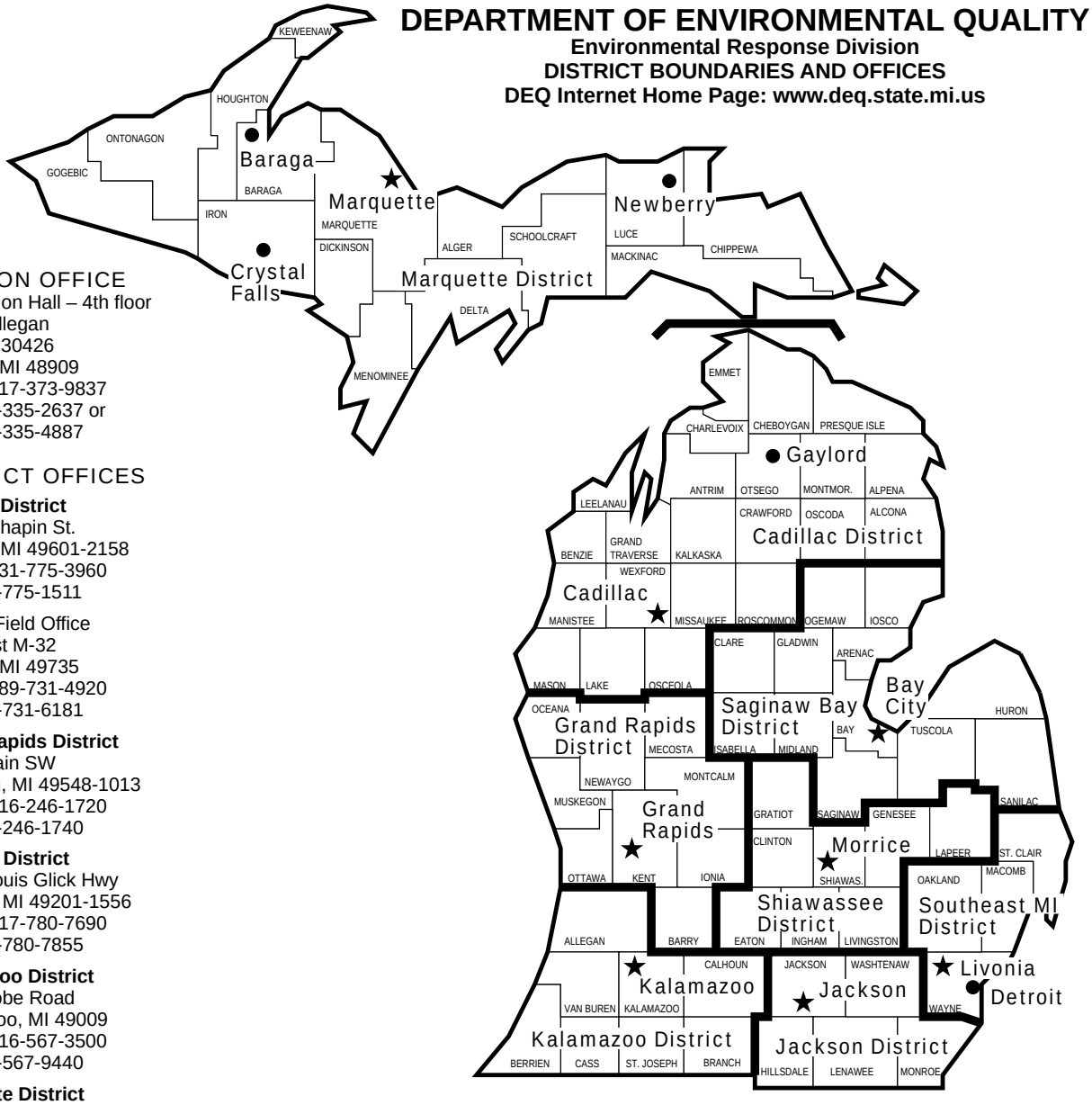
DAYS EXAMS ARE GIVEN

Region 1: Tuesday
Region 2: Wednesday
Region 3: Monday
Region 4: Wednesday
Region 5: Friday
Region 6: Monday
Region 7: Wednesday and Thursday

APPENDIX E continued

DEPARTMENT OF ENVIRONMENTAL QUALITY

Environmental Response Division
DISTRICT BOUNDARIES AND OFFICES
DEQ Internet Home Page: www.deq.state.mi.us



DIVISION OFFICE

Constitution Hall – 4th floor
525 W. Allegan
P.O. Box 30426
Lansing, MI 48909
Phone: 517-373-9837
Fax: 517-335-2637 or
517-335-4887

DISTRICT OFFICES

Cadillac District
120 W. Chapin St.
Cadillac, MI 49601-2158
Phone: 231-775-3960
Fax: 231-775-1511

Gaylord Field Office
2100West M-32
Gaylord, MI 49735
Phone: 989-731-4920
Fax: 989-731-6181

Grand Rapids District
245 Colrain SW
Wyoming, MI 49548-1013
Phone: 616-246-1720
Fax: 616-246-1740

Jackson District
301 E. Louis Glick Hwy
Jackson, MI 49201-1556
Phone: 517-780-7690
Fax: 517-780-7855

Kalamazoo District
7953 Adobe Road
Kalamazoo, MI 49009
Phone: 616-567-3500
Fax: 616-567-9440

Marquette District
1990 U.S. 41 South
Marquette, MI 49855-9198
Phone: 906-228-6568
Fax: 906-228-5245

Baraga Field Office
427 U.S. 41 North
Baraga, MI 49908
Phone: 906-353-6651
Fax: 906-353-7464

Crystal Falls Field Office
1420 U.S. 2 West
Crystal Falls, MI 49920
Phone: 906-875-2071
Fax: 906-875-3336

Newberry Field Office
5100 State Highway M-123
Newberry, MI 49868
Phone: 9067-293-5131
Fax: 906-293-8728

Saginaw Bay District
503 N. Euclid Ave., Suite 9
Bay City, MI 48706-2965
Phone: 989-686-8025
Fax: 989-684-9799

Shiawassee District
10650 Bennett Dr.
Morrice, MI 48857-9792
Phone: 517-625-5515
Fax: 517-625-5000

Southeast Michigan District
38980 W. Seven Mile Road
Livonia, MI 48152-1006
Phone: 734-953-8905
Fax: 734-953-1544

Detroit Office
300 River Place, Suite 3600
Detroit, MI 48207
Phone: 313-392-6480
Fax: 313-392-6488

ENVIRONMENTAL ASSISTANCE CENTER
(for general DEQ information):
Phone: 1-800-662-9278
Fax: 1-517-241-0673
E-mail: deq-ead-env-assist@state.mi.us

FOR POLLUTION EMERGENCIES:
1-800-292-4706

APPENDIX E continued

Michigan Groundwater and Freshwater Protection Act – Sources of information and assistance:

Michigan Department of Agriculture
Environmental Stewardship Division
Constitution Hall
P.O. Box 30017
525 W. Allegan Street
Lansing, MI 48909
Phone: (517) 335-6529
Fax: (517) 335-3131
Internet: www.mda.state.mi.us

PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of February 2002

Human Pesticide Poisoning

POISON CONTROL

From anywhere in the United States, call

1-800-222-1222

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

_____
Phone No.

or

Animal Health Diagnostic Laboratory (Toxicology) Michigan State University:

(517) 355-0281

Pesticide Fire

Local fire department:

_____
Phone No.

and

Fire Marshal Division, Michigan State Police:
M – F: 8 –12, 1– 5

(517) 322-1924

Traffic Accident

Local police department or sheriff's department:

_____
Phone No.

and

Operations Division, Michigan State Police:

**(517) 336-6605*

***** *Telephone Number Operated 24 Hours*

Environmental Pollution

District Michigan Department of Environmental Quality (MDEQ) Office Phone No.

_____
Phone No.

and

MDEQ Pollution Emergency Alerting System (PEAS):

**1-800-292-4706*

also

**1-800-405-0101*

Michigan Department of Agriculture Spill Response

Pesticide Disposal Information

Michigan Clean Sweep, Michigan Department of Agriculture Environmental Stewardship Division.

Monday – Friday: 8 a.m.–5 p.m.

(517) 335-6529

National Pesticide Information Center

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

7 days a week; excluding holidays

6:30 a.m. – 4:30 p.m. **Pacific Time Zone**

1-800-858-7378

FAX: 1-541-737-0761

Revised by Carolyn J. Randall, *Pesticide Education Program, Michigan State University Extension*

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