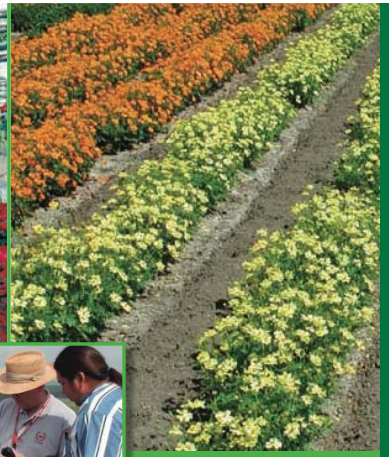


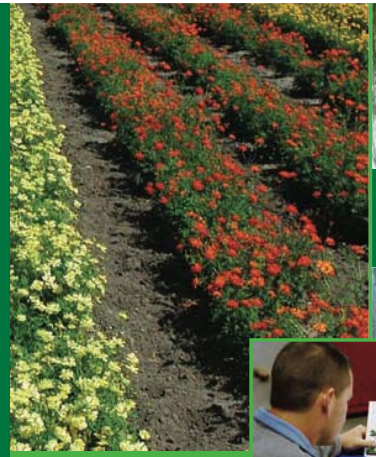








NATIONAL PESTICIDE APPLICATOR CERTIFICATION CORE MANUAL







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INTRODUCTION

HOW TO USE THIS MANUAL

This manual is intended as a study guide for preparing to take the National Pesticide Applicator Certification Core Exam that was developed jointly by the U.S. Environmental Protection Agency and the Pest Management Regulatory Agency of Canada. Check with the pesticide regulatory agency within your individual state, tribe, territory, or federal department/agency to determine whether this manual prepares you for commercial or private applicator certification or recertification or registered technician status. This manual satisfies the basic applicator training requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). More specific pest management information and pesticide terminology are covered in category-specific manuals.

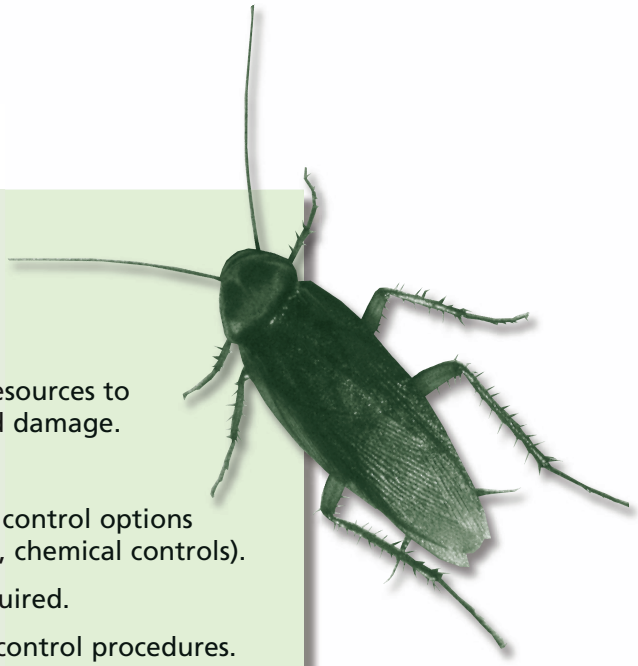
The National Core Exam is based on information found in this manual. The table of contents helps you identify important topics and understand how they relate to one another through the organization of headings and subheadings. You may also check the index for key words and concepts. Each chapter begins with a set of learning objectives that help you focus on what you should learn from the chapter. Questions on the certification exam pertain directly to these learning objectives. As you prepare for the exam, read each chapter and answer the review questions located at the end. These questions are not on the certification exam. They are provided to help you prepare for the exam. The answers to the review questions are found in *Appendix A*, and a sample test is found in *Appendix E*.

Other appendices, including a glossary, provide supplemental information that help you understand the topics covered in the chapters. Terms in bold type throughout the manual are defined either within the text or in the glossary.

This certification manual benefits both you and the general public. By learning how to handle pesticides correctly, you will be able to protect yourself, others, and the environment from pesticide misuse. For further information, visit: **www.epa.gov** and select "Pesticides."

CHAPTER 1

Pest Management



LEARNING OBJECTIVES

After studying this chapter, you should:

- Know the main groups of common pests.
- Know how to use pest control references and resources to help identify pests and recognize symptoms and damage.
- Understand various pest control procedures.
- Understand integrated pest management (IPM) control options (e.g., biological, cultural, mechanical, sanitation, chemical controls).
- Understand when preventive pest control is required.
- Understand how pest population levels trigger control procedures.
- Anticipate effects on pest, hosts, and natural enemies of relevant environmental variables that influence pest populations (e.g., weather, geographic barriers, cultural practices, nutrient supply).
- Understand probable causes of non-effective pest control (e.g., incorrect pest identification, incorrect dosage, incorrect application timing, incorrect pesticide product).
- Know how to plan pest control strategies that minimize the development of pesticide resistance (e.g., rotation of pesticide types with different modes of action, application of pesticides that do not leave persistent residues, application of pesticides at below-label amounts).

Civilization has been combating insects and other pests throughout history. Records contain many examples of how pests have had major impacts on humans. Probably the most infamous was the Black Plague of Europe, when millions of people died in the 14th century from a mysterious scourge. Only centuries later was it determined that a bacterial disease spread by rat fleas was the cause. Rat fleas became infected with bacteria while feeding on diseased rats. When rats were unavailable as a food source, the fleas sought other warm-blooded hosts, often humans. Today this disease, known as bubonic plague, can be treated if properly diagnosed. Controlling rats and other rodents and fleas can reduce disease incidence.

One historical occurrence that directly influenced the population of the United States was the destruction

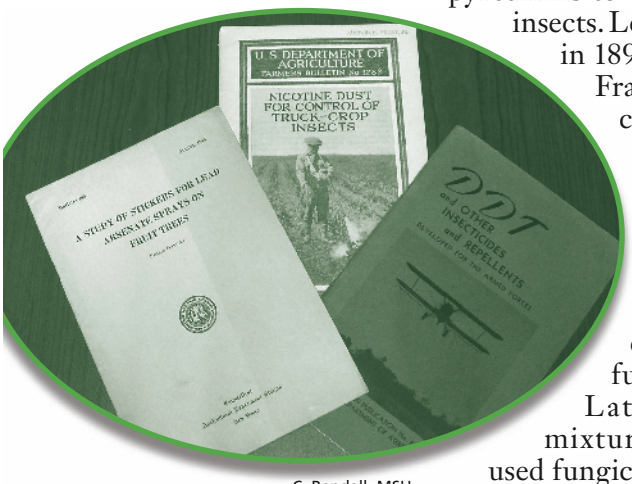
Above lady beetle photo: Marlin E. Rice, Ph.D., Iowa State University

of Ireland's potato crop by a pest in the 19th century. A fungal disease called late blight essentially eliminated potatoes, the staple food crop. Potatoes not destroyed in the field rotted in storage during the winter. Thousands of Irish starved in the resulting famine, and more than a million migrated to the United States. Late blight continues to be a major problem of potatoes, but today it is managed through the use of resistant cultivars, proper sanitation practices, and fungicides.

The above examples illustrate the potential enormity and complexity of pest problems. But what is a pest? Webster's Dictionary defines a pest as "any destructive or troublesome insect, small animal, weed, etc." Many insects, **pathogens** (disease-causing organisms), weeds, mollusks (slugs and snails), fish, birds, and a variety of mammals, from rats to deer, are competitors for our livestock and crops. In addition, some pests destroy buildings and other structures and reduce the aesthetic and recreational value of the landscape. The competition between humans and pests has evolved over time, and so have the methods of control.

PEST CONTROL OVER THE YEARS

Mystery surrounded the causes of crop failures and human and animal diseases for many centuries. The first pest control measures were crude—weeds were pulled, rats were clubbed, and beetles were plucked from foliage. The earliest use of chemicals as pesticides dates back to 2500 B.C., when sulfur was burned to control insects and mites. Through the years, experimentation and good fortune led to the recognition of additional chemicals with pesticidal activity. Early plant-derived insecticides included hellebore to control body lice, nicotine to control aphids, and pyrethrins to control a wide variety of insects. Lead arsenate was first used in 1892 as an orchard spray. In France during the late 19th century, a mixture of lime and copper sulfate was sprayed on grapevines to deter passers-by from picking the grapes. The farmer found the mixture also controlled downy mildew, a serious fungal disease of grapes. Later named Bordeaux mixture, it remains a widely used fungicide worldwide.



C. Randall, MSU

Early agricultural bulletins on pesticide application.

Until the 1940s, pest control chemicals were derived from plants and inorganic compounds. During World War II, DDT, a synthetic chemical, played a very important role, saving Allied soldiers from insect-transmitted diseases. DDT was hailed as the insecticide to solve all insect problems. The introduction of countless other synthetic organic pesticides followed. These synthetic products launched the modern-day chemical industry and began a new era in pest control. Given significant success at a relatively low cost, pesticides became the primary means of pest control. They provided season-long crop protection against pests and complemented the benefits of fertilizers and other production practices. The success of modern pesticides, particularly in agriculture and human health, encouraged widespread acceptance and eventual reliance on them.

In recent years, however, some drawbacks of heavy dependence on pesticides have become increasingly apparent. One of the most disturbing is the development of **pest resistance** to pesticides. Since the resistance of the San Jose scale to lime sulfur was recognized in 1908, hundreds of insects have become resistant to one or more pesticides worldwide. Pesticide resistance also has arisen in more than 50 weeds and many plant pathogens. A dramatic example is the Colorado potato beetle in the eastern United States. This insect pest has developed resistance to every major group of insecticides, making control with chemicals difficult, if not impossible, to achieve.

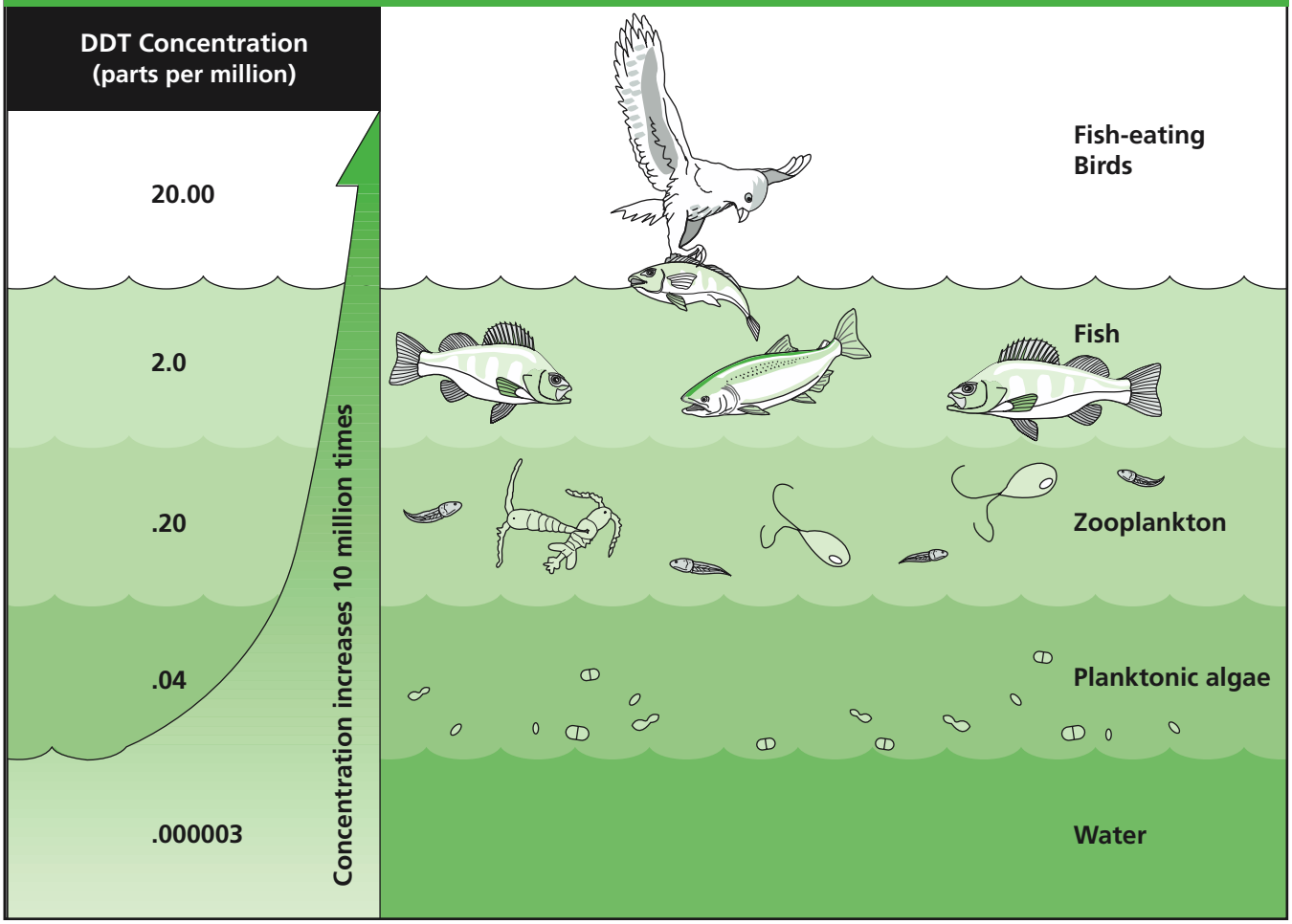
Growing concerns about the environmental and health hazards asso-

ciated with pesticides have also become significant factors challenging pesticide use. In 1962, Rachel Carson published *Silent Spring*, a book that examined pesticides and their effects on the environment. DDT and other chlorinated hydrocarbons were her primary concern because of their stability and persistence in the environment. Their long residual activity was a major factor contributing to their effectiveness, but a negative effect was their ability to accumulate in the fatty tissue of some animals (**bioaccumulation**). In certain situations, **biomagnification** of the insecticides occurred. Biomagnification is the process whereby some organisms accumulate chemical residues in higher concentrations than those found in the organisms they consume. Ecologists refer to a **food chain** as the sequence of animals feeding in the natural environment. A particular plant, animal, or microorganism is eaten by an animal, which is in turn eaten by another animal. At each succeeding level, an animal normally eats a number of individuals from the previous level. Figure 1.1 depicts how biomagnification of a pesticide can occur in a food chain. Organisms with pesticides in their tissues are eaten by fish, which are in turn eaten by birds. The birds at the top of the food chain accumulate the highest concentration of pesticide residues.

Since the publication of *Silent Spring*, the United States has experienced a level of environmental awareness and interest second to no other period in history. The U.S. Environmental Protection Agency (EPA) was created in 1970 with a mandate from Congress. Its task was then, and remains today, to implement by regulation the laws passed by Congress to protect the environment and the health of humans

Adapted from Penn. State *Pesticide Education Manual*

Figure 1.1 Biomagnification in the Food Chain



and other animals. Since the 1972 EPA ban on DDT use in the United States, regulatory action has been taken against many chemicals, including pesticides, thought to pose significant environmental and health hazards. Public concern has led to stringent regulation of pesticides and changes in the types of pesticides used.

PEST RECOGNITION

Pests are organisms that cause problems in various ways. Some compete with people for food or fiber. Others interfere with the raising of crops, livestock, or poultry. Certain types of pests damage property and personal belongings or disfigure ornamental plantings. Others transmit or cause plant, animal, or human diseases.

Before trying to control a pest, you need to identify it. Be certain any injury or observed damage is actually due to the identified pest and not some other cause. Once you have identified the pest and confirmed that it is causing damage, become familiar with its life cycle, growth, and reproductive habits. Then, use this information to form your pest control plans. Misidentification and lack of information about a pest could cause you to choose the wrong control method or apply the control at the wrong time. These are the most frequent causes of pest control failure.

In addition, some plants are damaged by non-living agents. These include such things as weather extremes, air pollutants, road salt, and inadequate or excessive fertilization. Sometimes this damage is mistaken for that caused by living pests.



Larry Schulze, University of Nebraska

Weed pest.



Invertebrate pest.



Disease pest.

The Four Main Groups of Pests

- Weeds (undesirable plants).
- Invertebrates (insects, mites, ticks, spiders, snails, and slugs).
- Disease agents or pathogens (bacteria, viruses, fungi, nematodes [roundworms], mycoplasmas [parasitic microorganisms], and other microorganisms).
- Vertebrates (birds, reptiles, amphibians, fish, and rodents and other mammals).

Ways to Identify Pests

Identify a pest by using the guidelines included in this chapter and then consulting reference materials such as identification books, Extension bulletins, and field guides that contain pictures and biological information on the pest. Another option is to have pests examined and identified by pest management specialists. When having pests identified, always collect several specimens. Have plastic bags, vials, or other suitable containers available when collecting samples in the field. For plant diseases, submit undamaged specimens, such as healthy foliage, along with the damaged foliage. For insects and their relatives, kill them first and send them to the specialist in a manner that will not damage body parts that aid in their identification. For weed/plant samples, it is best to submit whole plants, including roots, vegetative structures, and flowers, if possible. Plants may be pressed flat between paper or cardboard to prevent leaf crinkling or placed in plastic bags. Be sure to include the location and date of the collection.

The difficulty in identifying certain insects and most mites, nematodes, and plant pathogens in the field is their small size. Accurate identification requires the use of a hand lens or microscope, special tests, or careful analysis of damage. Often the pest's **host** (the animal or plant on which an organism lives) and location are important to making positive identifications. Information on the environmental conditions where you collect pests and the time of year of collection provides clues to the pest's identity.

Pest species may have different physical forms depending on their stage in their life cycles or the time of year. Weed seedlings, for example, often do not resemble the mature plant. Many insect species undergo changes in appearance as they develop from eggs through immature stages (nymph, larva, pupa) to the adult form.

Characteristic Damage

Pests may leave signs of their presence or damage that help you determine what they are. Birds and rodents build nests that are often characteristic to each species. The type of feeding damage helps you identify many insects. Rodents and some other mammals dig distinctive burrows in the ground and often leave identifying gnaw marks on tree trunks or other objects. Sometimes trails in grass or tracks in dirt are helpful clues to rodent identification. Insect and rodent fecal materials also are distinctive and important identification aids. Weeds may have unique flowers, seeds, or fruits, or unusual growth habits. Fungi and other pathogens often cause specific types of damage, deformation, or color changes in host tissues.



Lee Karney, USFWS

Vertebrate pest.

PEST MANAGEMENT METHODS

Once a pest problem is anticipated or identified, you can begin planning your pest management program. You must know what management methods are available and the benefits and limitations of each. Select methods that are the most effective and the least harmful to people and the environment. Whenever possible, combine the use of several compatible methods into an **integrated pest management (IPM)** program, and target the pest at the most susceptible stage for control.

Pest Management Methods

Natural controls

Applied controls

- Biological control
- Mechanical control
- Cultural control
- Physical/environmental modification
- Host resistance or genetic control
- Chemical control
- Regulatory Methods

Natural controls are the measures that check or destroy pests without depending on humans for their continuance or success. Natural controls include climatic factors such as wind, temperature, sunshine, and rain. Topographic features such as rivers, lakes, and mountains can influence pest movement. Naturally occurring predators, parasites, and pathogens can regulate pest populations.

When natural controls have not held pests in check, humans must intervene and apply pest management controls. **Applied controls** include biological, mechanical, cultural, physical, genetic, chemical, and regulatory methods.

Biological Control

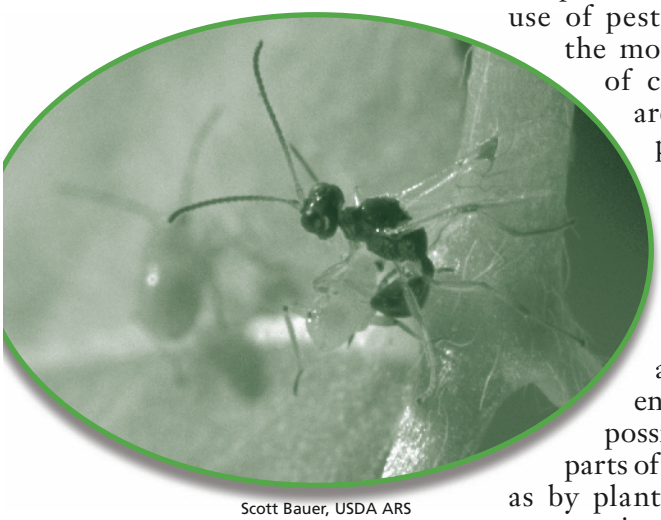
Most pests have natural enemies that control or suppress them effectively in some situations. Natural enemies, including pathogens, are being used successfully as biological control agents to manage certain insect, mite, fungal, fish, and weed pests.

Biological control is often directed against pests that are not native to a geographical area. Introduced pests are often problems in their new location because they lack natural enemies to help control them. Biological control involves locating the native home of an introduced pest and finding suitable natural enemies there. After extensive testing and evaluation, selected natural enemies are imported, reared, and released. If successful, the introduced natural enemies become established within large areas and effectively lower

target pest populations for long periods of time with no further need for intervention. The process is complicated because it is often difficult to locate the native home of some pests, and natural enemies cannot be released until it is proven that they will not become pests themselves. Laws have been enacted that strictly control the importation of all organisms, including biological control agents, into the United States. Other countries have similar restrictions.

Biological control also involves the mass release of large numbers of natural enemies into fields, orchards, greenhouses, or other locations to control specific pests. This method usually does not have long-term results, so these natural enemies must be released periodically. Several natural enemies are reared or cultured commercially. Predatory mites are used to control plant-feeding spider mites. Parasitic wasps and lacewings are used to control various insect pests. Nematodes and fungi are being studied as biological control agents for certain weeds and some insects. General predators such as praying mantids and lady beetles are sold with claims made for biological control. In many cases, however, their effectiveness has not been established.

Maintaining populations of natural enemies by avoiding damaging cultural practices or the indiscriminate use of pesticides can be one of the most economical means of control. If pesticides are part of your control program, select types that are known to be less toxic to natural enemies or, if recommended, apply pesticides at lower-than-label rates to avoid harming natural enemies. Sometimes it is possible to modify certain parts of the environment, such as by planting crops or ground covers, to maintain or enhance natural enemies.



Scott Bauer, USDA ARS

Parasitic wasps may be used as biological control agents.

Mechanical Control

Mechanical control involves the use of devices, machines, and other physical methods to control pests or alter their environment. Traps, screens, barriers, fences, and nets are examples of devices used to prevent pest activity or remove pests from an area.

Cultivation

Cultivation is one of the most important methods of controlling weeds. It is also used for some insects and other soil-inhabiting pests. Mechanical devices such as plows, disks, mowers, cultivators, and bed conditioners physically destroy weeds or control their growth and disrupt soil conditions suitable for the survival of some microorganisms and insects.



Exclusion

Exclusion is a mechanical control technique that consists of using barriers to prevent pests from getting into an area. Window screens, for example, exclude flies, mosquitoes, and other flying insects. Patching or sealing cracks, crevices, and other small openings in buildings can exclude insects, rodents, bats, birds, or other pests. Fences and ditches make effective barriers against many vertebrate pests. Wire or cloth mesh excludes birds from fruit trees. Sticky material painted onto tree trunks, posts, wires, and other objects prevents crawling insects from crossing.



M.J. Weaver, Virginia Tech Pesticide Programs

Live trap used to control vertebrate pests.

Trapping

Traps physically catch pests within an area or building. Several types of traps are commonly used. Some kill animals that come in contact with them; others snare animals so they can then be relocated or destroyed. Traps are either mechanical devices or sticky surfaces.

Cultural Control

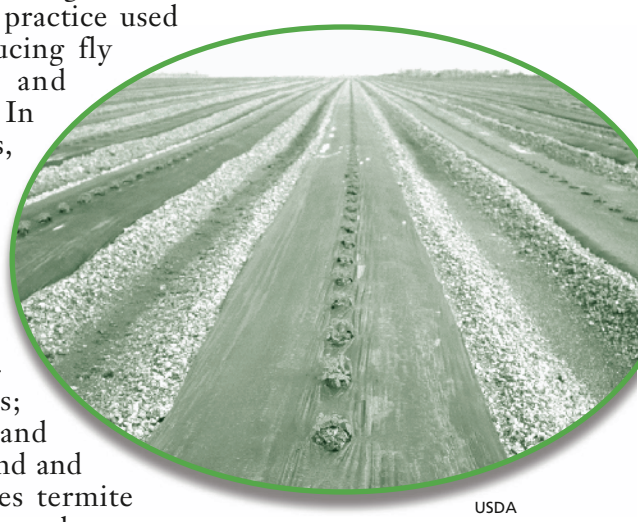
The goal of cultural control is to alter the environment, the condition of the host plant or site, or the behavior of the pest to prevent or suppress an infestation. It disrupts the normal relationship between the pest and the host plant or site and makes the pest less likely to survive, grow, or reproduce. Cultural practices and sanitation are two examples of cultural control.

Cultural Practices

Many cultural practices influence the survival of pests. In turf, mowing, irrigation, aeration, and fertilization are all important ways of producing healthy turf and preventing pest buildup and damage. In agricultural crops, selection of crop plant varieties, timing of planting and harvesting, irrigation management and timing, crop rotation, and use of trap crops help reduce populations of weeds, microorganisms, insects, mites, and other pests. Weeds also can be managed by mulching (with plastic, straw, shredded bark, or wood chips) and by using cover crops.

Sanitation

Sanitation, or source reduction, involves eliminating food, water, shelter, or other necessities important to the pest's survival. In crop production, sanitation includes such practices as removing weeds that harbor pest insects or rodents, eliminating weed plants before they produce seed, destroying diseased plant material or crop residues, and keeping field borders or surrounding areas free of pests and pest breeding sites. Animal manure management is an effective sanitation practice used for preventing or reducing fly problems in poultry and livestock operations. In non-agricultural areas, certain pests are controlled by draining standing water. Closed garbage containers and frequent garbage pickup eliminate food sources for flies, cockroaches, and rodents; removing soil, trash, and other debris from around and under buildings reduces termite and fungal rot damage and prevents rodent nesting.



USDA

Use of plastic mulch to control weeds.

Physical/Environmental Modification

Pests that occur in enclosed areas may sometimes be suppressed by altering physical and environmental conditions such as water, air movement, temperature, light, and humidity. Refrigeration, for example, protects stored food products, furs, and other items from insect pests; lowered temperatures either kill the insects, cause them to stop feeding, or prevent egg hatch or development. Installing bright lights in attics sometimes discourages bats from roosting there. Lowering the humidity of stored grains and other food products reduces damage from molds and some insects. Increasing air movement in glass or plastic houses

often helps to suppress fungal diseases from developing on plants.

Host Resistance or Genetic Control

Sometimes plants and animals can be bred or selected to resist specific pest problems. For example, particular livestock breeds are selected for physical characteristics that prevent attack by some pests or provide physiological resistance to disease or parasitic organisms. Resistance also is enhanced by maintaining the host's health and providing for its nutritional needs. Certain plant varieties are naturally resistant to insects, pathogens, or nematodes. Many plants actually repel various types of pests, and some contain toxic substances. Plant resistance to insect pests can sometimes be achieved by transferring genetic material from certain insect-destroying microorganisms to hybrid seed. Genetic control has been widely used in the past and offers great promise for the future, especially when combined with new gene manipulation techniques.

Chemical Controls

Chemical controls are pesticides that are either naturally derived or synthesized. Pesticides often play a key role in pest management programs and frequently may be the only control method available. Major benefits associated with the use of pesticides are their effectiveness, the speed and ease of controlling pests, and, in many instances, their reasonable cost compared with other control options. Usually pest damage stops or pests are destroyed within a few hours (for insects) to a few days (for weeds) after application of a pesticide. Using a fungicide may provide immediate, short-term protection against microorganisms.

A **pesticide** is defined as any material that is applied to plants, the soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth. Pesticides include a wide assortment of chemicals with specialized names and functions. They are commonly grouped according to the type of pest they control.

- **Avicides** control pest birds.
- **Bactericides** control bacteria.
- **Disinfectants (antimicrobials)** control microorganisms.
- **Fungicides** control fungi.
- **Herbicides** control weeds and other undesirable plants.
- **Insecticides** control insects and related arthropods.
- **Miticides (acaricides)** control mites.
- **Molluscicides** control snails and slugs.
- **Nematicides** control nematodes (roundworms).
- **Predacides** control predatory vertabrates.
- **Piscicides** control pest fish.
- **Repellents** repel insects, related invertebrates, birds, and mammals.
- **Rodenticides** control rodents.
- **Defoliants** cause leaves or foliage to drop from plants.
- **Desiccants** promote drying or loss of moisture from plant tissues.
- **Growth regulators** are substances (other than fertilizers or food) that alter the growth or development of a plant or animal.

Each group of pesticide includes several classes or families. For example, the classes of insecticides include, among others, the organophosphates, organochlorines, carbamates, pyrethroids, botanicals, insecticidal soaps, and microbials. The pesticides within a particular class have similar chemical structures or properties or share a common **mode of action**. The mode of action of a pesticide is how the pesticide works. In other words, it is what specific system(s) in the pest are affected by the pesticide. The various classes of chemicals

work in different ways and present different risks and problems.

Pesticides also vary in their **selectivity**. Fumigants, for example, are non-selective, controlling a wide variety of pests—fungi, insects, weeds, nematodes, etc. Some non-selective herbicides control any plant given a sufficient dose. In contrast, selective products control only certain species of pests or affect only a certain stage of pest development. For example, certain herbicides control broadleaf weeds while not harming grasses, and ovicides kill only the eggs of certain insects, mites, and related pests.

Pesticides may move in various ways after they come in contact with a host. **Systemic pesticides** are absorbed through leaves or roots and then transported within the treated plant. Similarly, systemic insecticides can be eaten by or injected into livestock to control certain pests. By contrast, **contact pesticides** are not absorbed by treated plants or animals. These pesticides must directly touch the pest or a site the pest frequents to be effective (see Figure 1.2).

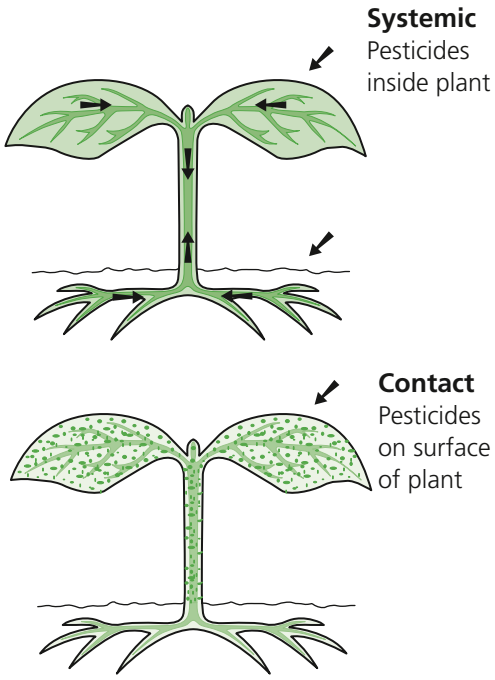
Pesticides also vary in their **persistence,** or how long they remain active to control pests. Some **residual pesticides** control pests for weeks, months, or even years. Others provide only short-term control, sometimes lasting only a few hours.

The production, sale, use, storage, and disposal of all pesticides are regulated at both the federal and state levels. The federal laws and regulations governing all aspects of pesticide use and handling are covered in Chapter 2.

Regulatory Pest Control

Some pest problems cannot be controlled successfully at a local level. These problems involve pests that seriously endanger public health or are likely to cause widespread damage to agricultural crops or animals, forests, or ornamental plants. Quarantine or eradication programs directed by governmental agencies according to federal and state laws are used to prevent the introduction and spread of such pests.

Quarantine is a pest control process designed to prevent entry of pests into pest-free areas. Some states maintain inspection stations at all major entry points to intercept pests or materials that might harbor pests. Regulatory agencies monitor airports and ocean ports. Quarantine also prevents movement of designated pests within a state. Produce and other identified items being shipped from a quarantine area must be fumigated to destroy pests before shipment. Nursery stock, plant cuttings, and budding and grafting material are also regulated to prevent the spread of pests.



Adapted from Penn. State *Pesticide Education Manual*

Figure 1.2
Systemic and contact pesticides on treated plants.

Eradication is the total elimination of a pest from a designated area; often, these pests are under quarantine restrictions. When eradication is required, the geographical extent of pest infestation is determined and control measures are taken to eliminate this pest from the defined area. Procedures may include an areawide spray program, releasing sterile insects, using mechanical and cultural practices, and intensive monitoring for pests within and around the borders of the infested area.



USDA APHIS

USDA regulates and inspects imported cargo to prevent pest introduction.

Government agencies are authorized to destroy weeds and plants that cause fire hazards, harbor harmful pathogens or animals, or are noxious to people or livestock in and around agricultural areas. Similar authority applies to diseased or infected livestock or poultry and to weeds and nuisance plants in residential, commercial, and industrial areas. Mosquito abatement is an important pest control function undertaken to protect public health. Under the authority of mosquito abatement laws, state agencies drain or treat standing water that provides breeding sites for mosquitoes.

INTEGRATED PEST MANAGEMENT (IPM)

Pesticide use is and will continue to be significant in food and fiber production, forestry, turf and landscape maintenance, and public health. In recent years, pest management has shifted from relying heavily on pesticides to using an integrated approach based on pest assessment, decision making, and evaluation. Using integrated pest management has benefited pest managers and the environment, and has reduced the occurrence of pesticide resistance in pest populations.

Integrated pest management (IPM) is a balanced, tactical approach to pest control. It involves taking action to anticipate pest outbreaks and to prevent potential damage. IPM is a pest management strategy that utilizes a wide range of pest control methods or tactics. The goal of this strategy is to prevent pests from reaching economically or aesthetically damaging levels with the least risk to the environment. Such pest management programs—based on the identification of pests, accurate measurement of pest populations, assessment of damage levels, and knowledge of available pest management strategies or tactics—enable the specialist to make intelligent decisions about control. IPM offers the possibility of improving the effectiveness of pest control programs while reducing some of the negative effects. Many successful IPM programs have reduced energy and pesticide use. IPM programs are very site-specific.

Integrated Pest Management (IPM)

A pest management strategy that utilizes a wide range of pest control methods or tactics. The goal of this strategy is to prevent pests from reaching economically or aesthetically damaging levels with the least risk to the environment.

Why Practice IPM?

You might be wondering why pest managers have shifted to IPM when chemical pesticides so often succeed at controlling pests. There are many reasons to broaden pest management beyond the use of chemicals.

IPM helps to keep a balanced ecosystem— Every ecosystem, made up of living things and their non-living environment, has a balance; the actions of one kind of organism in the ecosystem usually affect other species. Introducing chemicals into the ecosystem can change this balance, destroying certain species and allowing other species (sometimes pests themselves) to dominate. Pesticides can kill beneficial insects that consume pests, leaving few natural mechanisms of pest control.

Pesticides can be ineffective— Chemical pesticides are not always effective. As mentioned earlier, pests can become resistant to pesticides. In fact, some 600 cases of pests developing pesticide resistance have been documented to date, including many common weeds, insects, and disease-causing fungi. Furthermore, pests may survive in situations where the chemical does not reach pests, is washed off, is

applied at an improper rate, or is applied at an improper life stage of the pest.

IPM can save money— IPM can avoid crop loss and landscape and structural damage caused by pests and prevent unnecessary pesticide expense. Applicators can save on pesticide costs because the need for control rather than the calendar is the basis for applying pesticides.

IPM promotes a healthy environment— We have much to learn about the persistence of chemicals in the environment and their effect on living creatures. Cases of contaminated groundwater appear each year, and disposal of containers and unused pesticides still pose challenges for applicators. Make sure that environmental impacts are considered in any pest management decisions. Using IPM strategies helps keep unreasonable adverse effects to a minimum.

IPM maintains a good public image— IPM is now demanded by many sectors of our society. IPM has been implemented to grow our food, to manage turf and ornamentals, to protect home and business structures, to manage school grounds, and to protect humans, pets, and livestock health.

Components of IPM

All of the components of an IPM approach can be grouped into five major steps: identify the pest and understand its biology, monitor the pest to be managed, develop a sound pest management goal, implement an IPM program, and record and evaluate results.

1. Identify the Pest and Understand its Biology— Despite our best preventive efforts, some pest outbreaks inevitably occur. The first step in any pest management program is to identify the pest. Never classify an organism as a pest or treat it as a pest until it is clearly determined to be one. Identification is important whether you are dealing with an insect, weed, plant disease, or vertebrate.

The more that you know about a pest, the easier and more successful pest management becomes. Once you have identified a pest, you can access information about its life cycle and behavior, the factors that favor development, and the recommended control procedures. You can also determine the significance of the pest and the need for control. Some pests have little impact on a plant, animal, or structure and do not require control. Other pests warrant immediate control because they cause serious damage or present a significant threat to human health or public safety.

Most pests may be classified either as key pests, occasional pests, or secondary pests.

Key pests may cause major damage on a regular basis unless they are controlled. Many weeds, for example, are key pests because they compete with crop or ornamental plants for resources and require regular control efforts to prevent or reduce damage.

Occasional pests become troublesome only once in a while because of their life cycles or environmental influences, or as a result of human activities. For instance, ants sometimes become occasional pests when sanitation practices change, providing them with food where previously none existed. They also may move into buildings after a rainfall or other event destroys an outdoor food source.

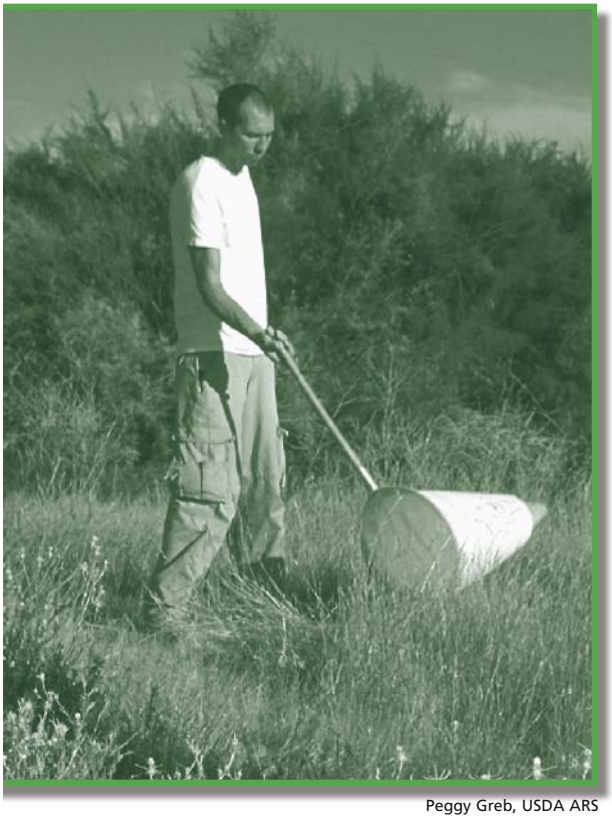
Secondary pests become problems when a key pest is controlled or eliminated. For example, some weed species become pests only after key weeds, which are normally more successful in competing for resources, are controlled. Certain species of fleas, ticks, and blood-feeding bugs attack people only when their natural hosts, such as pet dogs or cats, are no longer present.

2. Monitor the Pest to be Managed— The key to a successful IPM program is regular monitoring. Monitoring involves measuring pest populations and/or the resulting damage or losses. The procedures for monitoring vary with the pest and the situation.

Scouting and trapping are commonly used to monitor insects and their activity. Weather and temperature data

Why Practice IPM?

- IPM helps to keep a balanced ecosystem.
- Pesticides can be ineffective.
- IPM can save money.
- IPM promotes a healthy environment.
- IPM maintains a good public image.



Peggy Greb, USDA ARS

Pest monitoring by using a sweep net.

are particularly helpful in following a pest's life cycle or in predicting how long it takes a certain pest to develop. Models have been developed for a number of insects and plant diseases to predict the need for and timing of pesticide applications.

Use Pest Population Thresholds

Producers of agricultural or ornamental products must understand the concept of economic thresholds. The presence of a pest does not always cause a loss in quality or quantity of an agricultural or ornamental product. To justify the cost of control, pest populations must be large enough to cause significant damage. This population level is called the **economic threshold (ET)**. The economic threshold is the pest population density (number of pests per unit of area) at which control measures are needed to prevent the pest from reaching the economic injury level. The **economic injury level (EIL)** is the pest population density that causes losses equal to the cost of control measures. To make a control practice profitable, or at least break even, it is necessary to set the ET below the EIL (see Figure 1.3). Otherwise, producers lose money, first from the damage caused by the pest, and then by the cost of applying the control. Setting the ET below the EIL triggers pesticide application and other controls before pests reach the economic injury level.

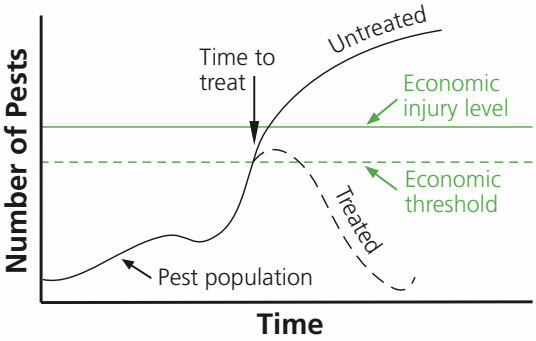


Figure 1.3
To make a control practice profitable, or at least break even, it is necessary to set the economic threshold (ET) below the economic injury level (EIL).

Economic thresholds are available for many pests and crops. Several factors can influence an economic threshold. These factors include the current value of the agricultural or ornamental product, its stage of development, the degree of damage caused under various environmental conditions, the cost and effectiveness of control measures, and the anticipated yield. For example, even slight damage to an ornamental or floricultural crop may reduce the value significantly and render it unsalable, so the economic threshold must be set quite low.

For pest managers who are not directly involved in production, the concept of **action thresholds** is more appropriate. An action threshold is the pest level at which some type of pest management action must be taken. It is a predetermined pest level that is deemed to be unacceptable. Factors besides economics come into consideration for establishing action thresholds. In some situations, the action threshold for a pest may be zero (i.e., no presence of the pest is tolerated). This is especially true when the pest is capable of transmitting a human pathogen (mosquitoes and the West Nile virus), has a venomous bite or sting (some spiders, wasps), or may create a public health emergency (cockroaches, rodents). In an urban landscape, action thresholds must consider not only the economic value of the landscape but also its ecological and aesthetic roles. Even a slight amount of pest damage may be unacceptable in such an environment. Action thresholds can vary by pest (a stinging insect in a classroom vs. an ant), by site (a storage room vs. a school infirmary), and by season (some pests are present only a few weeks out of an entire year). Often the action threshold is expressed as the number of pests per unit area. Below the action threshold level, IPM technicians do not use any control measures, though they should continue to monitor the situation and do sanitation inspections as needed. Once a pest is at or above the action threshold, the technician should implement a full range of IPM strategies to control the pest.

Action thresholds are easy to understand, but establishing them is more difficult. In a new IPM program, a practical approach is to establish an arbitrary action threshold for the major pests you encounter. As you gain insight and experience into specific pest management settings, the action levels can be revised up or down.

3. Develop the Pest Management Goal—The goal of most IPM programs is to maintain pest damage at economically acceptable levels. Prevention and suppression techniques are often combined in an effective IPM program. In rare instances, eradication may be the goal of an IPM program. Once the goal of the program has been determined, the strategy for a sound IPM program is to coordinate the use of multiple tactics into a single integrated system. Pesticides are just one method for controlling pests. Non-chemical methods may provide longer and more permanent control of a pest and should always be considered when developing a pest management strategy. Evaluate the costs, benefits, and liabilities of each control tactic.

Prevention

Often economical and environmentally sound ways are available to prevent loss or damage from pests. Such techniques include planting weed- and disease-free seed and growing varieties of plants resistant to diseases or insects. Other choices are using cultural controls to prevent weedy plants from seeding and choosing planting and harvesting times that minimize pest problems. Sanitation methods often reduce the buildup of pests. Other preventive methods involve excluding pests from the target area or host and using practices that conserve natural enemies. Making sure that plants, poultry, or livestock receive adequate water and nutrients often reduces stress and susceptibility to diseases or pests.

Pesticides are sometimes used for pest prevention. For instance, growers treat some crops and landscapes with preplant or preemergence herbicides because they know weed seeds are present. If plant pathogens have already infected susceptible plants, economic damage usually cannot be prevented. For this reason, fungicides are normally applied before infection occurs whenever environmental conditions favor infection. Likewise, pesticides are applied to structural lumber before construction to protect it from insects and fungi.

Suppression

Suppressive pest control methods are used to reduce pest population levels. The methods chosen usually do not eliminate all pests but reduce their populations to a tolerable level or to a point below an economic injury level; additional suppressive measures may be required. Suppression sometimes lowers pest populations so natural enemies are able to maintain control. Suppression is the goal of most pesticide applications. Other techniques, such as cultivation or mowing of weeds and release of biological control agents, are also used to suppress pest populations.

Eradication

Eradication is the total elimination of a pest from a designated area. This is a common objective of pest control efforts in buildings or other small, confined spaces where, once the pest is eliminated, it can be excluded. For example, eliminating cockroaches, rats, and mice from commercial food establishments involves eradication. Over larger areas, however, eradication is very expensive and often has limited success. Large eradication programs are usually directed at exotic or introduced pests posing an areawide public health or economic threat. Such programs are generally coordinated by governmental agencies. Efforts to eliminate Mediterranean fruit fly and hydrilla (an aquatic weed) in California and Florida, respectively, are examples of this type of pest management.

The pest control strategy you choose depends on the nature of the pest, the environment of the pest, and economic or tolerance considerations. Combining prevention and suppression techniques usually enhances a pest management program. Objectives sometimes differ, however, for the same pest in different situations. For example, the Mediterranean fruit fly (Med fly) is an established pest in Hawaii, so the emphasis there is to use prevention and suppression techniques to reduce crop damage. Regulatory agencies in California and Florida, however, use eradication measures to

Components of IPM

1. Identify the pest and understand its biology.
2. Monitor the pest to be managed.
3. Develop the pest management goal.
4. Implement the integrated pest management program.
5. Record and evaluate results.

prevent the Mediterranean fruit fly from becoming permanently established in these states.

4. Implement the Integrated Pest Management Program— The following steps should be taken before implementing an IPM program:

- Identify the pest.
- Set up a monitoring program.
- Know the pest level that triggers control.
- Know what control methods are available.
- Evaluate the benefits and risks of each method.

When implementing the IPM program, try to select the methods that are the most effective and the least harmful to people and the environment. Use several methods whenever possible, and be sure to use them correctly. It is also important to observe all local, state, and federal regulations regarding the methods chosen.

5. Record and Evaluate Results— It is extremely important to record and evaluate the results of your control efforts. Some control methods, especially non-chemical procedures, are slow to yield measurable results. Other methods may be ineffective or even damaging to the target crop, animal, treated surface, or natural predators and parasites. Consider how well your strategies work and their impact on the environment before implementing them again.



EFFECTIVENESS OF PEST MANAGEMENT PROGRAMS

Pesticides often play a significant role in pest management programs. Their use requires certain precautions be taken to avoid the development of resistant pest populations. Although pest resistance can occur, it does not cause every pesticide failure. Make sure that you have used the correct pesticide and the correct dosage, and that you have applied the pesticide according to label instructions. Sometimes a pesticide application fails to control 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 the correct time—the pest may not have been in the area during the application, or it may have been in a life cycle stage or location where it was not susceptible to the pesticide. Also, remember that the pests that are present may be part of a new infestation that developed long after the chemical was applied.

Even non-chemical pest management tactics become ineffective if the pest and the susceptible stage(s) of its life cycle are not identified correctly. Successful pest management programs do not happen by accident—they depend on careful observation, a thorough knowledge of the pest and the damage it causes, an understanding of all available pest control options, and a caring, professional attitude.

Pesticide Resistance

Pesticide resistance can be defined as the ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it. Resistance develops because intensive pesticide use kills the susceptible individuals in a population, leaving only the resistant ones to reproduce. Initially, higher labeled rates and more frequent applications are needed to control resistant pests. Eventually, however, the pesticide

will have little or no effect on the pest population (see Figure 1.4).

Resistance may develop to only a single insecticide, fungicide, herbicide, or rodenticide. More often, however, pest populations become resistant to all chemically related pesticides in a class of compounds. It is also possible for a pest to develop resistance to pesticides in two or more classes of compounds with unlike modes of action.

Continual use of pesticides from the same chemical class, such as all organophosphate or all pyrethroid insecticides, increases the likelihood that resistance will develop in pest populations. Frequent applications and persistence of the chemical further increase the chances of resistance occurring. Finally, the spread of resistance through a pest population can occur much more rapidly in pests that have many generations per year and many offspring per generation, such as many insects, fungi, and rodents.

Several pest management tactics help prevent or delay the occurrence of pesticide resistance. One approach involves the use of new or altered pesticides. Using new compounds with different modes of action will lessen the likelihood of resistance developing in a population. Unfortunately, new replacement products are often quite complex, difficult to synthesize, and very costly to develop, and they have very specific modes of action, which can rapidly lead to the development of resistant pest populations even after very limited use in the field. No longer can we expect to respond to pesticide resistance by merely substituting one pesticide for another.

Changing pesticide use patterns is an important step in preventing resistance. When dosages are reduced, fewer pests are killed, so the pressure to develop resistant pest populations is decreased. Applying pesticides over limited areas reduces the proportion of the total pest population exposed to the chemical, thereby maintaining a large pool of individuals still susceptible to the pesticide. This tactic has a tendency to delay the development of a resistant population because pesticide-susceptible individuals in the population continue to interbreed with resistant ones, thus diluting the resistance in the population. Also, treating alternate generations of pests with pesticides that have different modes of action decreases the selection pressure for resistance.

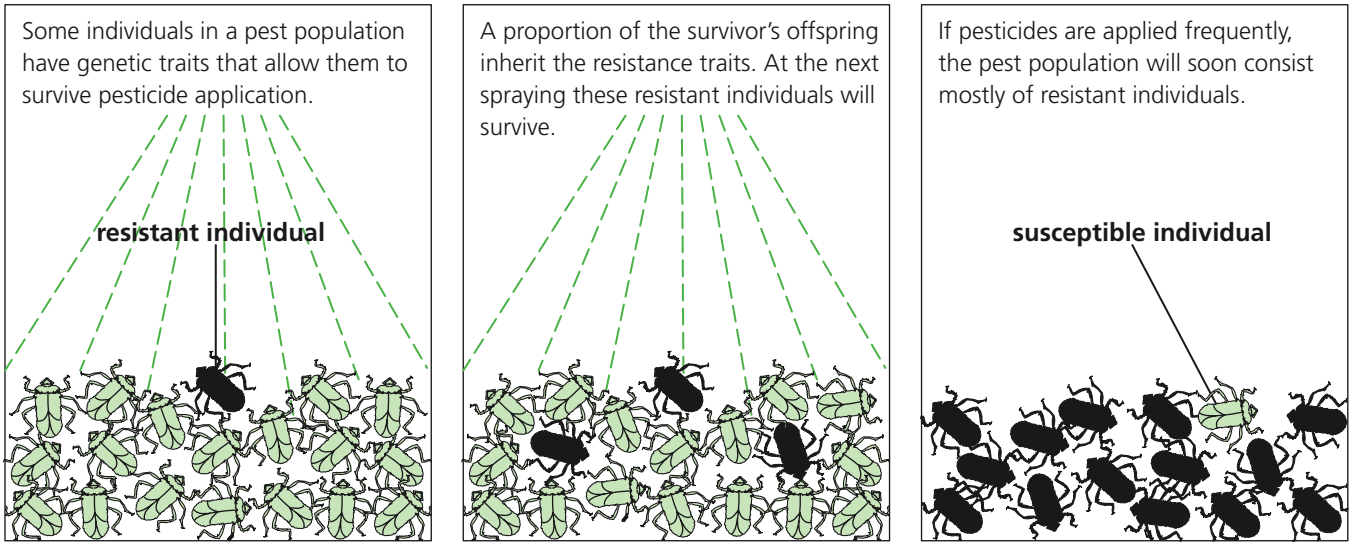
Managing pesticide resistance is a very important aspect of integrated pest management. Monitor pest populations carefully and treat only when necessary, rather than treating on a calendar basis. Good pesticide application records are

Resistance Management

- Use new or altered pesticides.
- Change pesticide use patterns.
- Treat only when necessary.

Figure 1.4 Pest resistance

Adapted from U. of C. *The Safe and Effective Use of Pesticides*



an important component of resistance management. Pesticides are more effectively managed when treatment history is known. Resistance must be detected when it is at a very low level and then controlled by using all available pest management techniques to extend the useful life of our current pesticides.

SUMMARY

To be successful, a pest management program must start with the proper identification of the pest. Choosing the appropriate pest control method depends on recognizing and understanding the pest, its life cycle, habits, and habitat. Integrated pest management (IPM) programs attempt to balance the need for pest control with the desire to protect the environment from risks associated with pesticide use. IPM methods include both chemical and non-chemical means to prevent and control pest populations from reaching economically damaging levels. These prevention and control tactics include biological, mechanical, cultural, physical, genetic, chemical, and regulatory methods.

Monitoring techniques used in IPM programs are critical to knowing when and what type of control measures to apply. Monitoring also helps to establish pest population thresholds that may be used for deciding when pest control action should be taken. Evaluation and recording results help to determine how well the IPM program is working and whether there are any harmful human or environmental effects.

Minimizing pesticide resistance is also an important consideration for sustaining the effectiveness of pest management programs. Many tools and techniques are available (e.g., rotation of pesticide types with different modes of action, application of pesticides that do not leave persistent residues, application of pesticides at below-label amounts) that prevent or delay the occurrence of pesticide resistance. Whenever chemical controls are used, it is critical to read and follow all label directions correctly to avoid misapplication.

If the pest has not been properly identified, even non-chemical means of pest control will fail. It is the applicator's responsibility to consider all of the factors relevant to the pest control situation. Beyond simply identifying the pest and choosing a control strategy, the applicator must consider the effects of pest control actions on the entire treatment site, whether an outdoor area or inside a structure. Use good judgment, especially when pesticides are part of the control strategy, to avoid harmful effects to other living organisms and the environment.

Review Questions

CHAPTER 1: Pest Management

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

1. **Using barriers to prevent pests from getting into an area is an example of which type of pest management method?**
   - **A.** Biological control.
   - **B.** Mechanical control.
   - **C.** Genetic control.
   - **D.** Chemical control.

2. **Lowering the humidity of stored grains and other food products to reduce damage from mold is an example of which type of pest management method?**
   - **A.** Biological.
   - **B.** Mechanical.
   - **C.** Physical/environmental modification.
   - **D.** Regulatory pest control.

3. **Which statement is *true* about biological control methods?**
   - **A.** If pesticides are part of a biological control program to control an exotic pest, it is better to apply them at the strongest label rate and to choose the more toxic pesticides.
   - **B.** Modifying the environment to enhance natural enemies is a recommended practice in biological control.
   - **C.** Biological control involves the importation of exotic pests to control natural enemies.
   - **D.** Using several cultural practices and a wide variety of pesticides works best in biological control.

4. **Sealing cracks and crevices and small openings in buildings is an example of which type of mechanical control method?**
   - **A.** Exclusion.
   - **B.** Trapping.
   - **C.** Cultivation.
   - **D.** Mulching.

5. **Which statement is *true* about cultural control practices?**
   - **A.** Cultural practices alter the environment, the condition of the host, or the behavior of the pest to prevent or suppress an infestation.
   - **B.** Trapping is an important cultural control practice.
   - **C.** Sanitation is not considered a cultural practice.
   - **D.** Cultural controls involve the release of parasites and predators found in foreign countries.

6. **Which statement is *true* about regulatory pest control?**
   - **A.** Pests that pose a serious public health threat are rarely regulated by federal and state agencies.
   - **B.** Pests that are to be eradicated are rarely under quarantine restrictions.
   - **C.** Airports and ocean ports are monitored by pest quarantine regulatory agencies.
   - **D.** Entry of pests across state lines is not regulated.

7. **Which statement is *true* about pest management strategies in IPM?**
   - **A.** The goal is often to maintain pest damage at economically acceptable levels.
   - **B.** Eradication is never the goal of an IPM program.
   - **C.** Pesticides are not included in an IPM strategy.
   - **D.** Non-chemical methods usually provide only short-term control of a pest.

8. **Which would be considered a preventive pest management strategy?**

   A. Planting weed- and disease-free seed.
   B. Releasing natural enemies to help reduce pest populations.
   C. Eliminating rodents from a commercial food establishment.
   D. Removing from an area a pest that is a public health concern.

9. **Which statement is *true* about action thresholds?**

   A. The IPM technician needs to implement control measures below the action threshold level.
   B. The action threshold for a pest may be set at a zero pest population density.
   C. Action thresholds are usually easy to establish.
   D. In an urban landscape, action thresholds are usually more related to economics than aesthetics.

10. **Which would increase the likelihood of pesticide resistance?**

    A. An insect has only one generation per year.
    B. Continual use of the same pesticides or pesticides from the same chemical class.
    C. Limiting the number of pesticide applications.
    D. Applying a pesticide that has little or no residual effect.

CHAPTER 2

FEDERAL PESTICIDE LAWS

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to follow laws and regulations related to pesticide use.
- Know how to ensure that operation records, including application records, are accessible to officials.
- Understand the importance of maintaining records of pesticide applications (e.g., amounts, pests, dates, locations, registration numbers).
- Understand the importance of maintaining training records of persons handling pesticides.

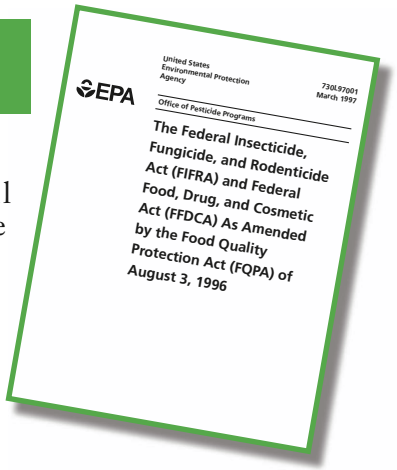


To protect public health and welfare and to prevent adverse effects to the environment, pesticides must be regulated. The purpose of the federal and state pesticide acts is to regulate in the best public interest the labeling, sale and distribution, storage, transportation, use and application, and disposal of pesticides. In essence, pesticides are under regulatory scrutiny from the time of their inception in the laboratory to their ultimate use in the field or their disposal in an approved manner. With the possible exception of human and veterinary drugs, no other class of chemicals receives such extensive testing in the United States before being registered and marketed.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

The U.S. Congress enacted legislation that regulates the production, transportation, sale, use, and disposal of all pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act, commonly referred to by its initials, FIFRA, was enacted in 1947. It was amended considerably in 1972, then again in 1975, 1978, and 1988. This statute is administered by the U.S. Environmental Protection Agency (EPA).

FIFRA provides the overall framework for the federal pesticide program. Under FIFRA, the EPA is responsible for registering or authorizng pesticide products for use in the United States. Pesticide registration decisions are based on a detailed assessment of the potential effects of a product on human health and



the environment when used according to label directions. These approved labels have the force of law. Anyone who uses a pesticide in any way not in accordance with the label directions and precautions may be subject to civil and/or criminal penalties. FIFRA also requires that the EPA reevaluate older pesticides to ensure that they meet more recent safety standards. FIFRA requires the EPA, states, tribes, and territories to establish programs to protect workers, and to provide training and certification for applicators.

The Environmental Protection Agency (EPA) is the agency responsible for administering the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

A major provision of FIFRA gives EPA the authority to stop the sale or use of any pesticide. The EPA can issue removal orders and seize products to keep them out of the market. Also, state restrictions on pesticides cannot be more liberal than those of FIFRA. Individual states may impose stricter regulations on a pesticide, but the labeling and packaging must be uniform nationwide. Uniform packaging standards include container type, size, and color.

Under FIFRA, all pesticides are classified according to their potential hazards under the circumstances in which they are to be used. The two main classifications are **unclassified use** and **restricted use**, though unclassified pesticides are commonly referred to as **general-use pesticides**. It should be noted that the EPA has classified very few pesticides as general use. Most pesticides that might be expected to fit into the general-use category currently remain unclassified. Normally they have a lower toxicity than restricted-use pesticides and so less potential to harm humans or the environment. They can be bought and used by the general public without special permits or restrictions. The EPA classifies a pesticide as restricted use if use of the pesticide might result in an unreasonable adverse effect on human health and/or the environment; however, application by trained persons according to label directions would protect against such an effect. This restricted-use classification must be stated on the label.

Some active ingredients in pesticides may be listed in both use categories, depending on the formulation, the application method, and the intended uses. For example, an emulsifiable concentrate formulation of a certain insecticide used on fruit trees might be classified as restricted use if it contains a high percentage of active ingredient (e.g., 70 percent). But the same chemical with a low percentage of active ingredients—e.g., 5 percent in a granular formulation used to treat turf insects—could be classified as a general-use pesticide.

Restricted-use pesticides (RUP) may be sold only to certified applicators. A **certified applicator** is an individual who has been recognized (certified) by the state, tribe, territory, or agency responsible for regulating pesticides as being competent to use or supervise the use of restricted-use pesticides. Certified applicators must know how to read a pesticide label and be able to follow directions to use them properly and safely. Under FIFRA there are two types of pesticide applicators—**private** and **commercial.** A **private applicator** is defined as a certified applicator who uses or supervises the use of any restricted-use pesticide for the purpose of producing an agricultural commodity (e.g., field and forage crops, fruit, vegetables, nursery stock, Christmas trees, greenhouse plants, livestock, etc.) on his/her own property or property he/she rents or leases. **Commercial applicators**



Restricted-use pesticides (RUPs) may be sold only to certified applicators.

are individuals who use or supervise the use of any restricted-use pesticide for any purpose on any property except for those provided for under the definition of a private applicator.

Only certified applicators or individuals under their direct supervision may mix, load, or apply restricted-use pesticides. To become certified, a person must exhibit a broad-based knowledge of and competency in pesticide use and handling. This provides an alternative to more stringent controls on, or even cancellation of, the use of these pesticides.

The certified applicator is not permitted to use any pesticide for any use other than that stated on the label except when specific exemptions are granted under Section 2 (ee) of FIFRA. Section 2 (ee) contains provisions that exclude several application procedures from being classified as uses "inconsistent with product labeling." (Note: Not all regulatory agencies recognize the provisions of Section 2 [ee] under FIFRA. Before making pesticide applications, you need to consult your pesticide regulatory agency to see if your respective state, tribe, territory, or agency recognizes these provisions.) These provisions allow:

- A pesticide may be applied to control a target pest not specified on the label if the pesticide is applied to a crop, animal, or site specifically listed on the label (e.g., interior of a home, food-handling establishments, exterior ornamental plants, corn, tomatoes, etc.).
- Any method of application may be used that is not prohibited by the label.
- A pesticide may be applied at a dosage, concentration, or frequency less than that specified on the label, except in the case of termiticides labeled for preconstruction treatments.
- A pesticide-fertilizer mixture may be used if the mixture is not prohibited by the label.

The certification process by all the states, tribes, and territories must be accomplished through EPA-approved programs. Each state is responsible for implementing the certification program. In addition, all states have signed cooperative agreements with the EPA that designate an agency within the state (i.e., the **state lead agency**) to enforce the provisions of FIFRA. In some situations, more than one agency within a state may be designated to enforce various components of FIFRA (e.g., some states have structural pest control boards responsible for regulating the structural pest control industry).

States, tribes, territories, and some local jurisdictions have their own legal requirements concerning pesticide use. You are responsible for knowing about these requirements and complying with them. Be sure you are up-to-date on 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.

Only certified applicators or individuals under their direct supervision may mix, load, or apply restricted-use pesticides.

PESTICIDE REGISTRATION

No pesticide can be registered or offered for sale unless its labeling provides for reasonable safeguards to prevent injury to humans and adverse effects on the environment. There are several types of registration and exemption actions that enable pesticides to be used in the United States:

- The federal registration of pesticides under Section 3 of FIFRA.
- Special local need registrations under Section 24(c).
- Emergency exemptions under Section 18.
- Exemption of minimum-risk pesticides from registration under Section 25(b) of FIFRA.

All of these registration and exemption actions are discussed in detail in Chapter



An example of a label for a Section 24(c) special local need registration.

3, Pesticide Labeling.

Another process involves experimental use permits (EUPs). Under Section 5 of FIFRA, EUPs allow manufacturers to field test pesticides under development. Manufacturers of conventional pesticides are required to obtain experimental use permits before testing new pesticides or new uses of pesticides if they conduct experimental field tests on 10 or more acres of land or one or more acres of water. **Biopesticides** (i.e., pesticides derived from natural materials) also require EUPs when used in experimental settings.

The EPA also has a role in regulating devices used to control pests. A "device" is any instrument or contrivance (other than a firearm) intended for trapping, destroying, repelling, or mitigating any pest. A black light trap is an example of a device. Unlike pesticides, the EPA does not require devices to be registered with the agency but does require the producing establishment to be registered. Devices are subject to certain labeling, packaging, record-keeping, and import/export requirements.

PESTICIDE REREGISTRATION

Since the passage of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) amendments in 1988, the EPA has been conducting a comprehensive review of older pesticides (those initially registered before November 1, 1984) to consider their health and environmental effects and to make decisions about their future use. The EPA examines health and safety data for these pesticide active ingredients and determines whether they are eligible for reregistration. To be eligible, a pesticide must have a substantially complete database and must not cause unreasonable risks to human health or the environment when used in accordance with its approved label directions and precautions.

FIFRA, as amended in 1996 by the Food Quality Protection Act (FQPA), requires that all pesticides meet new safety standards. The EPA must be able to conclude "with reasonable certainty" that no harm will come to infants, children, or other sensitive individuals exposed to pesticides. All pesticide exposures from food, drinking water, and home and garden use must be considered in determining allowable levels of pesticides in food. The cumulative effects of pesticides and other compounds with common mechanisms of toxicity also must be considered.

Through the reregistration program, the EPA is ensuring that older pesticides meet contemporary health and safety standards and product labeling requirements, and that their risks are moderated. In addition, the FQPA created a new program that requires the EPA to review every registered pesticide on a 15-year cycle. The public always will have assurance that pesticides are being reviewed periodically to meet current scientific and regulatory standards. Further information on the FQPA can be found later in this chapter.

TOLERANCES

Pesticides are widely used in producing food. These pesticides may remain in small amounts (called residues) in or on fruits, vegetables, grains, other foods, and animal feeds. To ensure the safety of the food supply, the EPA regulates the amount of each pesticide that may remain in food or feed at harvest or slaughter, and their residues are carefully monitored to avoid hazards to humans and domestic animals that eat them.

Before allowing the use of a pesticide on food crops, the EPA sets a **tolerance**, or maximum residue limit, which is the amount of pesticide residue

Tolerance

The maximum pesticide residue limit that may legally remain on or in treated crops and animals or animal products sold for food or feed.

that may legally remain on or in treated crops and animals (and animal products, such as milk or eggs) to be sold for food or feed. The tolerance is the residue level that triggers enforcement actions. Federal agencies monitor food and feed products for tolerance violations. If residues are found above that level, the commodity will be condemned or subject to seizure by the government, and violators may be prosecuted.

In setting the tolerance, the EPA must make a safety finding that the pesticide can be used with "reasonable certainty of no harm." To make this finding, the EPA considers:

- The toxicity of the pesticide and its breakdown products.
- How much of the pesticide is applied and how often.
- How much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed and prepared.

The EPA ensures that the tolerance selected is safe. The tolerance applies to food imported into this country, as well as to food grown in the United States. In addition, there must be a practical method for detecting and measuring levels of pesticide residues so the regulatory officials can ensure that residues are below the level found to be safe.

Several government agencies enforce the EPA's pesticide tolerances in food. The federal Food and Drug Administration (FDA) tests food produced in the United States and food imported from other countries for compliance with these residue limits. State enforcement agencies also check foods produced in this country. In addition, the U.S. Department of Agriculture (USDA) tests meat and milk. The USDA and the FDA have programs designed to develop statistically valid information on pesticide residues in foods. They provide this information to the EPA to use in its risk assessment for pesticides. If USDA staff members detect violations of tolerances in their data collection program, they notify the FDA.

Pesticide companies, or registrants, must submit a wide variety of scientific studies for review before the EPA sets a tolerance. The data are designed to identify possible harmful effects the chemical could have on humans (its toxicity), the amount of the chemical (or breakdown products) likely to remain in or on food, and other possible sources of exposures to the pesticide (e.g., through use in homes or other places).

All of this information is used in the EPA's risk assessment process. The risk assessment includes consideration of the amounts and types of food people eat and how widely the pesticide is used (i.e., how much of the crop is actually treated with the pesticide), as well as chemistry, toxicity, and exposure information. The EPA also uses data from the USDA on what foods people eat and how much they eat, collected through the Pesticide Data Program. Through these evaluations, the EPA is ensuring the overall safety of proposed pesticide uses, as required by the FQPA.

The EPA is reassessing old tolerances for all the pesticide and other ingredient tolerances and exemptions that were in effect as of August 3, 1996, when the Food Quality Protection Act was signed. This effort is designed to ensure that existing tolerances and exemptions meet the safety standard set by the FQPA.

The EPA is giving highest priority to pesticides that appear to pose the greatest risk. This reassessment is a large task—more than 450 pesticides and other ingredients have tolerances or exemptions from the requirement for a tolerance. Approximately 9,700 tolerances were in effect when the



Stephen Ausmus, USDA Agricultural Research Service

A USDA chemist prepares extracts of fruits and vegetables for analysis of pesticide residues.



Ken Hammond, USDA

The EPA uses data from the USDA on what food people eat and how much they eat, collected through the Pesticide Data Program.

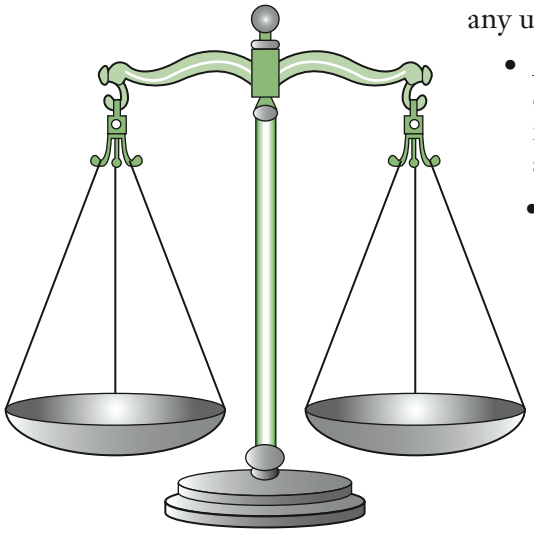
FQPA was passed. Many tolerances can be associated with a given chemical because that chemical might be used on multiple food crops, so the review can be highly complex.

A pesticide applicator cannot measure residues on crops and livestock because such measurements require highly specialized equipment and techniques. But by following labeling instructions, you can be sure that treated products have residues well below the tolerance level when marketed. Especially important are instructions on correct application rate and the minimum number of days allowed between the pesticide application and harvest, slaughter, freshening, or grazing.

VIOLATIVE ACTS AND FEDERAL PENALTIES

A variety of actions by pesticide manufacturers, sellers, and users are unlawful under the provisions of FIFRA. These acts include:

- Distributing, selling, or delivering any unregistered pesticide.
- Making any advertising claim about a pesticide not included in the registration statement.
- Selling any registered pesticide if its content does not conform to label data.
- Selling an adulterated or misbranded pesticide.
- Detaching, altering, defacing, or destroying any part of a container or label.
- Refusing to keep records or permit authorized EPA inspections.
- Making a guarantee other than that specified by the label.
- Advertising a restricted-use pesticide without giving the product classification.
- Making a restricted-use pesticide available to a non-certified applicator (except as provided by law).
- Using a pesticide in any manner not consistent with the label.



Both civil and criminal penalties can be assessed for FIFRA violations.

Remember…

The label is the law!

Penalties

Both civil and criminal penalties can be assessed for FIFRA violations.

Civil Penalties

In general, commercial applicators, wholesalers, dealers, and retailers "may be assessed a civil penalty…of not more than $5,000 for each offense" (Section 14 (a)(1) of FIFRA).

The first violation by a private applicator, as defined by statute, results in a warning from the EPA; each subsequent offense is subject to a fine up to $1,000.

In determining civil penalties, Section 14(a)(4) requires the EPA to consider the size of the business, how the penalty affects the ability of the firm to remain in business, and the gravity of the violation. In cases involving only minor violations, the EPA may issue a warning instead of assessing a penalty.

Criminal Penalties

Willful violation of FIFRA provisions is a misdemeanor. Upon conviction, a private applicator is subject to a fine of up to $1,000 and/or 30 days imprisonment; a commercial applicator is subject to a fine of up to $25,000 and/or up to one year imprisonment; and a producer is subject to a fine of up to $50,000 and/or up to one year imprisonment.

Remember, you must use all pesticides according to label directions—**the label is the law!**

OTHER FEDERAL LAWS AND REGULATIONS

As previously discussed, FIFRA is the main federal law regulating pesticide use. The other core statute providing the EPA regulatory authority for pesticides is the Federal Food, Drug, and Cosmetics Act (FFDCA). Other federal laws cover certain pesticide-related activities such as transportation, storage, disposal, protecting the safety of employees, and reporting accidents and spills. Applicators will encounter other laws and regulations that they must be aware of and comply with. In some cases, the pesticide label will alert you to them.

Federal Food, Drug, and Cosmetic Act (FFDCA)

The Federal Food, Drug, and Cosmetic Act (FFDCA) governs the establishment of pesticide tolerances for food and feed products. A tolerance is the maximum level of pesticide residues allowed in or on human food and animal feed. The EPA and the Food and Drug Administration (FDA) are responsible for administering this act.

Food Quality Protection Act (FQPA)

The Food Quality Protection Act (FQPA), passed in 1996, amended both FIFRA and the FFDCA and set a tougher standard for pesticides used on food. The FQPA established a single, health-based standard to be used when assessing the risks of pesticide residues in food or feed. The new safety standard considers the aggregate risk from dietary exposure and other non-occupational sources of exposure, such as drinking water and residential lawn uses. In addition, when setting new or reassessing existing tolerances under the new standard, the EPA must now focus explicitly on exposures and risks to infants and children. Decisions must take into consideration whether tolerances are safe for children—assuming, when appropriate, an additional safety factor to account for uncertainty in data.

Other FQPA requirements include:

- The EPA establishing a tolerance only if there is "a reasonable certainty" that no harm results from all combined sources of exposure to pesticides (aggregate exposures). The FQPA also considers the combined effects of human exposure to different pesticides that may act in similar ways on the body (cumulative exposure).
- The EPA reviewing all old pesticides to make sure that the residues allowed on food meet the new safety standard.
- The EPA testing pesticides for endocrine-disruption potential. Endocrine disruptors may be linked to a variety of sexual, developmental, behavioral, and reproductive problems.
- The EPA distributing a brochure discussing pesticides on foods to supermarkets to better inform the public.



C. DiFonzo, MSU

Figure 2.1
Under FQPA, the EPA must consider both dietary (food) and non-dietary (garden, home, water, pets, etc.) risks of exposure when setting tolerance levels for pesticide residues in food.

Worker Protection Standard (WPS)

The U.S. Environmental Protection Agency's Worker Protection Standard (WPS), as revised in 1992, is a regulation aimed at reducing the risk of pesticide poisonings, injuries, and exposure to agricultural workers and pesticide handlers. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these requirements include owners and operators of agricultural establishments and owners and operators of commercial businesses hired to apply pesticides or to perform crop advising tasks on agricultural establishments. The WPS protects employees on farms, forests, nurseries, and greenhouses from occupational exposure to agricultural pesticides. As part of the WPS, employers must provide pesticide safety



Gary Kramer, USFWS

Endangered mammal—gray wolf.



John and Karen Hollingsworth, USFWS

Endangered bird—northern spotted owl.



John and Karen Hollingsworth, USFWS

Endangered insect—Karner blue butterfly.



T.G. Barnes

Endangered plant—painted trillium.

training to agricultural workers and pesticide handlers and display a pesticide safety poster in the workplace (refer to Appendix D for further WPS requirements).

Endangered Species Act (ESA)

The Endangered Species Act (ESA) is a federal law administered by the U.S. Fish and Wildlife Service (USFWS) of the Department of the Interior. The law makes it illegal to kill, harm, or collect endangered or threatened wildlife or fish, or to remove endangered or threatened plants from areas under federal jurisdiction. It also requires other federal agencies to ensure that any action they carry out or authorize is not likely to jeopardize the continued existence of any endangered or threatened species, or to destroy or adversely modify its critical habitat. Therefore, the EPA must ensure that no registered pesticide use is likely to jeopardize the survival of any endangered or threatened species.

Each state pesticide program is responsible for implementing the federal Endangered Species Protection Program in cooperation with the EPA. Under this program, pesticide products that might adversely affect an endangered species carry a label statement instructing applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product. The EPA is developing these bulletins, which identify precautionary measures in each county. Precautionary measures may include buffer strips, reduced application rates, or timing restrictions, or an applicator might be prohibited from using the pesticide within the identified habitat. (See Appendix D for additional federal laws related to environmental protection.)

FEDERAL RECORD-KEEPING REQUIREMENTS

Application Records

Keeping application records meets the requirements of regulations. It is also a wise practice. Records can prove invaluable as documentation in the event of a complaint or lawsuit. If there is ever a legal claim against an applicator about the suspected use of a pesticide, the pesticide application records provide all information about the pesticides that have been applied and thus protect the applicator by providing documentation. They can also help to determine which pesticide treatments work, which treatments do not work, and why. They can help applicators plan future purchases of pesticides so that they buy only the actual amount needed. This helps avoid costly pesticide product and container disposal problems, helps increase profits, and can help in making decisions about integrated pest management. If medical treatment is needed, pesticide records can provide information necessary to the medical staff. The records also document the steps taken to protect farm workers and the environment. Finally, federal and state surveys often use information voluntarily supplied from pesticide records. The data obtained by these surveys can help show the safety of and the economic need for the use of certain pesticides. In addition, the EPA and USDA use pesticide survey information in determining benefits of pesticides being considered for reregistration. Without current, accurate records to rely on to generate survey data, it is often difficult to show whether a particular pesticide is beneficial.

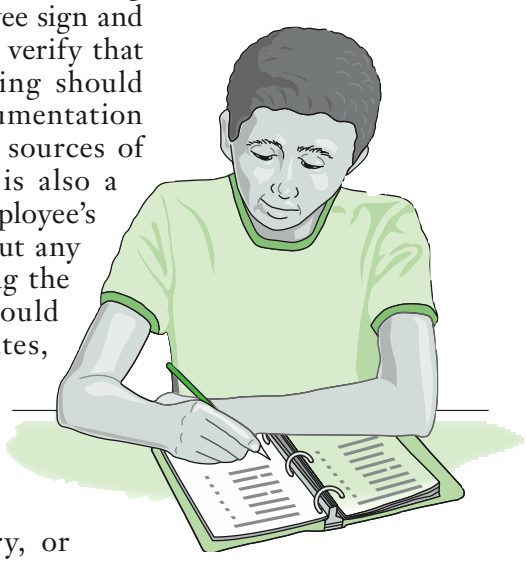
The EPA administers federal record-keeping requirements for commercial applicators, and the USDA administers the requirements for private applicators. Both private and commercial applicators must be aware of the record-keeping requirements for their industry (see Appendix D for a list of requirements).

States, tribes, territories, and other agencies often have their own record-keeping requirements for private and commercial applicators, which may be more stringent than federal standards.

Contact your state, tribe, territory, or agency about applicable requirements.

Maintaining Training Records

Owners and operators of pesticide application businesses should consider keeping documentation on employee training in the use of pesticides. Though not required by federal law through the provisions of either FIFRA or the WPS, this documentation can help substantiate that employees received training on the proper use of pesticides when they were hired. In the case of WPS, it documents that the mandatory training requirements were satisfied. Information such as the employee's name, Social Security number or work identification number, and the date the training was completed should be maintained as part of the training records. Having the employee sign and date the training record to verify that he/she received the training should also be considered. Documentation on training materials and sources of materials that were used is also a good idea. Not only an employee's initial pesticide training but any additional pesticide training the employee may receive should also be documented. States, tribes, territories, and other agencies often have their own record-keeping requirements related to employee training. Contact your state, tribe, territory, or agency about applicable requirements.



Both private and commercial applicators must be aware of the record-keeping requirements for their industry.

SUMMARY

Federal regulations about pesticides are designed to protect the public and the environment from potential adverse effects of pesticides. It is the applicator's responsibility to be familiar with these laws and to comply with the requirements. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the primary law that regulates how pesticides are produced, transported, sold, used, and disposed of. FIFRA also establishes the process for the registration and reregistration of pesticide products and directs the certification of pesticide applicators. All states, tribes, and territories must comply with FIFRA regulations and may establish additional pesticide regulations as long as they are not less stringent than the FIFRA requirements.

Other important pesticide-related laws include the Federal Food, Drug, and Act (FFDCA), the Food Quality Protection Act (FQPA), the Worker Protection Standard (WPS), and the Endangered Species Act (ESA). The FFDCA regulates the tolerances (i.e., the maximum amounts of pesticide residue) that may remain in human food and animal feed. Several government agencies, including the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA), test food and feed products to ensure they do not exceed legal tolerances. To set tolerance levels, the Environmental Protection Agency (EPA) has established a complex process that involves the review of many scientific studies. This process is necessary for ensuring the safety of food and feed products in the United States.

The FQPA, passed in 1996, has set up even more stringent requirements for assessing the risks of pesticide residues in food or feed. Under this new standard, the EPA must now consider the risk of aggregate exposures of pesticides—i.e., not only dietary exposure but other sources of exposure such as residential lawn and home uses of pesticides or residues that may be found in drinking water. The new standard also puts a greater emphasis on the risk of pesticide exposure to infants and children. Under the FQPA, the EPA must review all old and new pesticides to make sure the residues allowed on food and feed meet the new safety standard.

The WPS is a regulation aimed at reducing the risk of pesticide exposure to agricultural workers and pesticide

handlers. Under this regulation, owners and operators of agricultural establishments or commercial businesses must comply with a list of requirements for establishing a safe work environment for employees. Pesticide safety training for all agricultural workers and pesticide handlers is one of the WPS requirements.

The ESA protects endangered or threatened species from harm, including any harm they might encounter from pesticides. Under the Endangered Species Protection Program, pesticide products that might adversely affect an endangered species must carry a statement instructing applicators to consult a county bulletin to determine if they must take any special measures to protect an endangered species when using the product. It is the applicator's responsibility to obtain the bulletin and comply with the special precautions.

Lastly, applicators must be aware of federal record-keeping requirements administered by the EPA for commercial applicators and by the USDA for private applicators. They must also be aware of any pesticide record-keeping requirements mandated by their state, tribe, or territory. Even though it is not a federal requirement, it is a good idea to maintain employee training records. The training records may be required by the applicator's state, tribe, or territory, and training records also document that the WPS safety training requirement has been met.

Laws and regulations about pesticide use are constantly evolving. It is the certified applicator's responsibility to stay current on legal requirements at all governmental levels. By complying with federal and state pesticide laws, the applicator not only avoids penalties but also ensures that pesticides are handled and applied in as safe a manner as possible.

Review Questions

CHAPTER 2: FEDERAL PESTICIDE LAWS

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

1. **Which federal agency is responsible for registering or licensing pesticide products for use in the United States?**
   - **A.** U.S. Environmental Protection Agency (EPA).
   - **B.** U.S. Department of Agriculture (USDA).
   - **C.** U.S. Fish and Wildlife Service (USFWS).
   - **D.** Food and Drug Administration (FDA).

2. **Which federal law governs the establishment of pesticide tolerances for food and feed products?**
   - **A.** Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).
   - **B.** Federal Food, Drug, and Cosmetic Act (FFDCA).
   - **C.** Food Quality Protection Act (FQPA).
   - **D.** Worker Protection Standard (WPS).

3. **Which federal law requires that all pesticides meet new safety standards?**
   - **A.** Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).
   - **B.** Federal Food, Drug, and Cosmetic Act (FFDCA).
   - **C.** Food Quality Protection Act (FQPA).
   - **D.** Worker Protection Standard (WPS).

4. **Which statement about FIFRA is *false*?**
   - **A.** State restrictions on pesticides can be more liberal than those of FIFRA.
   - **B.** Approved pesticide labels have the force of law.
   - **C.** The EPA has the authority to remove pesticide products from the market.
   - **D.** FIFRA regulates the registration and licensing of pesticide products.

5. **Experimental use permits required under Section 5 of FIFRA can be used when conducting experimental field tests on new pesticides or new uses of pesticides on:**
   - **A.** 10 or more acres of land or 1 or more acres of water.
   - **B.** 5 or more acres of land or 1 or more acres of water.
   - **C.** 7 or more acres of land or 2 or more acres of water.
   - **D.** less than 1 acre of land or water.

6. **Both civil and criminal penalties can be assessed for FIFRA violations.**
   - **A.** True.
   - **B.** False.

7. **Which statement about the requirements of the FQPA is *true*?**
   - **A.** For setting new standards, the FQPA considers aggregate exposures to pesticides but not cumulative exposures.
   - **B.** The FQPA does not require review of older pesticides with established residue tolerances on food.
   - **C.** The FQPA does not consider additional safety standards to account for exposure risks to infants and children.
   - **D.** Testing of pesticides for endocrine-disruption potential is required under the FQPA.

8. **Under the federal Endangered Species Protection Program, what must be on pesticide products that might adversely affect an endangered species?**

   A. A label statement advising applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product.
   B. A label statement advising them to consult a local conservation officer for a permit to apply the pesticide.
   C. A label statement prohibiting them from applying pesticides in all areas where endangered species might be harmed.
   D. A label statement that lists the endangered species that might be harmed by the pesticide and how to prevent it.

CHAPTER 3

PESTICIDE LABELING

LEARNING OBJECTIVES

After studying this chapter, you should:



- Know how to distinguish between federal registrations, state registrations, special local need registrations, experimental use permits, and emergency exemptions.
- Know how to identify the common, chemical, and brand names of pesticides on their labels.
- Know how to identify the percentage of active ingredient in a formulation.
- Know how to determine who may use a pesticide and how it may be used on the basis of its use classification (i.e., restricted, unclassified).
- Understand relative hazard levels associated with pesticides whose labels contain the following signal words: DANGER—POISON, DANGER, WARNING, and CAUTION.
- Know how to interpret and follow label instructions (i.e., "directions for use"), warnings, terms, symbols, restrictions, and precautions.
- Know how to interpret and follow personal protective equipment statements and practical treatment/first-aid statements.
- Know how to interpret descriptions of environmental, physical, or chemical hazards and follow necessary precautions.
- Know how to interpret and follow mixing and loading, storage, and disposal statements.
- Know how to interpret and follow directions on restricted-entry statements, early-entry exceptions, preharvest intervals, and plantback/recropping limitations.
- Know how to access and interpret other documents and label referrals (e.g., pest control specialists, Extension agents) about pesticide uses.
- Know how to obtain and review information on material safety data sheets (MSDS).

The pesticide product **label** 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. ***By law, pesticide users are required to comply with all the instructions and use directions found on the pesticide product label.*** **Labeling,** on the other hand, includes the label itself plus all other information referenced on the label or received 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.

EPA APPROVAL OF PESTICIDE LABELING



Larry Schulze, Univeristy of Nebraska

No pesticide may be sold in the U.S. before it has been reviewed by EPA.

No pesticide may be sold in the United States until the federal Environmental Protection Agency (EPA) has reviewed the manufacturer's application for registration and determined that the use of the product does not present an unreasonable risk to humans, wildlife, or the environment. As part of the registration process, the EPA must approve all language that the manufacturer (registrant) proposes to include in the product labeling. Exceptions to this are covered under a specific exemption (see "Minimum-Risk Pesticides" section in this chapter).

The EPA reviews the labeling to make sure it contains all the information needed for safe and effective use of the pesticide product and that the information is backed up by data submitted (or cited) by the manufacturer. The EPA may require the manufacturer to change the labeling if the information is incomplete or incorrect.

The liaison between the EPA and the registrant is the EPA product manager. The role of the product manager is to coordinate the agency's internal review and to monitor the status of the registration. The product manager also facilitates discussion among agency scientists and helps resolve problems that occur during the registration process. The EPA's policy of delegating to one product manager the responsibility for the complete documentation of data on a specific **active ingredient** allows an individual to view the whole picture—i.e., health and safety issues, environmental and wildlife concerns, and product chemistry. Equally important, the product manager helps to coordinate an open line of communication among the EPA, the registrant, and the public.

Only after the EPA has reviewed the labeling and registered the product can a pesticide product be sold for use. If the manufacturer wants to change the information on the labeling after the product and labeling are registered, the EPA must approve the change.

THE LABEL

One of the more important tools for the safe and effective use of pesticides is the product label. Pesticide manufacturers are required by law to put certain information on the label. Failure to heed and follow that information can result in a pesticide accident and legal action against the violator. Labels are legal documents providing directions on how to mix, apply, store, and dispose of pesticide products.

Background of the Label

To appreciate the value of the information on a pesticide label, one must consider the time, effort, and money spent to gather it. The information on a product label is the result of years of research. This information takes a minimum of six years to obtain and costs a chemical company millions of dollars. Chemical companies continually make new compounds and then

screen them for possible pesticide use. For every new pesticide that successfully meets the standards, thousands of other compounds are screened and discarded for various reasons. Once a promising pesticide is discovered, its potential application must be evaluated. If a company believes it has a worthwhile product and a strong possibility exists for a significant sales market, it begins wide-scale testing and label registration procedures. In the development and labeling of a pesticide, the manufacturer is interested in proving not only that the chemical controls the pests but also that it does not cause unreasonable adverse effects. Many kinds of carefully controlled tests are conducted to determine the effectiveness and safety of each pesticide under a wide range of environmental conditions.

Toxicity and Toxicological Tests

How poisonous or dangerous is a pesticide to humans, wildlife, and other organisms? Does the chemical cause any long-term (chronic) effects? Does the chemical cause any skin (dermal) reactions? To determine these and other health effects, researchers administer the pesticide at various dosages to test animals, usually rats and mice. These toxicological tests alone often cost a company several million dollars to complete.

Efficacy or Performance Tests

Does the pesticide control the target pest? The company must have performance data to show that the pesticide controls a particular pest or group of pests on one or more hosts or sites, including plants, animals, soil, and structures. Data must show that the pesticide, when used for its intended purpose and according to directions, is a useful product.

Information is also needed on crop varieties, soil types, application methods and rates, and number of required applications. Tests must show that the pests are controlled, crops or animals are not injured, yield and/or quality has been improved, and that the pesticide definitely provides a worthwhile benefit.

Degradation, Mobility, and Residue Tests

What happens to the pesticide after it is applied? A series of studies is needed to show how long it takes for the compound to break down (degrade) into harmless materials under various conditions. In addition, it is important to know if the pesticide moves through the soil into groundwater or if it moves into the plant from treated soil.

Residue studies are conducted for each method of application on each treated crop or animal. These tests determine how much, if any, of the pesticide residue or its breakdown products remains on or in the crop or animal at the time of harvest or slaughter. From these data, the number of days from the last pesticide application until harvest or slaughter is determined. For each pesticide used on a crop or commodity, the EPA establishes a residue **tolerance,** which is the maximum amount of a pesticide residue that may legally remain on or in food or feed at harvest or slaughter. Tolerances are expressed in parts per million (ppm). For example, the tolerance for carbaryl (Sevin) insecticide on blackberries is 12 ppm; on blueberries, 10 ppm; but only 5 ppm in poultry. Pesticide residues on or in food or feed commodities must not exceed the residue tolerances when the crop or animal (including meat, milk, and eggs) is ready for market or livestock feeding.

Although specific tolerances are not included on product labels, **preharvest intervals** (days to harvest) and/or **preslaughter** intervals (days to slaughter) are often listed on labels of agricultural pesticides. These are the minimum number of days that must pass between the last application of a pesticide and the harvest of crops or the slaughter of livestock. Intervals are set by the EPA to allow time for the pesticide to break down on crops or in livestock. Adhering to these intervals prevents residues greater than EPA-approved tolerances on food, feed, or animal products. Food safety is a concern if residues exceed the EPA tolerance or if residues are found on commodities that do not have a tolerance. Under these conditions, the commodity may be condemned and destroyed.

Effects on Wildlife and the Environment

The company must determine the effects of field applications of the pesticide on wildlife and the environment. Any potentially harmful effects on wildlife and the environment that are recognized during these studies must be included in the environmental impact statement submitted to the EPA.

TYPES OF PESTICIDE REGISTRATION

Section 3 Registrations

You are responsible for applying only pesticides registered or exempted from registration by the EPA and your respective state, territory, or tribe. You may encounter two major types of EPA registrations—Section 3 standard registration or Section 24(c) special local need. In addition, the EPA also allows emergency exemptions from registration (Section 18).



Potential adverse effects of pesticides to wildlife and the environment must be included in environmental impact statements submitted to EPA.

Federal EPA or Section 3 registrations are the most common. Section 3 registrations are granted under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Look for the official EPA registration number that must appear on the label (except for products that the EPA classifies as minimum-risk pesticides) to be sure you are buying an approved product.

Occasionally pest problems arise that cannot be managed with currently registered pesticides. Sometimes the commodity, target, or site is not on the registered pesticide label. In some situations, you can request a special local need (SLN) registration or an emergency exemption.

Special Local Need Registrations

Special local need (SLN) registrations are categorized as 24(c) registrations. They allow states to expand or limit the uses of certain registered pesticides within their jurisdictions. For instance, some SLNs allow uses of pesticides for crops or sites not listed on the label. Others add limitations to the uses of a federally registered pesticide to accommodate area-specific conditions. Manufacturers must provide **supplemental labeling** for each SLN registration.

You must have the SLN labeling in your possession to use the pesticide for that purpose. The registration numbers of special local need labeling include the SLN number and the code for the state issuing the registration. These registrations are legal only in the region, state, or local area specified in the labeling. Applying a pesticide that has an SLN registration from another state or region makes you subject to civil and criminal penalties.

Emergency Exemptions

Emergency exemptions address pest problems for which no pesticides are registered. The EPA can issue an emergency exemption at the request of the state regulatory agency. First, the state must acknowledge the need and consider it appropriate. Usually these needs are based on specific public health quarantine emergencies or crises that require the use of an unregistered pesticide. There must be no feasible alternative to the exemption. Known as a **Section 18 exemption,** it allows the sale and use of a certain pesticide product for a specific non-registered purpose during a specified period of time.

Regulations impose strict controls

and require record keeping for all emergency uses. You must understand the special requirements and responsibilities involved whenever you use pesticides with emergency exemptions. The state pesticide regulatory agency prescribes application rates, safety precautions, and other vital application information. Applicators must have a copy of the Section 18 approval in their possession to legally use the product. Although they are often referred to as "labels" or "labeling," Section 18 use instructions are not true labels. The products have not been registered by the EPA. Applicators can, however, follow the instructions found on a copy of the EPA approval letter to the state authorizing the Section 18 exemption.

Minimum-risk Pesticides

In 1996, the EPA exempted from registration certain pesticides considered to pose minimum risk to humans and the environment, provided the products satisfy certain conditions. These products were exempted partly on the basis of their minimum-risk status and partly as an effort by the EPA to reduce the cost and regulatory burden on businesses. In addition, this allowed the EPA to focus its limited resources on pesticides that pose a greater risk.

Products identified as exempt under Section 25(b) of FIFRA do not require EPA label approval and do not undergo review by the agency. Furthermore, they have no label requirements for an EPA registration number, an EPA establishment number, any signal word, or any **personal protective equipment (PPE).**

To qualify for a Section 25(b) exemption from registration, each of the active ingredients in any such product must be on a list of specified minimal-risk active ingredients. In addition, any inert ingredients in these products must also be listed as minimal-risk inert ingredients.

Label requirements were established by the EPA for minimum-risk pesticides. Product labels may not claim to control microorganisms that pose a threat to human health. For example, the label may list a pest such as a mosquito or tick, but it must not claim to control any microorganisms that the pest transmits to humans.

Each state has its own statutes and regulations on pesticide registration. Many states do not permit the sale of a Section 25(b) product unless it is first registered in the state. You need to check with your state regulatory agency on the registration and use requirements of Section 25(b) products.



Tom Bowman, N.C. Dept. of Agric. & Consumer Services

Always read the label prior to purchasing and using the pesticide.

WHEN TO READ THE PESTICIDE LABEL

Applicators should read the pesticide label and supplemental labeling thoroughly:

- **Before buying the pesticide.** Make sure the pesticide is registered for your intended use. Confirm that there are no restrictions or other conditions that prohibit using this pesticide at the application site. Be certain its use is suitable for weather conditions at the time of application. Also, be sure it controls the appropriate life stage of your pest. Find out what personal protective equipment and special application equipment will be needed.
- **Before mixing and applying the pesticide.** Learn how to mix and apply the material safely. Find out what precautions to take to prevent exposure to people and non-target organisms. Learn what first aid and medical treatments are necessary should an accident occur.
- **When storing pesticides.** Find out how to store the pes-

ticide properly. Understand the special precautions to prevent fire hazards.

- **Before disposing of unused pesticides and empty containers.** Learn how to prevent environmental contamination and hazards to people. Before disposal, check with your state pesticide regulatory agency for any disposal restrictions and requirements, and find out whether your state has pesticide container recycling and waste disposal programs available.

PARTS OF THE LABEL

Some labels are easy to understand; others are complicated. It is the user's responsibility to read and understand the label before buying, using, storing, or disposing of a pesticide. Each of the label components will be discussed in this section. See Figure 3.1 (on page 44) for an example of a pesticide label.

Trade, Brand, or Product Name

Every manufacturer has trade names for its products. Most companies register each trade name as a trademark and will not allow any other company to use that name without permission. Various manufacturers use different trade names, even though the products contain the same active ingredient. The brand or trade name shows up plainly on the front panel of the label and is the one used in advertisements and by company salespeople.

The brand name often indicates the type of formulation and the percentage of active ingredient present. For example, "Sevin 50WP" is a brand name. Sevin is the registered trade name, and the formulation is a wettable powder containing 50 percent active ingredient.

Ingredient Statement

Every pesticide label must list the active ingredients and the percentage of each active ingredient found in that particular product. The **active ingredient,** or simply the a.i., is the chemical or chemicals in a pesticide product responsible for the pesticidal activity. It is the material in a pesticide formulation that actually destroys a pest or performs a desired function (e.g., repellent, growth regulator). **Inert ingredients** are not usually named, but the label must show what percentage of the total contents they make up. The ingredient statement must list the official chemical names and/or common names of the active ingredients. Let's look at the following Sevin insecticide example:

SEVIN 50WP

Active Ingredient:
Carbaryl (1-naphthyl N-methyl carbamate). **50%**

Inert Ingredients. **50%**

The **chemical name** is the complex name that identifies the chemical components and structure of the pesticide's active ingredient. This name must be listed in the ingredient statement on the label. For example, the chemical name of Sevin is 1-naphthyl N-methyl carbamate.

Because chemical names or active ingredients are usually complex, many are given a shorter **common name.** Only those common names officially accepted by the EPA may be used in the ingredient statement on the pesticide label. The official common name is usually followed by the chemical name in the list of active ingredients. The common name for Sevin is carbaryl. By purchasing pesticides according to the common or chemical names, you are certain of getting the right active ingredient, no matter what the brand name or formulation.

EXAMPLE OF AN INGREDIENT STATEMENT

Active ingredients:

Isoctyl (2-ethylhexyl) ester of 2,4-dichlorophenoxyacetic acid **32.45%**

2-ethylhexyl ester of (+)-r-2-(2,4-dichlorophenoxy) propionic acid **15.90%**

Dicamba: 3,6-dichloro-o-anisic acid **5.38%**

Inert Ingredients: 46.27%

Total 100.00%

Use Classification Statement

Currently, the EPA classifies every pesticide product as either **restricted use** or **unclassified/general use.** Every product that is federally classified as a restricted-use pesticide must include the following statement at the top of the front panel of the pesticide label:

RESTRICTED-USE PESTICIDE

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 certification.

Pesticides labeled for restricted use warrant special attention. Many pesticides are designated as restricted-use products if there is reason to believe they could harm humans, livestock, wildlife, or the environment, even when used according to label directions. The restricted-use statement indicates the specific hazard of that pesticide. For example, a product may be very toxic to humans and wildlife or pose a groundwater hazard. Persons using these products must be certified or have received special training and have demonstrated a certain level of competence to ensure that they can handle these pesticides properly.

Unclassified pesticides are commonly referred to as general-use pesticides. Typically they have a lower toxicity with less potential than restricted-use pesticides to harm humans or the environment. They can be purchased and used by the general public without special permits or restrictions.

Type of Pesticide

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

- Insecticide for control of certain insects on fruits, nuts, and ornamentals.
- Herbicide for the control of woody brush and weeds.
- Insecticide for broad-spectrum control of crawling, flying, and wood-infesting insect pests on indoor and outdoor surfaces, as well as pests of trees, landscape ornamentals, and residential and commercial lawns.

Net Contents

The pesticide label must show how much product is in the container. This is expressed as pounds or ounces for dry formulations or as gallons, quarts, or pints for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product. Many labels now also include metric units (grams, kilograms, liters) as part of the contents information.

Name and Address of Manufacturer

The law requires that the manufacturer or formulator of a product put the name and address of the company on the label. This is so you know who made or sold the product.

Emergency Telephone Number

Many pesticide manufacturers include an emergency telephone number on their product labels. These

companies are ready to assist anyone in the event of an emergency (poisoning, spill, fire) involving their products.

Registration Numbers

An EPA registration number must appear on all pesticide labels (except Section 25(b) labels). The EPA registration number indicates that the pesticide product has been registered and its label approved by the EPA. Most EPA registration numbers include just two sets of numbers, which identify the manufacturer and the specific product. Occasionally a third set of numbers is included. This is a distributor's identification number and appears only on labels of distributor products. In cases of a special local need, pesticide products may be approved for use in a specific state. This will be indicated in the registration number.



OSU

Signal words indicate the relative acute toxicity of the product to humans and animals.

EXAMPLES OF EPA REGISTRATION NUMBERS

EPA Reg. No. 3120-280-1492

"3120" identifies the manufacturer, "280" identifies the specific product, and "1492" identifies the distributor.

EPA SLN No. PA-990005

SLN indicates "special local need," PA means that the product is registered for use in Pennsylvania, "99" means it was registered in 1999, "0005" means it was the fifth special local-need product registered that year in Pennsylvania.

Establishment Number

An EPA establishment number (for example, EPA Est. No. 5840-AZ-1) must also appear on the pesticide label to identify the facility that produced the product. This is necessary in case a problem arises or the product is found to be adulterated in any way. The AZ in the establishment number indicates the product was manufactured in a specific facility in Arizona.

Signal Words and Symbols

Most pesticide labels must include a **signal word.** This important designation gives the user an indication of the relative acute toxicity of the product to humans and animals. The signal word must appear in large letters on the front panel of the pesticide label along with the statement "Keep Out of Reach of Children." Very low toxicity pesticides (Toxicity Category IV) are no longer required to display a signal word, although many manufacturers still include a "caution" signal word on the label of these products. The following signal words may be found on most pesticide labels:

- **DANGER—POISON,** *skull and crossbones symbol*—these words and symbol must appear on all products that are highly toxic by any route of entry into the body. The word "poison" must appear in red. They can cause death in very low doses. **PELIGRO,** the Spanish word for "**DANGER**," must also appear on the label.
- **DANGER**—products with this signal word can cause severe eye damage or skin irritation.
- **WARNING**—this word signals that the product is moderately toxic either orally, dermally, or through inhalation, or causes moderate eye and skin irritation. **AVISO,** the Spanish word for "**WARNING**," must also appear on the label.
- **CAUTION**—this word signals that the product is slightly toxic either orally, dermally, or through inhalation, or causes slight eye and skin irritation.

Signal words should be used to choose the least toxic chemical that provides the desired level of pest control.

Precautionary Statements

All pesticide labels contain additional statements to help applicators decide what precautions to take to protect themselves, their employees, and other persons (or animals) that could be

exposed. Sometimes these statements are listed under the heading "Hazards to Humans and Domestic Animals." These statements may be included in several sections of the label.

Routes of Entry Statements

These statements indicate which route or routes of entry (mouth, skin, lungs) are particularly hazardous. Many pesticide products are hazardous by more than one route, so study these statements carefully. A **DANGER** signal word followed by "May be fatal if swallowed or inhaled" gives you a far different warning than **DANGER** followed by "Corrosive—causes eye damage and severe skin burns."

Typical **DANGER** label statements include:

- Fatal if swallowed.
- Poisonous if inhaled.
- Extremely hazardous by skin contact—rapidly absorbed through skin.
- Corrosive—causes eye damage and severe skin burns.

Routes of entry statements are not uniform on all labels; many variations are found. More than one or even all four precautions may appear on a label.

Typical **WARNING** label statements include:

- Harmful or fatal if swallowed.
- Harmful or fatal if absorbed through the skin.
- Harmful or fatal if inhaled.
- Causes skin and eye irritation.

Typical **CAUTION** label statements include:

- Harmful if swallowed.
- May be harmful if inhaled.
- May irritate eyes, nose, throat, and skin.

Specific Action Statements

These statements usually follow the route of entry statements. The specific action statements recommend specific precautions to take and protective clothing and equipment to wear to reduce exposure to the pesticide. These statements are directly related to the toxicity of the pesticide product (signal word) and the routes of entry. **DANGER** labels typically contain statements such as:

- Do not breathe vapors or spray mist.
- Do not get on skin or clothing.
- Do not get in eyes.

Typical **WARNING** labels often combine specific action statements from **DANGER** and **CAUTION** labels.

CAUTION labels generally contain specific action statements that are less threatening than those on the **DANGER** label, indicating that the toxicity hazard is not as great:

- Avoid contact with skin or clothing.
- Avoid breathing dust, vapors, or spray mists.
- Avoid getting in eyes.

Protective Clothing and Equipment Statements

Pesticide labels vary in the type of information they contain on protective clothing and equipment. Some labels carry no such statement at all. Other pesticide labels fully describe appropriate protective clothing and equipment. A few list the kinds of respirators that must be worn when handling and applying the product; others require the use of a respirator but do not specify a type or model. Follow all advice on protective clothing or equipment that appears on the label. Note that the lack of such a statement or the mention of only one piece of equipment does not rule out the need for additional protection. To determine the proper type of protective



Follow label instructions on the use of protective clothing and equipment.

clothing and equipment needed, consider the signal word, the route of entry statements, and the specific action statements. Read the basic guidelines described in Chapters 5 and 6.

Other Precautionary Statements

Labels often list other precautions that should always be followed when handling the product. These are self-explanatory:

- Do not contaminate food or feed.
- Remove and wash contaminated clothing before reuse.
- Wash thoroughly after handling and before eating or smoking.
- Wear clean clothes daily.
- Not for use or storage in and around a house.
- Do not allow children or domestic animals into the treated area.

These are commonsense statements. The absence from the label of such statements *does not* indicate that these precautions should be ignored.

PRECAUTIONARY STATEMENTS

Hazard to Humans and Domestic Animals
WARNING/AVISO

This product may cause skin sensitization reactions in certain individuals. Causes eye irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed, inhaled, or absorbed through skin. Avoid breathing spray mist.

STATEMENT OF PRACTICAL TREATMENT

If in eyes: Flush with plenty of water. Get medical attention if irritation persists.

If on skin: Wash with plenty of soap and water. Get medical attention if irritation persists.

If swallowed: Do not induce vomiting. Promptly drink a large quantity of milk, egg whites, or gelatin solution. If these are not available, drink large quantities of water. Never give anything by mouth to unconscious person. Call a physician or Poison Control Center immediately.

If inhaled: Move victim to fresh air.

Be familiar with first aid procedures before using the pesticide.

Statement of Practical Treatment

This section lists first-aid treatments recommended in case of poisoning or accidental exposure. Typical statements include:

- In case of contact with skin, wash immediately with plenty of soap and water.
- In case of contact with eyes, flush with water for 15 minutes and get medical attention.
- In case of inhalation exposure, remove victim from contaminated area and give artificial respiration, if necessary.
- If swallowed, induce vomiting.

All **DANGER** labels and some **WARNING** and **CAUTION** labels contain a note to physicians describing the appropriate medical procedures and antidotes for poisoning emergencies. The label should always be available in emergencies.

Environmental Hazards

Pesticides can be harmful to the environment. Some products are classified as restricted use because of their environmental hazards. Watch for special warning statements on the label concerning hazards to the environment.

Special Toxicity Statements

If a particular pesticide is especially hazardous to wildlife, the label will say that. For example:

- This product is highly toxic to bees.
- This product is extremely toxic to fish and aquatic invertebrates.
- This product is toxic to birds and other wildlife.

These statements alert pesticide users to the special hazards a product poses. They should help applicators choose the safest product for a particular job and remind them to take extra precautions.

General Environmental Statements

Some of these statements appear on virtually every pesticide label. They are reminders to follow certain commonsense procedures to avoid contaminating the environment. The absence of any or all of these statements does not mean that you do not need to take adequate precautions. Sometimes

these statements follow a specific toxicity statement and provide practical steps to avoid harm to wildlife. Examples of general environmental statements include:

- Do not apply when runoff is likely to occur.
- Do not apply when weather conditions favor drift from treated areas.
- Do not contaminate water by improperly disposing of rinse water and other pesticide wastes.
- Do not apply when bees are likely to be in the area.
- Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark.
- The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

Physical or Chemical Hazards

This section of the label describes any special fire, explosion, or chemical hazards the product may pose. For example:

- **Flammable**—do not use, pour, spill, or store near heat or open flame. Do not cut or weld container.
- **Corrosive**—store only in a corrosion-resistant tank.

Hazard statements (hazards to humans and domestic animals, environmental hazards, and physical or chemical hazards) are not located in the same place on all pesticide labels. Some labels group them under the headings listed above. Other labels list them on the front panel beneath the signal word. Still other labels list the hazards in paragraph form somewhere else on the label under headings such as "Note" or "Important." Before using a pesticide, examine the label carefully for these statements to ensure that you handle the product properly and safely.

EXAMPLE OF AN ENVIRONMENTAL STATEMENT

Environmental Hazards

This product is toxic to aquatic invertebrates. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Under some conditions, this chemical may also have a high potential for runoff into surface water for several weeks or months after application. Do not cultivate within 10 feet of aquatic areas so as to allow growth of vegetative filter strip. Drift from applications of this pesticide is likely to result in damage to sensitive aquatic invertebrates in water bodies adjacent to treatment area.

For terrestrial uses, do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high-water mark, except under forest canopy when aerially applied to control forest pests. Do not contaminate water when disposing of equipment washwaters and rinsate. Do not apply when weather conditions favor drift or runoff from areas treated.

This pesticide demonstrates the properties and characteristics associated with chemicals detected in groundwater. The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

Agricultural Use Requirements

This section is found only on product labels that are covered by the EPA Worker Protection Standard (WPS). The WPS includes requirements for the protection of agricultural workers on farms and in forests, nurseries, and greenhouses, and handlers of agricultural pesticides. This section also contains requirements for training, decontamination, notification, emer-

gency assistance, personal protective equipment (PPE), and restricted-entry intervals (REI).

Restricted-entry Intervals (REI)

Many pesticide labels include a statement about a restricted-entry interval (REI). The REI specifies how much time must pass between the application of a pesticide and the reentry of unprotected workers into a treated area. The EPA sets REIs.

The REI statement can be found under the heading "Agricultural Use Requirements." If no REI or other restricted-entry statement appears on the label, then all persons should wait at least until sprays have dried or dusts have settled before reentering a treated area. If there are multiple REIs on a label, you can usually find the appropriate REI at the beginning of the use-direction section for each crop.



Under the federal Worker Protection Standard (WPS), workers must be notified about areas treated with pesticides so they may avoid inadvertent exposures.

The EPA has allowed for an exception to the WPS that permits, under specified conditions, workers to enter pesticide-treated areas during a restricted-entry interval (REI) to perform tasks that involve short-term, limited contact with pesticide-treated surfaces. This exception allows workers the flexibility to perform certain tasks during an REI that could not have been foreseen and which, if delayed, would cause significant economic loss. However, early-entry workers must wait at least four hours after the application and must be wearing the personal protective equipment (PPE) specified on the label.

Non-agricultural Use Requirements

The requirements in this section apply to pesticide uses that are not within the scope of the WPS, such as the application of pesticides to lawns, golf courses, ornamental plantings, structures (except greenhouses), aquatic areas, and rights-of-way. Specific reentry times are not generally listed for these uses, though the label often cautions people and pets not to enter treated areas until the spray has dried or dust has settled.

EXAMPLE OF AGRICULTURAL USE REQUIREMENTS

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) and restricted-entry interval. 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 12 hours. Exception: if the product is applied by drenching, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if there will be no contact with anything that has been treated.

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.
- Waterproof gloves.
- Shoes plus socks.

Storage and Disposal

All pesticide labels contain general instructions for the appropriate storage and disposal of the pesticide and its container. State and local laws may vary considerably, so specific instructions usually are not included. One or more statements may appear in a special section of the label titled "Storage and Disposal" or under headings such as "Important," "Note," or "General Instructions." these include:

- Store herbicides away from fertilizers, insecticides, fungicides, and seeds.
- Store at temperatures above 32°F (0°C).
- Do not reuse container; render unusable.
- Do not contaminate water, food, or feed by storage or disposal.
- Triple-rinse, or equivalent, and dispose of in an approved landfill.

Seek sound advice if needed to determine the best storage and disposal procedures for your operation and location. Read this section before you purchase the product to be sure you can meet the requirements.

Directions for Use

These instructions provide the directions on how to use the product (see Figure 3.1). The use instructions will tell you:

- The pests that the manufacturer claims the product will control.
- The crop, animal, or site the product is intended to protect.
- The proper mixing instructions.
- How much to use (rate) and how often.
- How close to harvest the product can be applied (preharvest interval).
- Phytotoxicity (damage to plants) and other possible injury.
- Where and when the material should be applied.
- Recropping, composting, grazing, and other restrictions.
- How to minimize drift.

It is illegal and considered a misuse to use any registered pesticide in a manner inconsistent with its labeling. Examples of pesticide misuse include applying a pesticide to a site that is not listed on the label, applying a pesticide at a higher-than-labeled rate, and handling a pesticide in a manner that violates specific label instructions (e.g., storage near food or water, improper container disposal).

Many terms are used on labels to describe when and how to use pesticides. Many technical terms also appear in leaflets and bulletins that you may get from your local Cooperative Extension office, land-grant university, state and federal pesticide regulatory agencies, pesticide manufacturers, and professional pest management associations. Your understanding of these terms will help you obtain optimum results from pesticide applications. Refer to the glossary in this manual. If you do not understand the directions on a label, check with your pesticide dealer or salesperson, a county Extension agent, your state pesticide regulatory agency, or your professional association.

The label provides a wealth of information. Failure to follow the instructions on a pesticide label can result in a serious pesticide accident and constitutes a legal violation that may make you subject to civil or criminal prosecution. Remember, the label is a legal document. The user is liable for personal injury, crop or site damage, or pollution that occurs through misuse of a pesticide.

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-1

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° 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 No Pest 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

Figure 3.1 Sample pesticide label (adapted from MSU Pesticide Applicator Core Training Manual).

MATERIAL SAFETY DATA SHEETS

Material safety data sheets (MSDS) are very useful documents for learning about specific chemical and physical properties of pesticides (herbicides, insecticides, fungicides, rodenticides, disinfectants, etc.) or other potentially hazardous substances. Manufacturers of these substances are required to develop and to provide upon request a MSDS for each product. The MSDS provides detailed information about the product's composition, physical and chemical properties and hazards, toxicological and ecological information, and first-aid procedures. Commercial establishments using pesticides and other products are required to keep appropriate MSDS and make them available to workers or others who may come into contact with the substance, its diluted end product, or its residues. Because there is no standardized form for the MSDS and because the information is presented in technical terms, the MSDS can be difficult for readers to decipher without specialized scientific training. The following explains how the MSDS is derived and arranged and helps the reader interpret the information contained in it.

Ideally, the MSDS is used in combination with the pesticide label, but it should never be used in place of the actual product label.

Development of the MSDS

Pesticide manufacturers must perform a wide range of tests before their products can be registered with the U.S. Environmental Protection Agency (EPA) for use in the United States. The MSDS reflects the results of these tests on the formulated product.

The Hazard Communication Standard of the Occupational Safety and Health Act (OSHA) requires the MSDS to be made available to workers in manufacturing or to any end user who handles the end-use formulated material. MSDS readers should remember that, except for applicators, people are usually exposed to diluted products or to residues rather than to the product for which the MSDS was developed. Incidental exposure from dilute sprays does not equate to workplace exposure information presented in the MSDS, and the information should be interpreted with this in mind.

Components of the MSDS

The information contained in the MSDS may appear under various headings and does not have to follow the same order, but the elements of the MSDS are the same.

Chemical Product Identification

This section identifies the ingredients in the product by common (generic) name and percentage of the active ingredient(s) and by percentage of inert ingredients. An **inert ingredient** is simply one for which no toxic activity against the pest is claimed; the **active ingredient** is the component that actually controls the pest. Inert ingredients, however, may have effects on humans or other animals, plants, etc. The exact identification of inert ingredients is considered proprietary information, so they are not required to be listed on either a label or the MSDS. However, the EPA maintains a list of inert ingredients considered not to present excess hazards, and registrants choose from those when they formulate products. This section of the MSDS may also provide information about the class of chemical, such as "organophosphate insecticide" or "chlorophenoxy herbicide." Because chemicals in a particular class share certain characteristics, this information may be helpful, particularly to the healthcare professional. This section also often provides synonyms, i.e., brand names of other products with the same composition.

PRODUCT AND COMPANY IDENTIFICATION

Product Name: VIP No Pest Gel
Product Code: 2777A1CC
Active Ingredient: Galactothion
Chemical Family: Chloronicotinyl
Molecular Formula: $C_{12}H_{20}Cl_{I2}O_3$ (galactothion)
Chemical Name: VIP 11815; 0,0-diethyl methyl phosphorothiate
Manufacturer: VIP Chemical Co.
Emergency Telephone Number: (800)111-2323

Example of chemical product identification information on a MSDS.

Physical and Chemical Properties

This section describes the product's physical appearance and provides information about how the product behaves under certain physical and chemical conditions. Particularly relevant are the measures for **solubility** in water, **vapor pressure, stability,** and **freezing/boiling point.**

Water solubility is a factor in whether a substance is likely to be carried off the site in runoff water or in leachate. In general, the lower the solubility, the more likely the substance is to bind to soil particles or organic matter rather than to dissolve in water. A relatively high solubility in water can be a benefit, however, because water-soluble products are excreted in urine rather than stored in body fat.

PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point: 212°F **Melting Point:** NI
Evaporation Rate (Butyl Acetone = 1): NI
Vapor Pressure (mm Hg.): <17 @ 78 F
Vapor Density (Air = 1): >1
Specific Gravity (H20 = 1): 1.14600
Solubility in Water: Infinite
Appearance and Odor: Brown liquid; amine odor.
Other Information:
pH = 7.5–8.0
Density = 9.63 pounds/gallon
Freezing point <35°F
Percent volatile by volume 46%

Example of a physical and chemical properties section on a MSDS for an herbicide product.

A substance's vapor pressure helps determine whether the substance is likely to volatilize, or form a gas. Other factors involved include temperature; how tightly the substance binds to soil particles, plants, or the site of application; and how much water is present (combined with the substance's water solubility). Products with relatively high volatility are more likely to be detected through smell than products with low volatility. Some MSDS provide direct information about the odor of a product. Products may range from practically odorless to very apparent.

Stability and freezing and boiling points of a substance determine whether a product can be stored over the summer or winter. Freezing and excessive heating may degrade the product, resulting in a loss of efficacy against the pest.

Fire and Explosion Hazards

Some substances can spontaneously catch on fire at a certain temperature. In such cases, the MSDS identifies the temperature, called the **flash point,** at which the substance catches fire. The MSDS may list conditions to avoid, such as materials that are incompatible with the product. For instance, some substances can react with galvanized containers to form hydrogen gas, a highly combustible material.

Toxicological Information/ Human Health Data

The MSDS identifies by what route(s) of exposure the product may be harmful (i.e., **ingestion [oral],** through the mouth; **dermal,** through the skin; and **inhalation,** by breathing in the product's vapors). The MSDS also summarizes results of toxicological tests performed on laboratory animals and extrapolates them to the potential for effects on humans. The toxicological tests required by the EPA include **acute toxicity, chronic toxicity, delayed toxicity, oncogenicity** (ability to cause tumors), **carcinogenicity** (ability to cause malignant tumors, or cancer), **teratogenicity** (ability to cause birth defects), and **fetotoxicity** (other adverse effects on the fetus, such as low birthweight or spontaneous abortion). The MSDS also lists symptoms of acute overexposure and usually lists medical conditions that may be aggravated by exposure to the product.

It is important to remember that a substance's level of acute toxicity is not related to its ability to cause chronic or delayed effects. The MSDS usually provides specific information about the product's ability to cause eye and skin irritation or allergic responses. Allergic responses are also not related to the chemical's level of acute toxicity. Thus, it is possible for a slightly toxic pesticide (Category III) to be associated with adverse long-term effects or allergic reactions and, conversely, for a highly toxic pesticide (Category I) to have no known long-term or allergic effects. (See Chapter 5 for a discussion of toxicity categories.)

Cholinesterase Inhibition

If the pesticide can inhibit **cholinesterase** (an enzyme that regulates nerve impulses), the MSDS may identify it as a cholinesterase inhibitor. Such identification was not required until recently.

Regulatory Levels and Classification

Some compounds have regulatory limits on the amount of time a worker can be exposed to them. Some substances have been classified on their ability to act as carcinogens (cancer-producing substances).

Personal Protection Recommendations

Special equipment to be worn while handling the concentrate product is specified by the MSDS. Many products do not require special protective equipment. Others require chemical-proof gloves, goggles, respirators, or other gear. Remember that the equipment listed pertains to the product as formulated. Refer to the pesticide label to check whether gear listed on the MSDS is required to be worn while handling the diluted product.

Additional Information

The MSDS must also provide information on:

- **Emergency and first-aid procedures**—provides specific information about first aid and emergency treatment for persons exposed to the product. If the chemical is a cholinesterase inhibitor, the MSDS states this and provides treatment information for the physician.
- **Ecological or environmental hazards**—provides information on acute and chronic effects on wildlife in similar terms as the statements pertaining to humans.
- **Spills, fires, and accident procedures**—provides directions for cleaning up spills and leaks, as well as special information for firefighters.
- **Storage and disposal**—provides directions on how to store and properly dispose of the pesticide. This information may range from very specific to quite general.

It is a good idea to have an MSDS available for every pesticide product that you are using. Read both the pesticide label and the MSDS for a more complete picture of the potential hazards associated with the pesticide. Both the label and the MSDS provide valuable information in case of a pesticide emergency.

SUMMARY

The language on pesticide labels is strictly regulated by the EPA in coordination with pesticide manufacturers to provide precise information on how to use pesticides correctly and safely. It is the applicator's responsibility to read, understand, and follow the label directions to ensure that pesticides are applied according to regulations. The label directions are written to instruct the applicator how to use the pesticide for effective control of the target pest while minimizing harmful effects to other organisms and the environment. Make sure the pesticide has both federal and state registration for its intended use.

Be familiar with all sections on a pesticide label and know where to find the specific directions and precautions for each pest control situation that you manage. Know both the trade and common names of the chemical you are using, and be familiar with the product's active ingredients. Signal words and symbols help the applicator recognize how toxic (i.e., dangerous) the pesticide is. These signal words are often accompanied by precautionary statements that further explain how the pesticide may cause injury and what to do to prevent it (e.g., routes of entry statements, specific action statements, protective clothing and equipment statements). Other parts of the label let the applicator know how, when, where, and on what target pest the pesticide may be applied (e.g., directions for use, mixing and loading instructions). Still other parts of the label inform users

what to do should an accident occur and what precautions to take to avoid harming themselves, other persons, the environment, or non-target organisms (e.g., practical treatment statements, environmental hazards, storage and disposal, physical or chemical hazards). All parts of the pesticide label must be carefully read and followed. The label, however, may not provide all of the information needed to avoid harmful effects of pesticides. It is a good practice to take even further precautions such as using additional protective clothing and equipment beyond what the pesticide label recommends.

Pesticide labels in combination with MSDS provide a wealth of information on the hazards associated with each pesticide. Carefully review these documents before applying any pesticide. Applicators are better prepared to avoid any harmful effects if they understand the properties of the pesticide more thoroughly. Remember, it is the applicator's responsibility to ensure that pesticides are applied effectively and as safely as possible.

Review Questions

CHAPTER 3: Pesticide Labeling

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

1. **What is needed to apply a pesticide legally when a pest problem arises for which a food or feed commodity is not on the registered pesticide label or a tolerance has not yet been established?**
   - **A.** An emergency exemption.
   - **B.** Use a restricted-use pesticide.
   - **C.** A minimum-risk pesticide classification.
   - **D.** An emergency registration.

2. **Which of the following sections under FIFRA exempts from registration pesticides considered to pose minimum risk?**
   - **A.** Section 3.
   - **B.** Section 18.
   - **C.** Section 24 (c).
   - **D.** Section 25 (b).

3. **The active ingredient in Lorsban 75WG is listed as chlorpyrifos: 0,0-diethyl 0-(3,5,6-trichloro 2-pyridinyl) phosphorothioate. What does the term "chlorpyrifos" represent?**
   - **A.** The brand name.
   - **B.** The chemical name.
   - **C.** The common name.
   - **D.** The registered trade name.

4. **Which statement about pesticide label names and ingredients is *true*?**
   - **A.** The active ingredients and the inert ingredients must be listed by chemical name.
   - **B.** Various manufacturers use different trade names, even though the products contain the same active ingredient.
   - **C.** The common names are those accepted officially by the manufacturer.
   - **D.** Inert ingredients are responsible for the pesticidal activity.

5. **What is the purpose of the signal word?**
   - **A.** To give the user an indication of the relative acute toxicity of the product to humans and animals.
   - **B.** Informs the user of what type of PPE to wear.
   - **C.** Informs the user of how toxic the pesticide is to wildlife and the environment.
   - **D.** Tells the user what type of first-aid treatment to seek in case of exposure.

6. **The route of entry statement on a label "Extremely hazardous by skin contact—rapidly absorbed through the skin" would most likely appear with which signal word?**
   - **A.** DANGER.
   - **B.** WARNING.
   - **C.** CAUTION.
   - **D.** No signal word required.

7. **The statement "Do not breathe vapors or spray mist" is an example of:**
   - **A.** A specific action statement.
   - **B.** A statement of practical treatment.
   - **C.** A route of entry statement.
   - **D.** A protective clothing statement.

8. **Which is *true* about statements of practical treatment?**
   - **A.** They are not associated with signal words.
   - **B.** It is not important to have the pesticide label in case of a poisoning emergency.
   - **C.** Statements about inducing vomiting are not found on the label.
   - **D.** All DANGER labels contain a note to physicians describing appropriate medical procedures.

9. **Directions for mixing and loading a pesticide are usually found under:**

   A. The agricultural use requirements.
   B. The directions for use.
   C. Environmental hazards.
   D. Precautionary statements.

10. **Who is responsible for developing MSDSs on specific chemicals and providing them on request?**

    A. The EPA.
    B. The USDA.
    C. OSHA.
    D. The product manufacturer.

CHAPTER 4

PESTICIDE FORMULATIONS

LEARNING OBJECTIVES

After studying this chapter, you should:

- Understand what a pesticide formulation is.
- Know how to interpret common abbreviations used to describe formulations (e.g., WP, DF, EC, RTU, S, G, ULV).
- Know how to identify advantages and disadvantages of common formulation types (e.g., dusts, granules, wettable powders, dry flowables, microencapsulated, aerosols).
- Know how to explain the role of adjuvants (e.g., buffers, stickers, spreaders) during pesticide application.



Pesticide chemicals in their "raw" or unformulated state are not usually suitable for pest control. These concentrated chemicals (**active ingredients**) may not mix well with water, may be chemically unstable, and may be difficult to handle and transport. For these reasons, manufacturers add inert substances such as clays and solvents to improve application effectiveness, safety, handling, and storage. **Inert ingredients** do not possess pesticidal activity and are added to serve as a carrier for the active ingredient. The mixture of active and inert ingredients is called a **pesticide formulation.** This formulation may consist of:

- The pesticide active ingredient that controls the target pest.
- The carrier, such as an organic solvent or mineral clay.
- Surface-active ingredients, such as stickers and spreaders.
- Other ingredients, such as stabilizers, dyes, and chemicals that improve or enhance pesticidal activity.

Usually you need to mix a formulated product with water or oil for final application. Baits, granules, gels, and dusts, however, are ready for use without additional dilution. Manufacturers package many specialized pesticides, such as products for households, in ready-to-use formulations.

A single active ingredient often is sold in several kinds of formulations. Abbreviations are often used to describe the formulation (e.g., WP for wettable powders); how the pesticide is used (e.g., TC for termiticide concentrate); or the characteristics of the formulation (e.g., LO for a low-odor formulation). The amount of active ingredient (a.i.) and the kind of formulation are listed on the product label. For example, an 80% SP contains 80 percent by weight

Table 4.1 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 (liquid)
G	=	Granules
GL	=	Gel
L	=	Liquid (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 or soluble packet
ULV	=	Ultra low volume
ULW	=	Ultra low weight or ultra low wettable
W	=	Wettable powder
WDG	=	Water-dispersible granules
WP	=	Wettable powder
WS	=	Water soluble
WSG	=	Water-soluble granules
WSL	=	Water-soluble liquid
WSP	=	Water-soluble powder or water-soluble packet

of active ingredient and is a soluble powder. If it is in a 10-pound bag, it contains 8 pounds of a.i. and 2 pounds of inert ingredient. Liquid formulations indicate the amount of a.i. in pounds per gallon. For example, 4F means 4 pounds of the a.i. per gallon in a flowable formulation. Some common formulation abbreviations are listed in Table 4.1.

If you find that more than one formulation is available for your pest control situation, you should choose the best one for the job. Before you make the choice, ask yourself several questions about each formulation. For example:

- Do I have the necessary application equipment?
- Can the formulation be applied appropriately 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 damage the surface to which you will apply it?
- Could I choose a less hazardous formulation that would still be as effective?

To answer these kinds of questions, you need to know something about the characteristics of different types of formulations and the general advantages and disadvantages of each type.

AN OVERVIEW OF THE FORMULATION PROCESS

The ingredients in pesticide products come from many sources. Some, such as nicotine, pyrethrum, and rotenone, are extracted from plants. Others have a mineral origin (e.g., copper, sulfur), while a few are derived from microbes (e.g., *Bacillus thuringiensis*). However, the vast majority of active ingredients are made in the laboratory. These synthetic active ingredients may

have been designed by a chemist or discovered through a screening process examining chemicals generated by various industries.

Regardless of their source, pesticide active ingredients have a range of solubilities. Some dissolve readily in water; others, only in oils. Some active ingredients may be relatively insoluble in either water or oil. Solubility characteristics and the intended use of the pesticide generally define which formulations best deliver the active ingredient.

Usually, an active ingredient is combined with appropriate inert materials prior to packaging. The brief review of basic chemical terminology below should prove helpful in understanding differences among the various types of formulations.

Solution

A solution results when a substance is dissolved in a liquid. The components of a true solution cannot be mechanically separated. Once mixed, a true solution does not require agitation to keep its various parts from settling. Solutions are frequently transparent, although if they are dark colored, this may not be the case.

Suspension

A suspension is a mixture of finely divided, solid particles dispersed in a liquid. The solid particles do not dissolve in the liquid, and the mixture must be agitated to keep the particles evenly distributed. Most suspensions will have a cloudy, murky appearance. The label directs the user to shake well before using. Such products also form suspensions when mixed with water for application as a spray. Explicit label information describes the need for sufficient agitation to keep the solid particles of the product dispersed in the spray tank.

Emulsion

An emulsion occurs when one liquid is dispersed (as droplets) in another liquid. Each liquid retains its original identity. Some degree of agitation generally is required to keep the emulsion from separating. Emulsions usually have a milky appearance. The active ingredient is dissolved in an oil-based solvent. When the product is mixed with water, an emulsion (oil in water) is formed. An emulsifying agent (often called an **emulsifier**) formulated into product helps prevent the emulsion from separating.

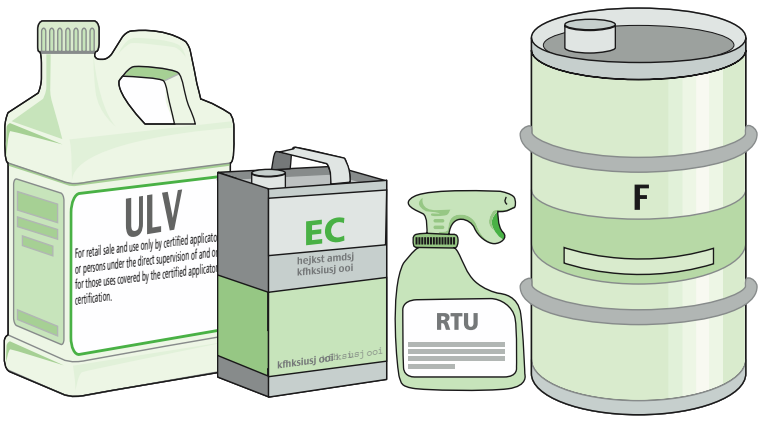
Familiarity with these terms and processes leads to a greater understanding and appreciation of the advantages and disadvantages of many commonly used pesticide formulations.

LIQUID FORMULATIONS

Liquid formulations are generally mixed with water, but in some instances labels may permit the use of crop oil, diesel fuel, kerosene, or some other light oil as a carrier.

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains a liquid active ingredient, one or more petroleum-based solvents (which give EC formulations their strong odor), and an agent that allows the formulation to be mixed with water to form an emulsion. Most ECs contain between 25 and 75 percent (2 to 8 pounds) active ingredient per gallon. ECs 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.
- Will not plug screens or nozzles.
- Little visible residue on treated surfaces.

Disadvantages:

- High a.i. concentration makes it easy to overdose or underdose through mixing or calibration errors.
- May cause damage to desirable plants (**phototoxicity**).
- 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.

Solutions (S)

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

Ready-to-use Low-concentrate Solutions (RTU)

Low-concentrate formulations are ready to use and require no further dilution before application. They consist of a small amount of active ingredient (often 1 percent or less per unit volume) dissolved in an organic solvent. They usually do not stain fabrics or have unpleasant odors. They are especially useful for structural and institutional pests and for household use. Major disadvantages of low-concentrate formulations include limited availability and high cost per unit of active ingredient. Many organic solvents are harmful to foliage, so they often cannot be used as plant sprays.

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 a specified carrier and are used at rates of no more than 1/2 gallon per acre. 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.
- Remain in solution; little agitation required.
- Not abrasive to equipment.
- Will not plug screens and nozzles.
- Leave little visible residue on treated surfaces.

Disadvantages:

- Difficult to keep pesticide on target—high drift hazard.
- Specialized equipment required.
- Easily absorbed through skin of humans or animals.
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate.
- Calibration and application must

be done very carefully because of the high concentration of active ingredient.

Invert Emulsions

An invert emulsion contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. Invert emulsions aid in reducing drift. With other formulations, some spray drift results when water droplets begin to evaporate before reaching target surfaces; as a result, the droplets become very small and light. Because oil evaporates more slowly than water, invert emulsion droplets shrink less; therefore, more pesticide reaches the target. The oil helps to reduce runoff and improves rain resistance. It also serves as a sticker-spreader by improving surface coverage and absorption. Because droplets are relatively large and heavy, it is difficult to get thorough coverage on the undersides of foliage. Invert emulsions are most commonly used along rights-of-way where drift to susceptible non-target plants or sensitive areas can be a problem.

Flowables (F)/Liquids (L)

A flowable or liquid formulation combines many of the characteristics of emulsifiable concentrates and wettable powders. Manufacturers use these formulations when the active ingredient is a solid that does not dissolve in either water or oil. The active ingredient, impregnated on a substance such as clay, is ground to a very fine powder. The powder is then suspended in a small amount of liquid. The resulting liquid product is quite thick. Flowables and liquids share many of the features of emulsifiable concentrates, and they have similar disadvantages. They require moderate agitation to keep them in suspension and leave visible residues, similar to those of wettable powders.

Flowables/liquids are easy to handle and apply. Because they are liquids, they are subject to spilling and splashing. They contain solid particles, so they contribute to abrasive wear of nozzles and pumps. Flowable and liquid suspensions settle out in their containers. Always shake them thoroughly before pouring and mixing. Because flowable and liquid formulations tend to settle, manufacturers package them in containers of 5 gallons or less to make remixing easier.

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredients. There are two types of aerosol formulations—the ready-to-use type commonly available in pressurized sealed containers, and those products used in electrical or gasoline-powered aerosol generators that release the formulation as a "smoke" or "fog."

Ready-to-use Aerosols

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

Disadvantages:

- Practical for only 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.

Advantages:

- Easy way to fill entire enclosed space with pesticide.

Disadvantages:

- Highly specialized use and equipment.
- Difficult to confine to target site or pest.
- May require respiratory protection to prevent risk of inhalation injury.

Liquid Baits

An increasing number of insecticides and rodenticides are being formulated as liquid baits. Liquid rodenticides are mixed with water and placed in bait stations designed for these products. They have two major benefits. Liquid rodenticides are effective in controlling rodents, especially rats, in areas where they cannot find water. They are also effective in areas of poor sanitation where ready availability of food renders traditional baits ineffective.

Liquid insecticide baits are used primarily by the structural pest control industry for controlling ants and, to a lesser extent, cockroaches. They are packaged as ready-to-use, sugar-based liquids placed inside bait stations. Liquid insecticide ant baits have a number of advantages. They are very effective against certain species of sugar-feeding ants. These ants typically accept and transfer liquid baits into the ant colonies. However, some ants will not feed on liquid baits. Liquid baits also must be replaced often.

DRY OR SOLID FORMULATIONS

Dry formulations can be divided into two types: ready-to-use and concentrates that must be mixed with water to be applied as a spray.



Dusts (D)

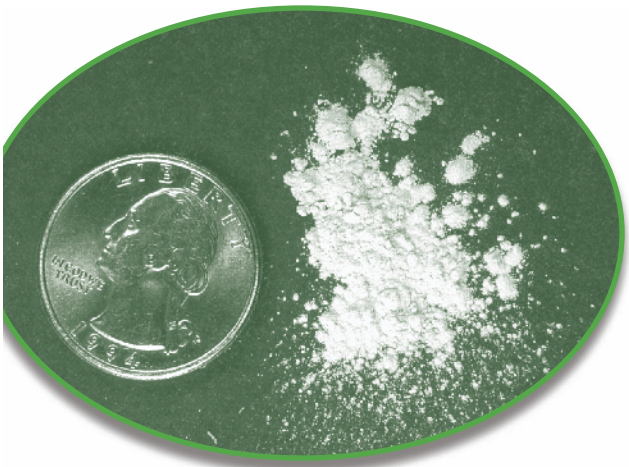
Most dust formulations are ready to use and contain a low percentage of active ingredients (usually 10 percent or less by weight), plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies.

A few dust formulations are concentrates and contain a high percentage of active ingredients. Mix these with dry inert carriers before applying.

Dusts are always used dry and can easily drift to non-target sites. They are widely used as seed treatments and sometimes for agricultural applications. In structures, dust formulations are used in cracks and crevices and for spot treatments to control insects such as cockroaches. Insects ingest poisonous dusts during grooming or absorb the dusts through their outer body covering. Dusts also are used to control lice, fleas, and other parasites on pets and livestock.

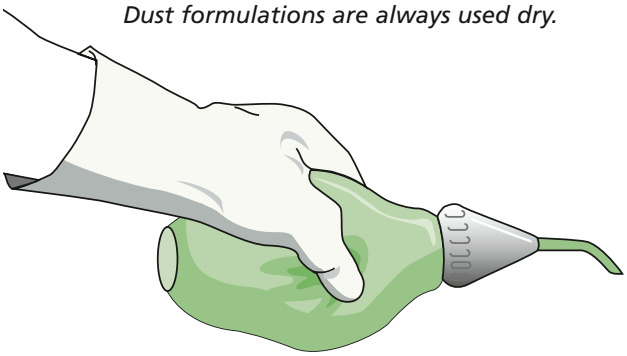
Advantages:

- Most are ready to use, with no mixing.



Arlene Blessing, Purdue Pesticide Programs

Dust formulations are always used dry.



A bulb duster used for applying dust formulations to cracks, crevices, and voids in buildings.

- 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.
- Will not stick to surfaces as well as liquids.
- Dampness can cause clogging and lumping.
- Difficult to get an even distribution of particles on surfaces.

Tracking Powders

Special dusts known as tracking powders are used for rodent and insect monitoring and control. For rodent control, the tracking powder consists of finely ground dust combined with a stomach poison. Rodents walk through the dust, pick it up on their feet and fur, and ingest it when they clean themselves. Tracking powders are useful when bait acceptance is poor because of an abundant, readily available food supply. Non-toxic powders, such as talc or flour, often are used to monitor and track the activity of rodents in buildings.

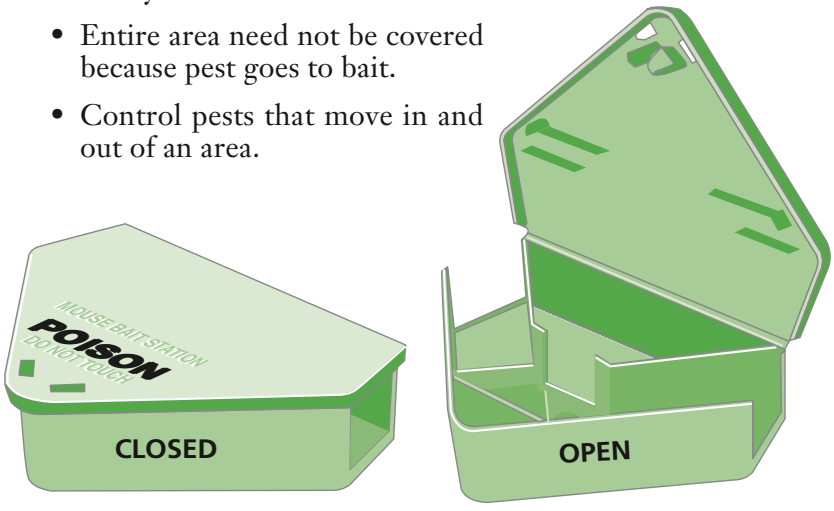
Baits (B)

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 bait that contains the pesticide. 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, other insects, and rodent control. Outdoors they sometimes are used to control snails, slugs, and insects such as ants and termites. Their main use is for control of vertebrate pests such as rodents, other mammals, and birds.

Advantages:

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



A bait station used in rodent control in the closed and open positions. Bait formulations are placed inside the tamper-resistant station.

Disadvantages:

- Can be attractive to children and pets.
- May kill domestic animals and non-target wildlife outdoors.
- Pest may prefer the crop or other food to the bait.
- Dead vertebrate pests may cause odor problem.
- 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.

Pastes, Gels, and Other Injectable Baits

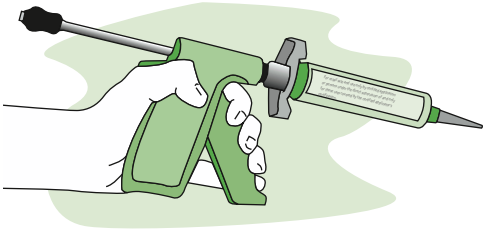
Pastes and gels are mainly used in the pest control industry for ants and cockroaches. Insecticides formulated as pastes and gels are now the primary formulations used in cockroach control. They are designed to be injected or placed as either a bead or dot inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels—syringes and bait guns. The applicator forces the bait out of the tip of the device by applying pressure to a plunger or trigger.

Advantages:

- They are odorless, produce no vapors, have low human toxicity, and last for long periods.
- Applicator exposure is minimal.
- Hidden placements minimize human and pet exposure.
- Very accurate in their placement and dosage.
- Easily placed in insect harborage for maximum effectiveness.

Disadvantages:

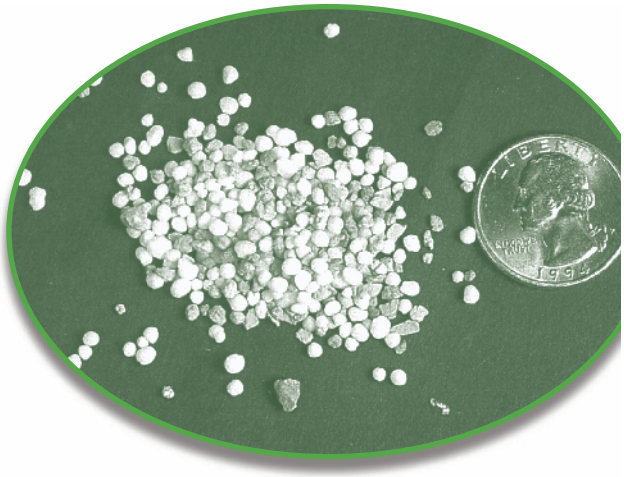
- Can become contaminated from exposure to other pesticides and cleaning products.
- When exposed to high temperatures, gels can run and drip.
- May stain porous surfaces.
- Repeated applications can cause an unsightly buildup of bait.



A bait gun used by the pest control industry to treat small cracks and crevices.

Granules (G)

Granular formulations are similar to dust formulations except granular particles are larger and heavier. The coarse particles are made from materials such as clay, corncobs, 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 by weight.



Arlene Blessing, Purdue Pesticide Programs

Granular formulations are larger and heavier than dust formulations.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil, or for absorption into plants through the roots. Granular formulations are sometimes applied by airplane or helicopter to minimize drift or to penetrate dense vegetation. Once applied, granules release the active ingredient slowly. Some granules require soil moisture to release the active ingredient. 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.
- 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 needed, such as seeders or fertilizer spreaders.
- May break down more slowly than WPs or ECs because of a slow-release coating.

Disadvantages:

- Often difficult to calibrate equipment and apply uniformly.
- Will not stick to foliage or other uneven surfaces.
- May need to be incorporated into soil or planting medium.
- May need moisture to activate pesticide.
- May be hazardous to non-target species, especially waterfowl and other birds that mistakenly feed on the seedlike granules.
- May not be effective under drought conditions because the active ingredient is not released in sufficient quantity to control the pest.

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations; the terms often are used interchangeably. In a pellet formulation, however, all the particles are the same weight and shape. The uniformity of the particles allows use with precision application equipment. A few fumigants are formulated as pellets. However, these are clearly labeled as fumigants. Do not confuse them with non-fumigant pellets.

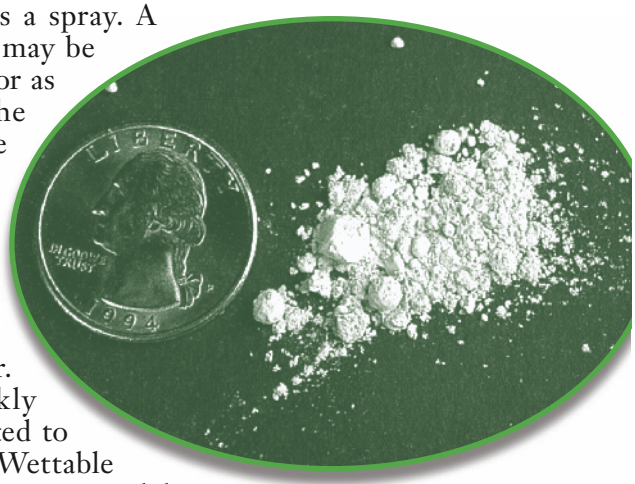


Arlene Blessing, Purdue Pesticide Programs

In pellet formulations, all particles are the same weight and shape.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts. They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder—the choice is left to the applicator. Wettable powders contain 5 to 95 percent active ingredient by weight; usually 50 percent or more. The particles do not dissolve in water. They settle out quickly unless constantly agitated 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. Wettable powders have excellent residual activity. Because of their physical properties, most of the pesticide remains on the surface of treated porous materials such as concrete, plaster, and untreated wood. In such cases, only the water penetrates the material.

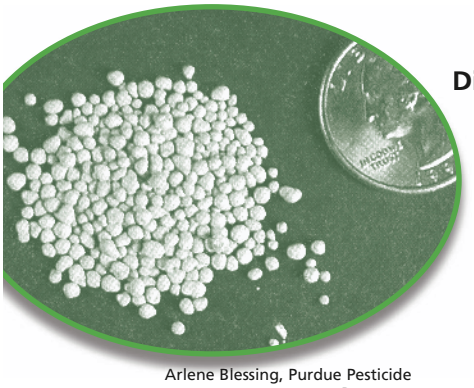


Arlene Blessing, Purdue Pesticide Programs

Wettable powders are dry, finely ground formulations that look like dusts.

Advantages:

- Easy to store, transport, and handle.
- Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals, and surfaces.



Arlene Blessing, Purdue Pesticide Programs

Water-dispersible granule before mixing.



Arlene Blessing, Purdue Pesticide Programs

Water-dispersible granule after mixing.

- Easily measured and mixed.
- Less skin and eye absorption than ECs and other liquid formulations.

Disadvantages:

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

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 by weight; it usually is more than 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 readily soluble in water.

Water-dispersible Granules (WDG) or Dry Flowables (DF)

Water-dispersible granules, also known as dry flowables, are like wettable powders except instead of being dustlike, they are formulated as small, easily measured granules. Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine particles similar to wettable powders. The formulation requires constant agitation to keep them suspended in water. The percentage of active ingredient is high, often as much as 90 percent by weight. Water-dispersible granules share many of the same advantages and disadvantages of wettable powders except:

- They are more easily measured and mixed.
- Because of low dust, they cause less inhalation hazard to the applicator during handling.

OTHER FORMULATIONS

Other formulations include chemicals that cannot be clearly classified as liquid or as dry/solid pesticide formulations.

Microencapsulated Materials

Manufacturers cover liquid or dry pesticide particles in a plastic coating to produce a microencapsulated formulation. Microencapsulated pesticides are mixed with water and sprayed in the same manner as other sprayable formulations. After spraying, the plastic coating breaks down and slowly releases the active ingredient. Microencapsulated materials have several advantages:

- Highly toxic materials are safer for applicators to mix and apply.
- Delayed or slow release of the active ingredient prolongs its effectiveness, allowing for fewer and less precisely timed applications.
- The pesticide volatilizes more slowly; less is lost from the application site.
- These formulations often reduce injury to plants.

In residential, industrial, and institutional applications, microencapsulated formulations offer several advantages. These include reduced odor,

release of small quantities of pesticide over a long time, and greater safety. Microencapsulated materials offer fewer hazards to the skin than ordinary formulations. Microencapsulated materials, however, pose a special hazard to bees. Foraging bees may carry microencapsulated materials back to their hives because they are about the same size as pollen grains. As the capsules break down, they release the pesticide, poisoning the adults and brood.

Breakdown of the microencapsulated materials to release the pesticide sometimes depends on weather conditions. Under certain conditions, the microencapsulated materials may break down more slowly than expected. This could leave higher residues of pesticide active ingredient in treated areas beyond normal restricted-entry or harvest intervals with the potential to injure fieldworkers. For this reason, regulations require long restricted-entry intervals for some microencapsulated formulations.

Water-soluble Packets

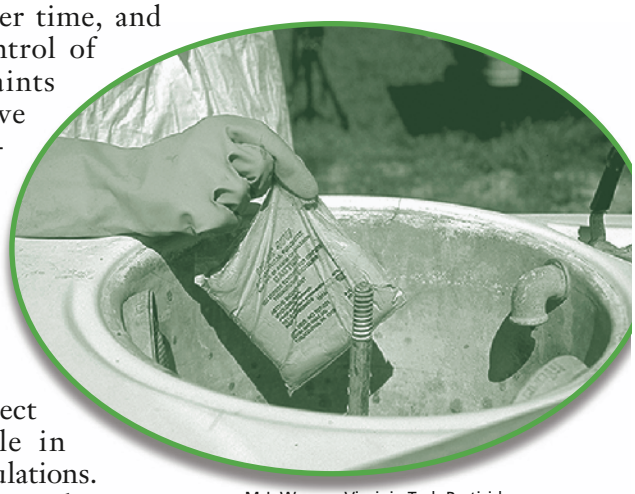
Water-soluble packets reduce the mixing and handling hazards of some highly toxic pesticides. Manufacturers package precise amounts of wettable powder or soluble powder formulations in a special type of plastic bag. When you drop these bags into a filled spray tank, they dissolve and release their contents to mix with the water. There are no risks of inhaling or contacting the undiluted pesticide as long as you do not open the packets. Once mixed with water, pesticides packaged in water-soluble packets are no safer than other tank mixtures.

Attractants

Attractants include **pheromones**, sugar and protein hydrolysate syrups, yeasts, and rotting meat. Pest managers use these attractants in sticky traps and capture bags. Attractants also can be combined with pesticides and sprayed onto foliage or other items in the treatment area.

Impregnates

Manufacturers **impregnate** (saturate) pet collars, livestock ear tags, adhesive tapes, plastic pest strips, and other products with pesticides. These pesticides evaporate over time, and the vapors provide control of nearby pests. Some paints and wood finishes have pesticides incorporated into them to kill insects or retard fungal growth. Fertilizers also may be impregnated with pesticides.



M.J. Weaver, Virginia Tech Pesticide Programs

Adding water-soluble packet to a spray tank.

Repellents

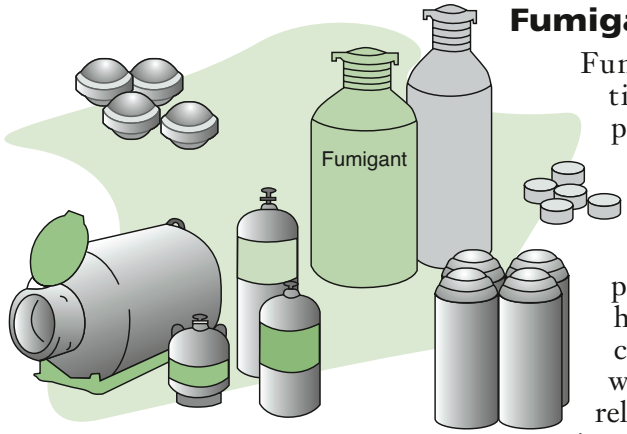
Various types of insect repellents are available in aerosol and lotion formulations. People apply these to their skin or clothing or to plant foliage to repel biting and nuisance insects. You can mix other types of repellents with water and spray them onto ornamental plants and agricultural crops to prevent damage from deer, dogs, and other animals.

Animal Systemics

Systemic pesticides protect animals against fleas and other external blood-feeding insects as well as against worms and other internal parasites. A systemic animal pesticide is one that is absorbed and moves within the animal. These pesticides enter the animal's tissues after being applied orally or externally. Oral applications include food additives and premeasured capsules and liquids. External applications involve pour-on liquids, liquid sprays, and dusts. Most animal systemics are used under the supervision of veterinarians.

Pesticide/Fertilizer Combinations

Pest managers frequently use insecticides, fungicides, and herbicides in combination with fertilizers. This provides a convenient way of controlling pests while fertilizing crops or lawns. Homeowners commonly use these combinations, although the unit cost of pesticide in these formulations is usually high. In commercial applications, dealers or growers custom mix pesticides with fertilizers to meet specific crop requirements.



Fumigants are packaged in liquid and solid forms. Both turn into poisonous gases when applied.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids when packaged under high pressure and change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and therefore 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, greenhouses, granaries, and grain bins.

Advantages:

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

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping.
- Non-specific—highly toxic to humans and all other living organisms.
- Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants.

PESTICIDE MIXTURES



Edward Crow, Maryland Department of Agriculture

Incompatibility is a condition that prevents pesticides from mixing together properly to form a uniform solution or suspension.

Combining two or more pesticides and applying them at the same time is convenient and cost effective. Most pesticide manufacturers sell some of their products as premixes, but often you must still combine two or more pesticides at the time of application. When you combine mixtures of two or more pesticides and/or fertilizers at the time of application, you create a **tank mix.** A common tank mix involves combining fungicides with insecticides as a spray for tree fruit crops. Another involves combining two or more herbicides to increase the number of weed species controlled. Some people mix pesticides with micronutrients or fertilizers. This practice saves money by reducing the time, labor, and fuel required for multiple applications. Tank mixes reduce equipment wear and decrease labor costs. They lessen the mechanical damage done to crops and soil by heavy application equipment. Combinations may, however, affect the toxicity and the physical and chemical properties of any of the components of the tank mix increase residues, and damage or injure the target site, plant, or animal.

If you mix DANGER—POISON pesticides with WARNING or CAUTION pesticides, treat the mixture as a DANGER—POISON pesticide. You must use the required safety equipment and follow all other label restrictions found on the label having the greatest restrictions.

Incompatibility

Incompatibility is a condition that prevents pesticides from mixing together properly to form a uniform solution or suspension. The formation of flakes, crystals, or oily clumps, or severe separation is unacceptable. Such incompatible mixtures clog application equipment and limit even distribution of the active ingredient in the spray

tank. This prevents good pesticide coverage.

The cause of incompatibility may be the chemical nature of the materials you are mixing. Impurities in the spray tank or water also may affect compatibility. Even the order in which you mix pesticides in the spray tank is important. Sometimes the types of formulations being mixed influence compatibility. Pesticide formulations of the same type are rarely incompatible with one another because they usually contain many of the same inert ingredients and solvents. Always evaluate a tank mixture by performing the compatibility test described in Chapter 10.

Sometimes tank mixes seem compatible during testing and after mixing in the spray tank, but problems arise during application. This is known as **field incompatibility**. The temperature of the water in the tank can cause this problem. It could also be due to water impurities. Water pH (acidity vs. alkalinity) also may unexpectedly change for some unknown reason. Sometimes the amount of time the spray mixture has been in the tank causes field incompatibility.

ADJUVANTS

Adjuvants are chemicals that do not possess pesticidal activity. Adjuvants are either premixed in the pesticide formulation or added to the spray tank to improve mixing or application or to enhance pesticidal performance. They are used extensively in products designed for foliar applications. Adjuvants can be used to customize the formulation to specific needs and compensate for local conditions.

The right adjuvant may reduce or even eliminate spray application problems, thereby improving overall pesticide efficacy. Because adjuvants themselves have no pesticidal properties, they are not registered by the EPA. As a result, there is no set of standards for composition and quality, although some states have modified registration requirements for these chemicals and may require labels, technical data sheets, and efficacy information.

Before using any adjuvant, consult the pesticide label. Many registered pesticide products have very specific recommendations on their labels for use with one or more adjuvants. Failure to follow these instructions is as much a violation of the product label as inappropriate use of the pesticide.

If you have questions about the specific properties of an adjuvant, contact the manufacturer before attempting to use it. Companies that produce adjuvants can provide labels, technical data sheets, MSDS, supplemental labeling, and promotional literature about their products.

Adjuvants are designed to perform specific functions, including wetting, spreading, sticking, reducing evaporation, reducing volatilization, buffering, emulsifying, dispersing, reducing spray drift, and reducing foaming. No single adjuvant can perform all these functions, but compatible adjuvants often can be combined to perform multiple functions simultaneously.

Types of Adjuvants

Much of the confusion surrounding adjuvants can be attributed to the lack of understanding of adjuvant terminology. For example, many people use the terms **adjuvant** and **surfactant** interchangeably. These terms can refer to the same product because all surfactants are adjuvants. However, not all adjuvants are surfactants.

Surfactants

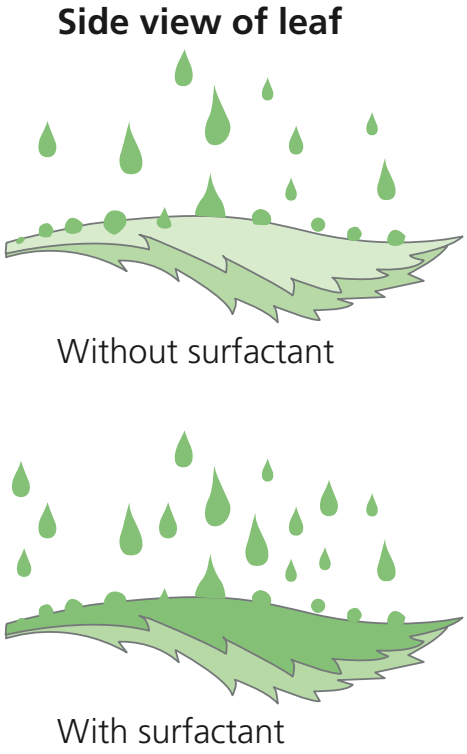
Surfactants, also called wetting agents and spreaders, physically alter the surface tension of a spray droplet. For a pesticide to perform its function properly, a spray droplet must be able to wet the foliage and spread out evenly over a leaf. Surfactants enlarge the area of pesticide coverage, thereby increasing the pest's exposure to the chemical. Surfactants are particularly important when applying a pesticide to waxy or hairy leaves. Without proper

TYPES OF ADJUVANTS

- **Surfactants**
  - Wetting agents and spreaders
- **Stickers**
- **Extenders**
- **Plant penetrants**
- **Compatibility agents**
- **Buffers or pH modifiers**
- **Drift retardants**
- **Defoaming agents**
- **Thickeners**

wetting and spreading, spray droplets often run off or fail to cover leaf surfaces adequately. Too much surfactant, however, can cause excessive runoff and reduce pesticide efficacy.

Surfactants are classified by the way they ionize or split apart into electrically charged atoms or molecules called ions. A surfactant with a negative charge is anionic. One with a positive charge is cationic, and one with no electrical charge is nonionic. Pesticidal activity in the presence of a nonionic surfactant can be quite different from activity in the presence of a cationic or anionic surfactant. Selecting the wrong surfactant can reduce the efficacy of a pesticide product and injure the target plant. Anionic surfactants are most effective when used with contact pesticides (i.e., pesticides that control the pest by direct contact rather than being absorbed systemically). Cationic surfactants should never be used as stand-alone surfactants because they usually are phytotoxic.



Adapted from Penn. State Pesticide Education Manual

Figure 4.1
Surfactants increase the ability of the pesticide to spread evenly over the surface of a leaf or fruit.

Nonionic surfactants, often used with systemic pesticides, help pesticide sprays penetrate plant cuticles. Nonionic surfactants are compatible with most pesticides, and most EPA-registered pesticides that require a surfactant recommend a nonionic type.

Stickers

A sticker is an adjuvant that increases the adhesion of solid particles to target surfaces. These adjuvants can decrease the amount of pesticide that washes off during irrigation or rain. Stickers also can reduce evaporation of the pesticide, and some slow down the degradation of pesticides by sunlight. Many adjuvants are formulated as spreader-stickers to make a general-purpose product.

Extenders

Some adjuvant manufacturers have named their products "extenders." Extenders function like stickers by retaining pesticides longer on the target area, slowing evaporation, and inhibiting degradation by sunlight.

Plant Penetrants

These adjuvants have a molecular configuration that enhances penetration of some pesticides into plants. An adjuvant of this type may increase penetration of a pesticide on one species of plant but not another. Enhanced penetration increases the activity of some pesticides.

Compatibility Agents

Pesticides are commonly combined with liquid fertilizers or other pesticides. Certain combinations can be physically or chemically incompatible, which causes clumps and uneven distribution in the tank. Occasionally the incompatible mixture plugs the pump and distribution lines resulting in expensive cleanup and repairs. A compatibility agent may eliminate these problems.

Read product label directions carefully before adding a compatibility agent to a spray mix. You may wish to do a compatibility test in a quart jar to determine the stability of the mixture. After adding the desired pesticides and the compatibility adjuvant to the jar, shake the mixture and then check for clumping, separation, thickening, and heat release. Any one of these signs indicates an incompatibility problem.

Buffers or pH Modifiers

Most pesticide solutions or suspensions are stable between pH 5.5 and pH 7.0 (slightly acidic to neutral). Above pH 7.0 (alkaline or basic), the pesticide may be subject to degradation. Once a pesticide solution becomes alkaline, the risk exists that the pesticide degrades. Buffers and acidifiers are adjuvants that acidify and stabilize the water in the spray tank. Buffers must be added to the tank mix water first. The water must be neutralized or slightly acidified prior to adding pesticides and adjuvants

Drift Control Additives

Drift is a function of droplet size. Small, fine drops with diameters of 100 microns or less tend to drift away from targeted areas. Drift control additives, also known as deposition aids, improve on-target placement of the pesticide spray by increasing the average droplet size. Drift reduction can be very important near sensitive sites and may well be worth the small reduction in efficacy that may result from the change in droplet size.

Defoaming Agents

Some pesticide formulations create foam or a frothy "head" in spray tanks. This is often the result of both the type of surfactant used in the formulation and the type of spray tank agitation system. The foam usually can be reduced or eliminated by adding a small amount of a defoaming agent.

Thickeners

As the name suggests, thickeners increase the viscosity (thickness) of spray mixtures. These adjuvants are used to control drift or slow evaporation after the spray has been deposited on the target area. Slowing evaporation is important when using systemic pesticides because they can penetrate the plant cuticle only as long as they remain in solution.

How to Choose the Right Adjuvant

Many factors must be considered when choosing an adjuvant for use in a pest management program. Following are some guidelines:

- Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides because they may interfere with pesticide performance.
- Remember, there are no miracle adjuvants. It is generally wise to be skeptical of such claims as "keeps spray equipment clean" or "causes better root penetration" unless the manufacturer has supporting evidence to back up such claims.
- Make sure the adjuvant has been thoroughly tested and proven effective for your intended use. Test questionable products on a limited area before proceeding with full-scale use.
- Certain pesticides and application procedures require certain types of adjuvants. Determine the correct type and use only an adjuvant of that type. For example, do not substitute an anionic surfactant when a nonionic surfactant is recommended.
- A particular pesticide label may require one or more adjuvants for a certain use yet prohibit any adjuvant for another use. Read the pesticide label carefully.
- Using an adjuvant is not always necessary. It is just as important to know when not to use an adjuvant as it is to know when to use one.

Spray adjuvants can contribute substantially to safe and effective pest control. Many spray adjuvants are available, each formulated to solve problems associated with a particular type of application. Check pesticide and adjuvant labels to make sure adjuvants are suitable for the site you plan to spray, the target pest, your equipment, and, of course, the pesticide you plan to use.

Remember, many pesticide products already contain an adjuvant. If a pesticide is already formulated properly for your crop, using an additional wetting agent, for example, may not give better spreading or coverage; instead, it could increase runoff, reduce deposit, and even severely damage the target plants.

SUMMARY

A pesticide formulation consists of both active and inert ingredients. The active ingredient (a.i.) functions as the pesticide; the inert ingredient includes the carrier and adjuvants. The active ingredient includes always listed on the product label. The type of formulation may also be given. Persons handling pesticides must become familiar with the active ingredients and formulation types to better understand the nature of the products.

Pesticides are formulated in a variety of processes such as being dissolved in a solution or dispersed in a suspension or an emulsion. Many liquid and dry formulations are available, including emulsifiable concentrates (EC), solutions (S), flowables (F), dusts (D), baits (B), and soluble powders (SP), to mention a few. Other formulations are available that cannot be clearly classified as either liquid or dry/solid pesticide formulations. These products, such as microencapsulated materials and water-soluble packets, have special properties that make them preferable for certain pest control situations. Understanding the relative advantages and disadvantages of the various formulation types helps the applicator decide which one is best to use in a given pest control situation.

Adjuvants are added to pesticide formulations to improve the pesticide's ability to control pests, although the adjuvants themselves do not possess pesticidal activity. For example, surfactant type adjuvants function as wetting agents or spreaders that improve pesticide coverage over an area such as a leaf surface. The pesticide handler should know how and when to use an adjuvant. Always read the pesticide label carefully to determine whether adding an adjuvant is recommended for use with the pesticide product.

In summary, the pesticide user must consider several factors when selecting a pesticide formulation, such as the risks associated with the formulation type, the practicality of using the formulation on the target site or pest, and whether it will provide effective control. Having a basic understanding of formulation types before using pesticides helps the user avoid mistakes and accidents in choosing, mixing, loading, and applying the product.

Review Questions

CHAPTER 4: PESTICIDE FORMULATIONS

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

1. **The name "Sevin 5G" on a pesticide label indicates:**
   - **A.** A granular pesticide with 5 percent inert ingredients.
   - **B.** A gel pesticide with 5 percent active ingredients.
   - **C.** A granular pesticide with 5 percent active ingredients.
   - **D.** A gel pesticide with 5 percent inert ingredients.

2. **Which is the pesticide formulation process by which solid particles are dispersed in a liquid?**
   - **A.** ULV solvents.
   - **B.** Solution.
   - **C.** Suspension.
   - **D.** Emulsion.

3. **Which liquid pesticide formulation consists of a small amount of active ingredient (often 1 percent or less per unit volume) dissolved in an organic solvent?**
   - **A.** Emulsifiable concentrate (EC).
   - **B.** Ready-to-use low-concentrate solutions (RTU).
   - **C.** Ultra-low volume (ULV).
   - **D.** Flowables (F)/liquids (L).

4. **Which liquid pesticide formulation may approach 100 percent active ingredient?**
   - **A.** Emulsifiable concentrate (EC).
   - **B.** Ready-to-use low-concentrate solutions (RTU).
   - **C.** Ultra-low volume (ULV).
   - **D.** Aerosols (A).

5. **Which is a disadvantage of both EC and ULV formulations?**
   - **A.** Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate.
   - **B.** Contribute to abrasive wear of nozzles and pumps.
   - **C.** Require constant agitation to keep in suspension.
   - **D.** Difficult to handle, transport, and store.

6. **Which dry/solid formulation is mixed in water and reduces the risk of inhalation exposure during mixing and loading?**
   - **A.** Dusts (D).
   - **B.** Wettable powders (WP).
   - **C.** Soluble powders (SP).
   - **D.** Water-dispersable granules (WDG) or dry flowables (DF).

7. **Which type of dry/solid pesticide formulation consists of particles that are the same weight and shape?**
   - **A.** Dusts.
   - **B.** Granules.
   - **C.** Pellets.
   - **D.** Baits.

8. **Which is an advantage of microencapsulated materials?**
   - **A.** They pose few hazards to bees.
   - **B.** Delayed or slow release of the active ingredient prolongs its effectiveness.
   - **C.** Their pesticidal activity is independent of weather conditions.
   - **D.** They usually require only short restricted-entry intervals.

9. Which type of adjuvant functions as wetting agents and spreaders (i.e., they physically alter the surface tension of spray droplets)?

A. Surfactants.
B. Stickers.
C. Extenders.
D. Buffers.

10. Which type of adjuvant increases the viscosity of spray mixtures?

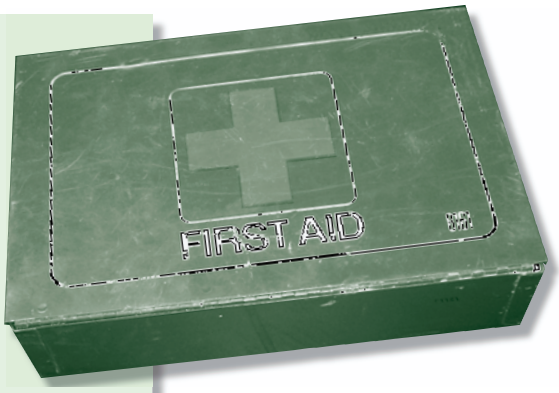
A. Stickers.
B. Extenders.
C. Plant penetrants.
D. Thickeners.



CHAPTER 5

PESTICIDE HAZARDS AND FIRST AID

LEARNING OBJECTIVES



After studying this chapter, you should:

- Know how to identify and differentiate between types of harmful effects (i.e., acute, delayed, allergic, chronic) associated with pesticide application.
- Understand the hazard level classification system for pesticides, including the associated signal words.
- Know how to identify common exposure routes for various pesticides and application methods.
- Know how to recognize typical symptoms of pesticide exposure in humans and be aware of the appropriate first-aid response.
- Know how to identify other health risks that may occur during pesticide application (e.g., heat stress) and know when to give first aid.

Pesticides are designed to be toxic to living organisms so that control of unwanted pests (plants, insects, rodents, fungi, bacteria, etc.) can be achieved. Though pesticides are also toxic to humans, they vary significantly in the hazards they present. In many respects, living organisms are not all that different from one another, and something that is toxic to one species (animal or plant) may also be toxic to other organisms. This is especially true if the organisms are related. For example, insects, rodents, and humans are all animals and have similarities in their nervous, circulatory, and respiratory systems. These similarities are the reasons that pesticides can affect people.

Pesticides can cause both short-term and long-term effects in humans. Refer to the signal word on the product label and the information contained in the "Hazards to Humans and Domestic Animals" section included in the "Precautionary Statements" section of the label to learn more about human toxicity concerns. Products also can pose physical and chemical risks by being explosive and combustible. If the product presents either a physical or a chemical hazard, this information is included under the "Precautionary Statements." Refer also to the material safety data sheet (MSDS) for more information on toxicity and precautions.

TOXICITY, EXPOSURE, AND HAZARD

Toxicity refers to the ability of a pesticide to cause short-term (**acute**) or long-term (**chronic**) injury. Toxicity is a property of the product itself.

Exposure occurs when pesticides get onto or into the body through the skin, by inhalation, by swallowing, or by eye contact. Product formulations differ greatly in the exposure risk they present. Exposure is often associated with many routine procedures involving pesticides, such as handling opened containers; mixing and loading; working around contaminated application equipment; making spray, mist, or dust applications; cleaning up spills; and reentering a recently treated area before the spray has dried or the dusts have settled.

Hazard, or risk, is the true concern for the applicator or handler. It is the potential or probability for harm (injury, illness, or allergy) to occur because of product toxicity and human exposure. The words "toxicity" and "hazard" are often used interchangeably when describing a pesticide's toxic effect, but they are not the same. "Hazard" reflects both the pesticide's toxicity and the likelihood that you will be exposed to the product in a particular situation. "Toxicity" is a measure of the pesticide's capacity to cause injury, which is a combination of its chemical properties and its concentration. As a result, users of pesticides need to be concerned with the hazards associated with exposure to the chemical and not exclusively with the toxicity of the pesticide. A good equation to remember is:

Hazard (Risk) = Toxicity x Exposure

The following are two examples to illustrate that "hazard" takes into account both toxicity and exposure:

- Gasoline is extremely toxic to humans, especially if swallowed or inhaled. Yet every day, millions of people fill their gas tanks without incident. The toxicity is high, but gas pumps are designed to virtually eliminate human exposure. Therefore, the hazard associated with filling a car's gas tank is very low. If someone siphons gas, the hazard is much greater.
- Aspirin has a low toxicity to humans. However, if children are allowed access to a bottle and ingest many pills, they can become very ill. In this case, aspirin toxicity is low, but the potential for exposure is high, increasing the overall hazard.

Engineering controls such as gas pumps and childproof caps are often designed to reduce exposure. Engineering controls are also available for pesticide mixing and loading that reduce handler exposure (see Chapter 11). These controls include lock-and-load devices and water-soluble bags containing formulated product.

Often the greatest hazard to the applicator occurs during the mixing and loading of the pesticide concentrate. A significant risk of exposure to the chemical in its most concentrated, toxic form exists unless engineering controls are used. Hazards associated with the actual application are frequently much lower because diluted pesticides are being handled or applied. The hazards can still be substantial, however, if a single exposure is high or many exposures occur over an extended period of time.

The best way to avoid or reduce the hazards associated with pesticide use is to understand what you are using and how to use it safely. This means reading the label carefully and following instructions. The attitude of the user is of utmost importance. If applicators mistakenly assume they know exactly how to use a pesticide without reading the product label or do not care to take precautions indicated on the label, accidents are more likely to occur. Pesticide users have legal and moral obligations when using pesticides. In addition to protecting themselves, applicators

must be aware of unprotected people, wildlife, or pets that may be in or near the treatment area which could be exposed to the pesticide during or after the application. Taking adequate precautions and following good safety practices greatly reduces the potential for accidents from pesticide use.

Remember, the pesticide registration process requires that manufacturers perform studies to assess the risk to applicators during the application and the risk to unprotected people after the application. Using the knowledge from these studies, the manufacturer develops product labels that provide details on exposure concerns, personal protective equipment, engineering controls, symptoms of overexposure, first aid, and postapplication restricted-entry intervals (REIs). ***Be sure to read and follow all label directions.***

HARMFUL EFFECTS OF PESTICIDES

Human pesticide injuries occur because products can cause damage by **contact** with skin, eyes, or respiratory tract; can be absorbed by the body and cause **systemic** effects; and can induce **allergic** responses. Any chemical can be harmful; some, even deadly. Many chemicals we are exposed to daily have risks associated with their use because of their toxicity and overexposure. Given pesticides and any other chemical, the risk of illness or injury is determined by both the dose (level of exposure) and the toxicity.

Contact Effects

Contact symptoms include skin irritation (dermatitis), such as itching, redness, rashes, blisters, and burns. Skin discoloration may also occur. Many herbicides and fungicides cause dermatitis. Fumigants can cause severe blisters. If you consider herbicides are the most commonly applied pesticide group, and they predominantly cause contact injury, you can easily understand why ***contact skin effects are the most common form of pesticide injury or poisoning*** to applicators.

Herbicides, fungicides, insecticides, and fumigants may cause eye irritation or injury, sometimes resulting in irreversible damage. Swelling, stinging, and burning of the eyes, nose, mouth, or throat are relatively common contact symptoms. Permanent respiratory damage occurs less often.

Systemic Effects

Systemic effects in humans occur primarily when people are exposed to pesticides that target animals. For example, the nervous system of insects is very similar to that of humans. Thus, an insecticide targeting an insect nervous system often affects a human if the dose is sufficient. Likewise, the blood system in rodents is similar to the human circulatory system. Therefore, rodenticides that target the blood system of rodents may also affect a human. Fumigants are another class of pesticides that can cause systemic injury. The herbicide paraquat causes lethal systemic effects in humans.



CONTACT EFFECTS

Injury at the point of contact, including skin discoloration and irritation (dermatitis) such as itching, redness, rashes, blisters, and burns. Also, swelling, stinging, and burning of the eyes, nose, mouth, or throat are contact effects.

Symptoms of systemic injury include:

- Nausea, vomiting, diarrhea, or stomach cramps.
- Headache, dizziness, weakness, or confusion.
- Excessive sweating, tearing, chills, or thirst.
- Chest pains.
- Breathing difficulties.
- Body aches and muscle cramps.



SYSTEMIC EFFECTS

Poisoning effects that occur at sites other than the entry point into the body.

Allergic Effects

Allergic effects are harmful effects some people develop in reaction to substances that do not cause the same reaction in most other people. If someone develops an allergy to

ALLERGIC EFFECTS /ALLERGY

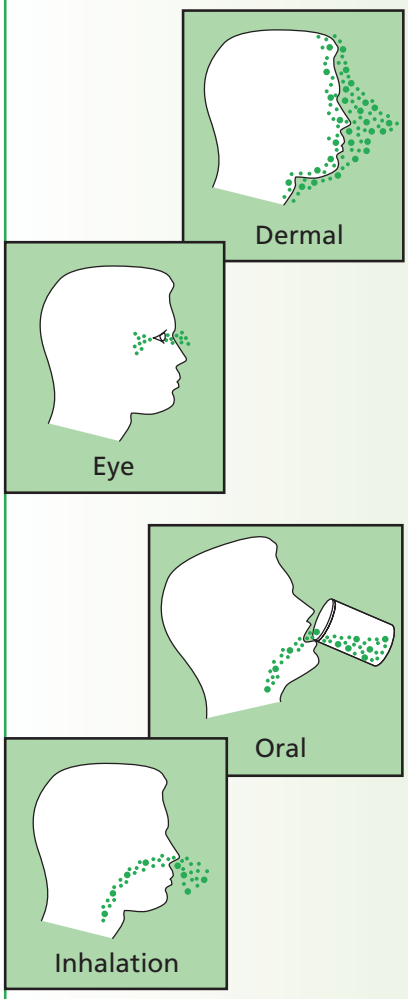
A hypersensitivity to a specific substance, often called the allergen. An allergy may cause dermatitis, blisters, hives, and itching of the eyes. It could also cause illness, asthma-like symptoms or life-threatening shock. Often the entire body is affected.

a chemical contained in a product formulation, the allergy may cause dermatitis, blisters, or hives; it could also cause more serious problems such as asthma or even life-threatening shock. Pesticide allergy symptoms are similar to other allergy symptoms—reddening of the eyes, itchy eyes, respiratory discomfort, and asthma-like symptoms. Unfortunately, there is no way to predict which people will develop allergies to a particular product.

EXPOSURE—HOW PESTICIDES ENTER THE BODY

Pesticide exposure occurs when pesticides get onto or into the body. A pesticide can enter or contact the human body by four primary routes of exposure: the skin (dermal), the eyes, the mouth (oral), and the lungs (inhalation).

Common ways in which pesticide handlers and other workers are exposed to pesticides



Dermal exposure

- **Not wearing gloves or other protective clothing.**
- **Not washing hands after handling pesticides, product containers, or application equipment.**
- **Not washing hands before using the toilet.**
- **Splashing or spilling pesticide on skin.**
- **Being exposed to spray or dust drift.**
- **Applying pesticides in windy weather or above your head.**
- **Touching treated plants, soil, or livestock.**

Eye exposure

- **Rubbing eyes with contaminated gloves or hands.**
- **Splashing pesticide in eyes.**
- **Handling dry formulations when not wearing eye protection.**
- **Applying pesticides in windy weather.**

Oral exposure

- **Not washing hands before eating, smoking, chewing, or drinking.**
- **Splashing pesticide in mouth.**

Inhalation exposure

- **Handling pesticides in confined or poorly ventilated areas.**
- **Handling dusts or powders.**
- **Using an inadequate or poorly fitting respirator.**
- **Being exposed to spray or dust drift.**

Skin or Dermal Route

In most exposure situations, the skin is the primary route of pesticide entry onto or into the body. Evidence indicates that about 97 percent of all body exposure to pesticides during a spraying operation is by skin contact. Dermal absorption or contact injury may occur as the result of airborne dust, splashes, spills, or spray mist when mixing, loading, applying, or disposing of pesticides. Skin exposure may also result from contact with pesticide residues on treated surfaces or contaminated equipment during cleaning or repair.

If absorption and the resulting systemic injury are the primary concerns with a particular product, the specific hazard depends on the extent of the exposure, the site of contamination on the body, the way the pesticide is formulated, and the absorption rate into the body. Some products that cause systemic injury are just as toxic when absorbed through the skin as when they are swallowed.

Parts of the body differ in their ability to absorb pesticides. Warm, moist areas such as the groin, armpits, head, neck, backs of hands, and tops of the feet tend to absorb more than the palms and forearms (Figure 5.1). However, the palms and forearms must still be protected because they get the most exposure. Cuts, abrasions, and skin rashes can increase absorption.

Pesticide formulations vary in their ability to penetrate skin. In general, water-soluble liquids or powders, wettable powders, dusts, and granular pesticides do not penetrate skin very easily. However, oil-based liquid formulations such as emulsifiable concentrates are readily absorbed, and wettable powder and emulsifiable concentrate products have a higher concentration of active ingredient than dusts and granules.

Application techniques can also affect exposure levels for applicators. Making overhead applications, using blower application equipment for mists and dusts, using animal pour-ons or dipping livestock and pets are all application methods that tend to have high dermal exposure levels. Contaminated hands or gloves can transfer pesticides to other body parts. Again, a reminder on personal hygiene—be sure to wash your hands and gloves after each pesticide handling event.

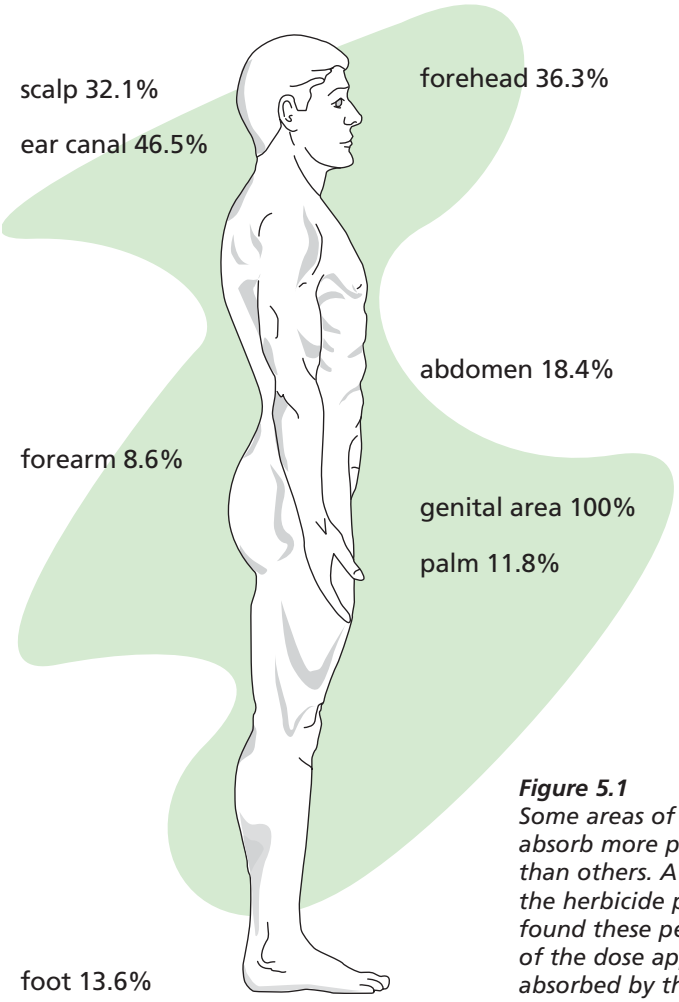


Figure 5.1
Some areas of the skin absorb more pesticide than others. A study of the herbicide parathion found these percentages of the dose applied were absorbed by the skin over a 24-hour period (Maibach and Feldman, 1974).

Eyes

The tissues of the eye are extremely absorbent. Blood vessels are very close to the surface of the eye, so pesticides can be easily absorbed into the bloodstream. Under certain conditions and using certain pesticides, absorption through the eyes can be significant and particularly hazardous. Eyes are very sensitive to many pesticides and, for their size, are able to absorb surprisingly large amounts of chemical. In addition to systemic concerns, some products are corrosive and can cause severe eye damage or even blindness. Serious eye exposure can result from airborne dusts or particles,

splashes or spills, broken hoses, spray mists, or from rubbing the eyes with contaminated hands or clothing.

Inhalation Route

Protecting the lungs is important when mixing, loading, or applying pesticides especially in confined areas. If inhaled in sufficient amounts, pesticides can cause contact damage to nose, throat, and lung tissue. Once breathed into the lungs, pesticides can enter the bloodstream very rapidly and completely, eventually resulting in damage to other body organs (systemic illness). Another major concern is the aspiration of petroleum solvents (emulsifiable concentrate formulations) and other materials into the lungs when someone has induced vomiting after a particular product has been swallowed. As the person vomits, some of the material is suctioned (aspirated) into the lungs, where it can cause severe damage.

Oral Route

Accidental oral exposure occurs most frequently when children have access to rodent baits or other improperly stored pesticides in the home or when pesticides have been taken from the original, labeled container and put into an unlabeled bottle or food container. Unfortunately, children are the most common victims of these mishaps.

When people work around pesticides, oral exposure can occur when liquid concentrates splash into the mouth during mixing and loading of pesticides or cleaning of equipment. Never use your mouth to clear a spray line or to begin siphoning a pesticide. Chemicals can also be swallowed when eating, drinking, or smoking, or even licking one's lips, especially if contaminated hands transfer product to the mouth. Because many pesticides are rapidly and completely absorbed by the intestinal tract, wash your hands and face thoroughly before eating, drinking, or smoking. Mark all pesticide measuring cups and containers to ensure that no one uses them for water, drink, or food. Never store pesticides in beverage or other food containers. Practice good personal hygiene and wear the proper protective equipment to avoid exposure. Preventing exposure is a key principle in the safe use of pesticides.

PRODUCT TOXICITY AND HEALTH CONCERNS

ACUTE TOXICITY

Injury or illness produced from a single exposure. LD_{50} and LC_{50} are common measures of the degree of acute toxicity.

CHRONIC TOXICITY

The ability of small amounts of pesticide from repeated, prolonged exposure to cause injury or illness.

Toxicity of a particular pesticide is estimated by subjecting test animals (usually rats, mice, rabbits, and dogs) to various dosages of the active ingredient and to each of its formulated products. Toxicity, measured for both short-term (**acute**) exposure and long-term (**chronic**) exposure, is evaluated at a range of doses that cause no immediate effects, at doses where there are some immediate effects, at doses where there are delayed or long-term effects, and at the dose where death occurs.

Acute Toxicity

Acute toxicity is the measure of harm (systemic or contact) caused by a single, one-time exposure event. Acute effects are determined after test animals have been exposed through contact with their skin and eyes, and through ingestion and inhalation. The harmful effects may be systemic or contact in nature (or a combination of both), depending on the product, formulation, dose, and route of exposure. Acute effects occur shortly after exposure, usually within 24 hours.

The following example of acute toxicity illustrates the harmful effects that can occur when people are exposed to a harmful dose of alcohol:

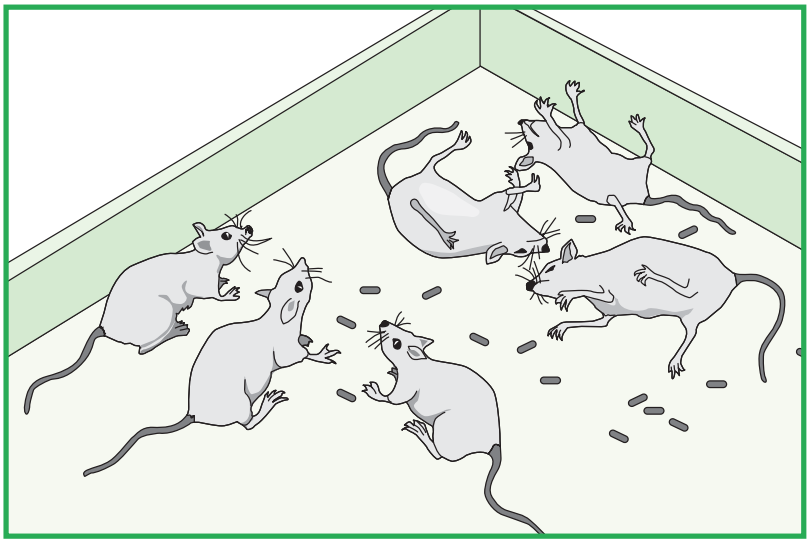
> *Alcohol consumption is fairly common. Annually, only a few people die from lethal alcohol toxicity due to a single exposure event. Many people, however, have varying levels of harmful effects due to overexposure, such as headaches, digestive disorders, and disorientation. People's symptoms from drinking alcohol depend on the dose, the exposure period, and their own body chemistry and weight.*

Acute systemic toxicity is the measure of illness or death resulting from a change in critical body function in the animal. The common method used for comparing acute toxicity is the **LD_{50}**, or lethal dose 50 percent. The LD_{50} is the dose of a toxicant required to kill 50 percent of the population of test animals under a standard set of conditions. For comparison purposes, LD_{50} values of pesticides are recorded in milligrams of toxicant per kilogram of body weight of the test animal (mg/kg). When the test animal is exposed to the material by feeding, the result is referred to as the **oral LD_{50}**. When the material is tested by skin exposure, the result is referred to as the **dermal LD_{50}**. A few products are toxic at low doses by either dermal or oral exposure, such as the insecticides parathion and methamidophos.

Another commonly used measure of acute toxicity is the **LC_{50}** or lethal concentration 50 percent. This is the concentration of a substance in air or water required to kill 50 percent of the test population. The LC_{50} is generally expressed as a ratio of the proportional amount of pesticide to a total volume of air or water. This is commonly expressed in parts per million (ppm) or milligrams per liter (mg/l). The LC_{50} is a common measure of lethal effects of chemicals on fish and other aquatic organisms. The LC_{50} values most directly applicable to human health are those expressing lethal concentration of chemicals in air.

The LD_{50} and LC_{50} values are useful in comparing the systemic toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD_{50} value of a pesticide, the less it takes to kill 50 percent of the population of test animals. Therefore, the greater the toxicity of the chemical. Pesticides with an LD_{50} value of less than 50mg/kg by oral exposure or 200 mg/kg by dermal exposure, or an LC_{50} value of less than 0.2 mg/l by inhalation exposure are legally classified as **poisons**. Poisons are those products that have the potential to kill humans at very low exposures (less than a teaspoon). Any product with this toxicity concern has the **signal words** DANGER—POISON in red letters and the skull and crossbones symbol on the label. Products with the POISON classification include most fumigants, some rodenticides, several insecticides, and a few herbicides.

The LD_{50} and LC_{50} have limitations because they measure only one toxic effect—death. They do not give any indication of what dose may lead to other less serious, acute systemic effects or to other, possibly equally serious contact effects or delayed systemic effects. Also, they do not translate directly to humans because our body systems are slightly different from those of test animals (e.g., rats, mice, etc.). Lastly, the LD_{50} and LC_{50} are measures of a single exposure, not the potential buildup of effects resulting from multiple exposures.



Adapted from University of Illinois *General Standards* manual

LD_{50} is the amount of pesticide that kills half of the test animals.

Some pesticides produce acute toxic effects because of their corrosive or irritant properties. These can result in respiratory, skin, or eye irritation or damage. Some can cause severe burns or permanent blindness. Chemicals with these irritant or corrosive properties need to be used with extra care. Fungicides, herbicides, and some insecticides pose contact injury concerns. Manufacturers list non-lethal systemic and contact effects in addition to the signal word. Systemic and contact acute toxicity concerns are indicated by the signal words and further explained in the "Precautionary Statements" portion

The lower the LD_{50} value of a pesticide, the less it takes to kill 50 percent of the population of test animals. Therefore, the greater the toxicity of the chemical.

of the product label under the "Hazards to Humans and Domestic Animals" section.

DANGER/POISON
PELIGRO



Fatal if swallowed. May cause blindness if swallowed. May be fatal if inhaled or absorbed through eyes. Causes irreversible eye damage. Do not get in eyes, on skin, or on clothing. Do not breath vapors or spray mist.

Hazard Class 1 pesticides that are highly toxic due to acute oral, dermal, and inhalation toxicity must have the signal words DANGER and POISON and the Spanish word for danger, PELIGRO, in red letters, and the skull and crossbones symbol prominently displayed on the package label.

The EPA and the manufacturer take into account both systemic and contact toxicity measures in assigning the product's signal word and toxicity category. These are assigned on the basis of the greatest concern, be it oral, dermal, or inhalation systemic effects, or skin, eyes, or respiratory tract contact effects.



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Hazard Class 1 pesticides that are highly toxic due to acute contact toxicity must have the word DANGER but not the word POISON or the skull and crossbones symbol.

Signal words and skull and crossbones symbol

There are four distinct signal words found on pesticide labels: DANGER—POISON, DANGER, WARNING, and CAUTION. Signal words are also found on other chemical products used around work and home, such as paint, oven cleaner, dish soap, antifreeze, and window cleaner, to name a few. Signal words are based on the toxicity of the product. Depending on their toxicity, they are categorized into several classes of hazard. Some very low toxicity products (Hazard Class IV) are not required to have a signal word.

Danger—Poison

Pesticides classified as highly toxic (Hazard Class I) with acute oral LD_{50} values from a trace to 50 mg/kg must have the signal words DANGER and POISON (in red letters) and a skull and crossbones symbol prominently displayed on the package label. The lethal toxicity may be based on oral, dermal, or inhalation exposure.

PELIGRO, the Spanish word for DANGER, must also appear on the labels of highly toxic chemicals. As little as a few drops of a DANGER—POISON material taken orally could be fatal to a 150-pound person. Note that the human oral LD_{50} of paraquat, a herbicide active ingredient, is 3 to 5 mg/kg, whereas the rat oral LD_{50} is 150 mg/kg. Consult the precautionary statements that follow the signal word and symbol on the label to learn more about the product's hazard to humans. Most fumigants, some insecticides and rodenticides, and a few herbicides are assigned the DANGER—POISON signal word.

Danger

Some highly toxic (Hazard Class I) pesticide products carry the signal word DANGER (without the word "poison" or the skull and crossbones symbol) because of their potential to cause acute contact injury. DANGER indicates the potential for permanent or severe damage to skin, eyes, or lungs. These contact effects are more dangerous than the acute systemic toxicity (LD_{50}) of the product. Several carry warnings of concern about their causing irreversible eye damage at low exposures. Consult the precautionary statements that follow the signal word on the label to learn more about the product's hazard for humans. Some herbicides, insecticides, and antimicrobials carry the DANGER signal word.

Table 5.1 Toxicity Categories

Signal Word & Symbol	Toxicity Level & Class	Oral LD_{50} (mg/kg)	LD_{50} Dermal (mg/kg)	LC_{50} Inhalation (mg/l)	Contact Injury Concern	Toxicity Concern
DANGER—POISON/ PELIGRO **Skull & Crossbones**	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2	Signal word based on oral, dermal, or inhalation toxicity.	Very low dose could kill a person (a few drops to 1 teaspoon).
DANGER/ PELIGRO	Highly toxic, Hazard Class I				Corrosive—permanent or severe skin, eye, or respiratory damage.	Based on the corrosive or irritant properties of the product.
WARNING/ AVISO	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2	Moderate skin, eye, or respiratory damage.	Small to medium dose could cause death, illness, or skin, eye, or respiratory damage (1 teaspoon to 1 ounce).
CAUTION	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20	Mild skin, eye, or respiratory irritation.	Medium to large dose could cause death, illness, or skin, eye, or respiratory damage (1 ounce to 1 pint or 1 pound).
CAUTION or no signal word	Hazard Class IV	Greater than 5,000	Greater than 20,000	Greater than 20	Slight concern for skin, eye, or respiratory injury.	Slight to none (over 1 pint or 1 pound).

Warning

A pesticide product considered moderately toxic (Hazard Class II) must have the signal words WARNING and AVISO (Spanish) on its label. If the concern is due to systemic toxicity, the acute oral LD_{50} values range from 50 to 500 mg/kg; 1 teaspoonful to 1 ounce (2 tablespoons) of this material could be fatal to a 150-pound person. The concern could also be due to contact injury to skin, eyes, or respiratory tract. The WARNING signal word alone does not indicate whether the concern is systemic or contact or both. Consult the precautionary statements that follow the signal word on the label to learn about the product's specific contact or systemic hazard for humans.

Caution

Pesticide products classified as slightly toxic (Hazard Class III) are required to have the signal word CAUTION on the pesticide label. Acute toxicity may be systemic or contact in nature. If systemic, the acute oral LD_{50} values are between 500 mg/kg and 5,000 mg/kg. Contact effects are generally irritation of eyes, skin, or respiratory tract. Consult the precautionary statements that follow the signal word on the label to learn about the product's contact or systemic hazard to humans.

Hazard Class II pesticides must have the signal word WARNING (AVISO in Spanish) on its label.



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Hazard Class III pesticides are required to have the signal word CAUTION on the label.

Chronic Toxicity

The **chronic toxicity** of a pesticide is determined by subjecting test animals to long-term exposure to an

active ingredient, typically two years. The harmful effects that occur from small, repeated doses over time are termed chronic effects.

A non-pesticidal example of chronic toxicity is the relationship between tobacco and lung cancer. Not everyone who smokes gets lung cancer. However, a significant number of people who smoke for years do get lung cancer. Another example of chronic toxicity is liver damage resulting from long-term exposure to moderate or high levels of alcohol.

The suspected chronic effects from exposure to certain pesticides include genetic changes, non-cancerous or cancerous tumors, reproductive effects, infertility, fetal toxicity, miscarriages, birth defects, blood disorders, and nerve disorders.

If a product causes chronic effects in laboratory animals, the manufacturer is required to include chronic toxicity warning statements on the product label. This information is also listed on the MSDS. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. They may be delayed for weeks, months or even years. Whether or not you experience delayed effects depends on the pesticide, the extent and route of exposure(s), and how often you were exposed. Under "Precautionary Statements," the label states any delayed effects that the pesticide might cause and how to avoid exposures leading to them. Wearing extra protective gear and taking additional precautions may be necessary to reduce the risk of delayed effects. Delayed effects may be caused by either an acute exposure or chronic exposure to a pesticide.

SYMPTOM RECOGNITION

Symptoms can be correlated with certain groups of pesticides. For example, borates (insecticides) tend to be irritating to the skin, nose, and respiratory system, while some fungicides are irritants to the skin, eyes, and mucous membranes of the respiratory system. Anticoagulant-type rodenticides may cause bloody noses and bleeding gums. Organophosphate and carbamate insecticides may cause all of the systemic symptoms listed *(see sidebar on the next page)* that could ultimately result in respiratory failure and death. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, eye, and skin irritation. 2,4-D and some other related herbicides (dicamba, MCPA, and MCPP) are irritating to the skin and mucous membranes, and they can also cause vomiting, headaches, diarrhea, and confusion.



Reference material for toxicological symptoms.

Because symptoms of pesticide poisoning or exposure can vary widely, physicians need training to recognize this variability and treat appropriately. A manual entitled *Recognition and Management of Pesticide Poisonings* provides treatment guidelines for physicians to follow in the case of pesticide poisonings. This manual can be obtained through the EPA Office of Pesticide Programs or from the EPA Web site http://www.epa.gov/.

Cholinesterase Inhibition

Cholinesterase inhibition due to exposure to organophosphate or carbamate insecticides can cause acute or delayed effects. Each person has a certain baseline level of cholinesterase enzyme that is considered normal for that individual. Organophosphate or carbamate exposure inhibits cholinesterase, resulting in continual overexcitation of nerve-to-nerve and nerve-to-muscle communication. Large exposures to these insecticides can cause immediate illness. Smaller exposures may not outwardly cause symptoms, but small, repeated exposures over several days or weeks may continually reduce the body's cholinesterase level and ultimately trigger mild, moderate, or severe symptoms of overexposure.

In the case of cholinesterase inhibition, it is not always obvious whether a worker is showing symptoms from an acute exposure or experiencing delayed effects from repeated exposures. For example, an applicator who is exposed to a single, large amount of an organophosphate may suffer acute effects. However, if over time the applicator is exposed to several small amounts, cholinesterase levels are reduced slightly at each exposure. Eventually, a small additional exposure can cause illness. In this example, the illness sets in soon after an exposure, but only if there were previous repeated exposures.

Cholinesterase Monitoring

The blood cholinesterase test measures the effect of exposure to organophosphate and carbamate insecticides. Cholinesterase levels can vary considerably between individuals so a baseline must be established for each person. A small percentage of the population has a genetically determined low level of cholinesterase. Even minimal exposure to cholinesterase inhibitors can present a substantial risk to these people. Always conduct baseline testing during the time of year when insecticides are not being used or at least 30 days from the most recent exposure. Establishing an accurate baseline value often requires that two tests be performed at least 72 hours but not more than 14 days apart.

If you are using organophosphate or carbamate insecticides, cholinesterase tests can be periodically taken and results compared with your previously established baseline level. Also, anytime you feel ill or have mild or moderate symptoms of poisoning, your physician should conduct a blood test to evaluate your cholinesterase level and compare it with the baseline level. The purpose of routine or emergency cholinesterase monitoring is to enable a physician to recognize the occurrence of excessive exposure to organophosphate and carbamate insecticides. A significant reduction in your body's cholinesterase level indicates poisoning. A physician normally suggests that thepesticidehandler be removed from further exposure. A reduction in cholinesterase may require that you have no exposure for a certain period to allow your body time to build new cholinesterase. Your physician can help to establish the frequency of this testing program. Physicians who specialize in occupational and environmental medicine are most familiar with this type of testing program.

Common symptoms associated with organophospate and carbamate insecticide poisoning

Mild poisoning

- Fatigue
- Headache
- Dizziness
- Blurred vision
- Excessive sweating/salivation
- Nausea and vomiting
- Stomach cramps and diarrhea

Moderate poisoning

- Inability to walk
- Weakness
- Chest discomfort
- Constriction of pupils
- Mild symptoms more severe

Severe poisoning

- Unconsciousness
- Severe constriction of pupils
- Muscle twitching
- Running nose and drooling
- Breathing difficulty
- Coma and death

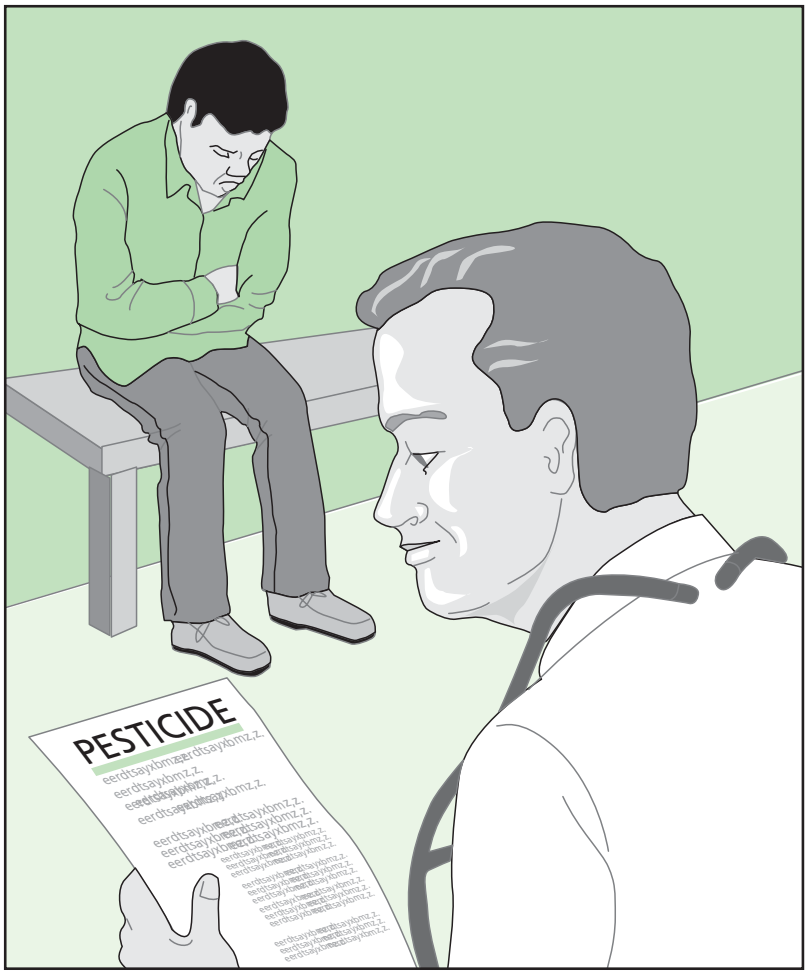
FIRST AID FOR PESTICIDE POISONING

National Poison Control Center
1-800-222-1222
(Staffed 24 hours)

Animal Poison Control Center (APCC)
1-888-426-4435

National Pesticide Information Center (NPIC)
1-800-858-7378

Get medical advice immediately if you or any of your fellow workers have unusual or unexplained symptoms that develop within 24 hours of a pesticide exposure. Be alert for the early symptoms of pesticide poisoning and contact effects in yourself and others. Recognizing symptoms early and providing an immediate first-aid response may save a life or prevent permanent injury. Do not wait until you or someone else gets dangerously ill before calling a physician or going to a hospital. It is better to be too cautious than to act too late. Take the pesticide label with you, either a duplicate copy or the one attached to the container (or at a minimum, the EPA registration number of the product). To avoid contamination and exposure, do not carry pesticides in the passenger space of the vehicle.



Always bring the label with you when seeking medical advice for exposure symptoms.

The doctor needs to know the pesticide ingredients to determine the proper course of treatment. It is a good idea to print off extra copies of the label from the Internet and place one copy in your service vehicle and one in your office for use during medical emergencies.

Remember, certain symptoms are not always the result of pesticide exposure. Common illnesses such as the flu, heat exhaustion or heat stroke, pneumonia, asthma, respiratory or intestinal infections, and even a hangover can cause similar symptoms. Contact with certain plants such as poison oak or poison ivy can also produce skin effects like those resulting from pesticide exposure. However, when symptoms appear after contact with pesticides, always seek medical attention immediately.

General First-aid

First aid is the initial effort to help a victim while medical help is on the way. If you are alone with the victim, make sure he/she is breathing and is not being further exposed to the pesticide before you call for emergency assistance. Protect yourself from pesticide exposure prior to and while giving assistance. Make sure you wear the appropriate personal protective equipment (PPE), including a respirator, before assisting someone in an enclosed area. Apply artificial respiration if the victim is not breathing and is not vomiting.

Immediate action can indeed be a life-or-death matter in a pesticide poisoning. The product label is the primary source of information. Follow the label's specific first-aid instructions carefully. In addition, call the **National Poison Control Center (1-800-222-1222)** or a physician. First aid is only the first response and is not a substitute for professional medical help. It is very important to get the victim to a hospital without delay. The following are a few key points to remember when administering first aid during a pesticide emergency:

- If oral or dermal exposure has occurred, the first objective is usually to dilute the pesticide and prevent absorption.
- Always have a source of clean water available. In an extreme emergency, even water from a farm pond, irrigation system, or watering trough could be used to dilute the pesticide.
- Never try to give anything by mouth to an unconscious person.
- If inhalation exposure occurs, get the victim to fresh air immediately.
- Become familiar with the proper techniques of artificial respiration; it may be necessary if a person's breathing has stopped or becomes impaired.
- If there is a likelihood of first responders being directly exposed to a pesticide, be sure they wear appropriate PPE.

In addition to the National Poison Control Center (it is staffed 24 hours each day); you can call the National Pesticide Information Center (NPIC). Located in Corvallis, Oregon, it provides a variety of information about pesticides to anyone in the United States seven days per week from 6:30 a.m. to 4:30 p.m. Pacific time (1-800-858-7378; http://npic.orst.edu). Post all emergency numbers by the telephone and in service vehicles involved in handling pesticides.

Pets, horses, and other livestock can also be poisoned by exposure to pesticides. Emergency information on the treatment of pets or livestock harmed by pesticide contamination or poisoning can be obtained by contacting the Animal Poison Control Center (APCC) at 1-888-426-4435.

Pesticide on the Skin

Proper hygiene helps to protect the skin from pesticide exposure. Always have an adequate water supply with you anytime that skin exposure is possible.

- Remove all contaminated clothing immediately.
- Wash the affected area, including the hair, with water and soap, then rinse well. Use of a shower is best. Avoid harsh scrubbing, which enhances pesticide absorption.
- Gently dry the affected area and wrap it in loose cloth or a blanket, if necessary.
- If the skin has chemical burns, cover the area loosely with a clean, soft cloth. Avoid using ointments, greases, powders, and other medications unless instructed to do so by a medical authority.



Washing your hands with water and soap after using pesticides prevents skin contamination.

It is often best to dispose of contaminated clothing, especially if there is any concern about getting the contaminated clothing clean. Place it in a plastic bag, seal the bag and write on the bag the name of the material that contaminated it. Take it to a household hazardous waste collection. If you decide to keep the clothing, store and wash it separately from the family laundry.

Pesticide in the Eye

Because the eyes readily absorb material that gets into them, fast action is required.

- Hold the eyelid open and immediately begin gently washing the eye with drips of clean water. Do not use chemicals or drugs in the wash water unless instructed to do so by a physician or a poison control center.
- Drip the water across the eye, not directly into the eye, or use an eyewash dispenser.
- Continuously rinse the eye for 15 minutes. If only one eye is involved, be careful not to contaminate the other eye.

- Flush under the eyelids with water to remove debris.
- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Pesticide

The basic first-aid procedure for someone who has inhaled a pesticide is to get the exposed person to fresh air.

- Immediately carry the victim to fresh air (do not allow the victim to walk).
- Do not attempt to rescue someone who is in an enclosed, contaminated area unless you are wearing appropriate PPE.
- If other people are in the area, warn them of the danger.
- Have the victim lie down and loosen clothing.
- Keep the victim warm and quiet. Do not allow him/her to become chilled or overheated.
- If the victim is convulsing, protect the victim's head and watch that breathing continues.
- Keep the person's chin up to ensure that air passages are open for breathing.
- If breathing stops or is irregular, give artificial respiration.

Pesticide in the Mouth or Swallowed

If pesticide has gotten in the mouth but has not been swallowed, rinse the mouth with plenty of water. After the mouth has been thoroughly rinsed, give the victim large amounts (up to 1 quart) of milk or water to drink. If the pesticide is swallowed, one of the most critical first-aid decisions is whether to induce vomiting. Induce vomiting **only** if the label instructs to do so. Several pesticides cause more harm when vomited than if they remain in the stomach. To provide first aid for a swallowed pesticide, you must know the appropriate treatment. The decision to induce vomiting must be made quickly and accurately—the victim's life may depend on it.

Never induce vomiting if the victim:

- Is unconscious or having convulsions.
- Has swallowed a corrosive poison, such as a strong alkali or acid. The material burns the throat and mouth as severely coming up as it did going down. Also, it can be aspirated into the lungs and cause more damage.
- Has swallowed an emulsifiable concentrate or oil solution product, which is dissolved in petroleum solvents. Emulsifiable concentrates and oil solutions may cause death if aspirated into the lungs during vomiting.

How to Induce Vomiting

Induce vomiting only as a first-aid measure until you can get the victim to a hospital. Do not waste a lot of time attempting to induce vomiting.

- Make sure the victim is kneeling forward or lying on his side to prevent vomit from entering the lungs and causing additional damage.
- First give the victim at least 2 glasses of water to dilute the product. Do not use carbonated beverages.
- To induce vomiting, put your finger or the blunt end of a spoon at the back of the throat. Do not use anything sharp or pointed. Do not use salt water to induce vomiting.
- Collect some of the vomitus for the doctor, who may need it for chemical analysis.

Activated charcoal is another first-aid treatment that can be administered when a pesticide has been swallowed. Give the patient 2 to 4 tablespoons of activated charcoal in at least 8 ounces of water. Activated charcoal acts as a magnet to adsorb many chemicals. Pharmaceutical grade activated charcoal is available from most drug

stores. Activated charcoal prepared for cleaning up pesticide spills may be substituted in an emergency. Take the victim to a physician or hospital.

Only general first-aid practices have been discussed here. Contact the Poison Control Center for further assistance in administering first-aid. If necessary, get the victim to a doctor or hospital, and take the pesticide label with you.

Antidotes

Antidotes are available for only a few classes of pesticides—anticoagulant-type rodenticides and the organophosphate or carbamate insecticides. Antidotes can be extremely dangerous if misused, so they should be prescribed and administered only by a qualified physician. Antidotes should never be used to prevent poisoning.

Atropine sulfate. This antidote is given for carbamate insecticide poisoning. The need and dosage are based on the body weight of the victim. It is always given alone for carbamate poisoning. It can be given repeatedly as symptoms reoccur.

Atropine sulfate in combination with 2-PAM (protopam chloride). This antidote combination is given for organophosphate insecticide poisoning. The combination actually helps to reactivate cholinesterase in organophosphate poisoning cases; reactivation does not occur with atropine treatment for carbamate poisonings.

Vitamin K_1. This antidote is used for treating exposures to anticoagulant rodenticides. Anticoagulant rodenticides cause internal bleeding and prevent blood clotting. Vitamin K_1 helps restore the ability of the blood to clot normally.

Note: Ipecac syrup, used as an emetic for almost 50 years, is **no longer recommended for routine use in most poisonings.** Clinical studies have demonstrated no benefit from its use. Ipecac works too slowly (about 20 minutes) in inducing vomiting and results in only about one-third of stomach contents being voided.

HEAT STRESS

Heat stress occurs when the body is subjected to a level of heat with which it cannot cope. Heat stress can affect both pesticide handlers and workers. With heat stress, the heat, not pesticide exposure, causes certain symptoms. PPE worn during handling or early-entry activities can increase the risk of heat stress. The protective qualities of the PPE may restrict the evaporation of sweat, thus impeding the body's natural cooling system. If you are under a physician's care, consult your physician before working in hot or humid conditions. Special PPE is available to assist in maintaining a cool body temperature.

Symptoms of Heat Stress

Mild forms of heat stress make people feel ill and impair their ability to do a good job. You may feel weak and get tired sooner than usual. In addition, you may be less alert and less able to use good judgment. Severe heat stress, also known as heat stroke, is life-threatening. The normal body temperature is 97.7 degrees F. With heat stroke, body temperature may exceed 105 degrees F. Staggering, unconsciousness, or convulsions may result. Lack of sweating is a common symptom of heat stroke. Brain damage or even death can occur if the heat stroke victim is not cooled down quickly. More than 10 percent of severe heat stress victims die, including young, healthy adults. Sometimes victims remain highly sensitive to heat for months and are unable to return to the same work.

Heat stress symptoms include:

- Fatigue (exhaustion, muscle weakness).
- Dizziness and fainting.
- Clammy skin or hot, dry skin.



Avoid heat stress by taking breaks and drinking water throughout the workday.

- Altered behavior—confusion, slurred speech, quarrelsome, irrational.
- Headache, nausea, and chills.
- Severe thirst and dry mouth.
- Heavy sweating or complete lack of sweating.

Learn more about symptoms of heat stress and take immediate action to cool down if you suspect you may be suffering from even mild heat stress. Drink plenty of water and take breaks in the shade throughout the workday.

SUMMARY

Pesticide risk can be summarized by the formula **hazard=toxicity x exposure**, where "toxicity" is the capacity of the pesticide to cause short-term (acute) or long-term (chronic) injury or illness and "exposure" is the means by which the pesticide gets into or onto the body. These two factors determine the likelihood that harm (i.e., hazard) will occur to the individual who handles pesticides. Pesticide users can reduce the chances of acute or chronic injury by taking measures to prevent exposure.

Harmful effects of pesticides may occur by direct contact, by uptake into the body (i.e., systemic effects and by allergic reactions). These risks can be reduced by understanding pesticide exposure routes, ways by which pesticides can enter or contact the body: by the skin (dermal), eyes, mouth (oral), and the lungs (inhalation). Pesticide handlers can prevent exposure by following label directions, using the proper application techniques, and wearing appropriate PPE.

Another way to reduce risk is to use the least toxic pesticide that will do the job, thereby reducing the risk of acute injury. In some cases, it may be better to choose a more toxic pesticide that can be used less frequently, thus reducing the risk of chronic injury or illness. The toxicity of a pesticide product is measured by the LD_{50} and the LC_{50} values. These values determine the type of signal word that occurs on a pesticide label. Signal words—DANGER—POISON, DANGER, WARNING, and CAUTION—help the user recognize how toxic the pesticide is and what precautions to take.

Pesticide handlers need to be aware of the symptoms of pesticide poisoning to know when to seek medical attention. Not all symptoms occur immediately following a pesticide exposure. Some symptoms are the result of chronic exposure (i.e., small, repeated doses over time). People who use pesticides routinely should have regular medical checkups to determine if they are experiencing any ill effects from pesticide use. For example, measuring blood cholinesterase is one way to determine if certain insecticides are affecting an individual before symptoms appear. People affected by chronic toxicity must remove themselves from the exposure situation.

Early recognition of symptoms of pesticide poisoning is the key to preventing the potential for further injury. Victims of single, acute toxic exposures must be assisted and taken to a doctor or hospital immediately following any necessary first-aid procedures. The first-aid methods used depends on how the exposure occurred—to the skin, eyes, or mouth, or by inhalation. The label often has important information on first-aid procedures for the particular pesticide product. Make sure a copy of the label is readily available whenever you are using pesticides, and take the label to the physician if a poisoning incident occurs.



Review Questions

CHAPTER 5: Pesticide Hazards and First Aid

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

1. **The capacity of a pesticide to cause short-term (acute) or long-term (chronic) injury is referred to as its:**
   - **A.** Toxicity.
   - **B.** Exposure.
   - **C.** Hazard.
   - **D.** Oral LD_{50}.

2. **Which statement is *false* about harmful effects of pesticides?**
   - **A.** The most common form of pesticide injury is by inhalation.
   - **B.** Fumigants can cause severe blisters.
   - **C.** Asthma-like symptoms may be caused by allergies to pesticides.
   - **D.** Many herbicides and fungicides cause dermatitis.

3. **Which signal word is associated with Hazard Class I and chemicals that have severe corrosive properties but do not necessarily have very low oral LD_{50} values?**
   - **A.** DANGER—POISON.
   - **B.** DANGER.
   - **C.** WARNING.
   - **D.** CAUTION.

4. **Which statement is *true* about pesticide toxicity?**
   - **A.** A pesticide with an oral LD_{50} of 250 mg/kg is more toxic than a pesticide with an LD_{50} of 5 mg/kg.
   - **B.** Manufacturers are not required to include chronic toxicity warning statements on product labels; only acute toxicity warnings are included.
   - **C.** Delayed effects occur only after a single acute toxicity exposure.
   - **D.** Cholinesterase inhibition due to exposure to organophosphate or carbamate insecticides can cause acute or delayed effects.

5. **What is the purpose of routine or emergency cholinesterase monitoring?**
   - **A.** To enable a physician to recognize the occurrence of excessive exposure to organophosphate and carbamate insecticides.
   - **B.** To enable a physician to recognize the occurrence of excessive exposure to pyrethroid insecticides.
   - **C.** To enable the pesticide handler to know when to stop using pesticide products during the course of a normal workday.
   - **D.** To enable the pesticide handler to know when he/she has been overexposed to restricted-use pesticides.

6. **When should a blood test for baseline cholinesterase be done?**
   - **A.** Baseline testing should be done during the time of year when pesticide use is the greatest and at least 14 days into the application season.
   - **B.** Baseline testing should be done during the time of year when pesticides are not being used or at least 30 days from the most recent exposure.
   - **C.** Baseline testing should be done during the time of year when pesticides are not being used or within one week of the most recent exposure.
   - **D.** Baseline testing should be done about halfway through the application season to measure the average amount of pesticide exposure.

7. **Which statement is *true* about pesticide exposure routes?**

   A. Oil-based liquid pesticide formulations, such as emulsifiable concentrates, do not absorb through the skin.
   B. Evidence indicates that about 97 percent of all body exposure to pesticides during a spraying operation is by inhalation.
   C. Some products that cause systemic injury are as toxic when absorbed through the skin as when they are swallowed.
   D. The palms and forearms absorb more pesticides than the warm, moist areas of the body.

8. **Which statement is *false* about first-aid response for pesticide exposure to the eye?**

   A. Hold the eye open and immediately begin gently washing the eye with drips of clean water.
   B. The water should be dripped directly into the eye, don't use an eyewash dispenser.
   C. Continuously rinse the eye for 15 minutes.
   D. Flush under the eyelid with water to remove debris.

9. **What is the *first* thing you should do to help a victim of inhalation exposure?**

   A. Get the victim to fresh air.
   B. Administer artificial respiration.
   C. Have the victim lie down and loosen clothing.
   D. Keep the chin up to ensure that air passages are open for breathing.

10. **Which statement is *true* about heat stress?**

    A. Wearing lots of PPE prevents heat stress.
    B. Constriction of pupils is a symptom of heat stroke.
    C. Less than 10 percent of people affected by severe heat stroke die.
    D. Lack of sweat is a symptom of heat stroke.

CHAPTER 6

PERSONAL PROTECTIVE EQUIPMENT

LEARNING OBJECTIVES

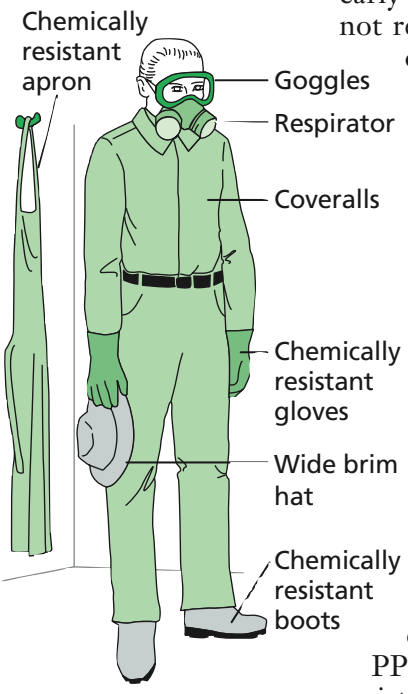
After studying this chapter, you should:

- Know how to identify the minimum personal protective equipment (PPE) required during pesticide application to be in compliance with regulations.
- Know how to select and wear safety equipment (e.g., gloves, boots, eye protection) according to label directions and regulations considering the length of exposure, exposure situation, and chemical to which one is exposed.
- Know how to select and properly wear PPE for protection of skin, eyes, and respiratory tract.
- Understand the importance of selecting, fit testing, and wearing respiratory devices (e.g., respirators, self-contained breathing apparatus) according to label directions and regulations.
- Know how to inspect for signs of wear and tear, damage, or other failures to PPE that may lead to exposure.
- Know when and how to dispose of personal protective equipment.
- Know how to clean, maintain, and store personal protective equipment according to manufacturers' recommendations.



Pesticides can pose hazards to humans. Remember, hazard depends on the product's toxicity and length of exposure. The severity of a pesticide poisoning depends on the pesticide's chemical makeup and formulation, its path into the body, the amount that enters the body, and the length of exposure. Wearing PPE can greatly reduce the potential for dermal, inhalation, eye, and oral exposure, and thereby significantly reduce the chances of a pesticide poisoning. "PPE" refers to clothing and devices worn to protect the human body from contact with pesticides or pesticide residues. PPE includes such items as coveralls or protective suits, footwear, gloves, aprons, respirators, eyewear, and headgear. PPE reduces exposure but does not necessarily eliminate it.

All pesticide handlers — applicators, mixer/loaders, flaggers, etc. — and early-entry agricultural workers are legally required to follow all PPE instructions that appear on the product label. A pesticide label lists



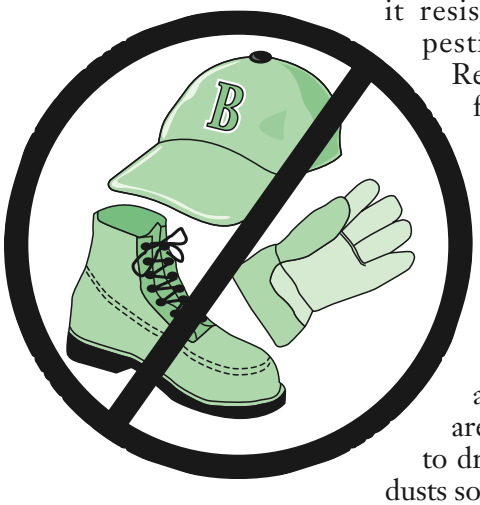
Wearing appropriate types of personal protective equipment (PPE) can greatly reduce the risk of pesticide exposure.

the *minimum* PPE that a person must wear while performing handling or early-entry activities. If the label does not require PPE or requires only one or two pieces of PPE, a cautious handler may decide to wear additional PPE for increased safety. Sometimes a label has different PPE requirements for pesticide handlers and early-entry workers. In addition, many states have specific labor laws and rules that regulate access to, training with, and use of PPE.

PPE offers various levels of protection, depending on the type of resistant material used. Some items of PPE simply act as filters by keeping dry or spray material off the skin. Others offer better protection against water-based products. Some offer protection from chemicals (solvent and/or active ingredient) that make up a concentrated pesticide product. PPE must be comfortable to ensure that people wear it and wear it properly. This chapter describes the types of PPE that are typically available for protection against pesticide exposure.

CHEMICAL-RESISTANT CLOTHING

The term **"chemical resistant"** means that no measurable movement of the pesticide through the material occurs during the period of use. Some PPE is **water resistant** only. "Water resistant" refers to PPE that keeps a small amount of fine spray particles or small liquid splashes from penetrating the clothing and reaching the skin. **Waterproof** (liquidproof) material keeps water-soluble materials out, but it may not necessarily keep out oil solvent-based products. Waterproof materials include items made of plastic or rubber. Some materials are actually chemically resistant. The chemical resistance of a material is an indication of how strongly it resists chemical penetration by pesticide products during use. Read the PPE packaging carefully to determine whether the protective item is chemical resistant, liquidproof, or water resistant.



Clothes made of cotton, leather, or canvas are not chemically resistant, even to dry formulations.

When making a decision about which protective equipment to use, follow these general guidelines. Cotton, leather, canvas, and other absorbent materials are not chemically resistant even to dry formulations. Powders and dusts sometimes move through cotton and other woven materials as quickly as liquid formulations. Also, they may remain in the fibers even after several launderings. Do not use a hat that has a cloth or leather sweatband, and do not use cloth or cloth-lined gloves, footwear, or aprons. Cloth is difficult or impossible to clean after it becomes contaminated with pesticide, and it is usually too expensive to be disposed of and replaced after one use.

Gloves, boots, aprons, suits, and hoods come in a variety of chemical-resistant materials. Generally, the best choices of materials are plastics, such as polyvinyl chloride (PVC); rubber, such as butyl, nitrile, neoprene, or vitron rubber; or non-woven fabrics coated with plastic or another barrier material such as Tyvek®. Barrier laminate materials such as 4H® or Silver Shield® are resistant to most pesticides, but many pesticide handlers consider them uncomfortable to wear and difficult to use while performing many tasks.

The ability of a given material to protect an individual from a pesticide product is largely a function of the type of solvent used to formulate the pesticide product. Watch for signs that the material is not chemically resistant to the pesticide product that you are using. Sometimes it is easy to see when plastic or rubber is not resistant to a pesticide. The material may change color, become soft or spongy, swell or bubble up, dissolve or become like jelly, crack or get holes, or become stiff or brittle. If any of the changes occur, discard the item and choose another type of resistant material.

Always read the pesticide labeling to see if it states which materials are resistant to the pesticide product. In some instances, a pesticide label's PPE

description lists a code letter (A-H) developed by EPA to help the user select suitable PPE. The EPA Chemical Resistance Category Selection Chart is given in Table 6.1.

The chart's code letters are based on the solvents used in a pesticide product, NOT the pesticide's active ingredient. By referring to this chart, a pesticide handler can determine how long a given material can be expected to withstand chemical exposure by a given solvent.

Table 6.1 EPA Chemical Resistance Category Selection Chart

Selection category on label	Type of Resistant Material							
	Barrier laminate	Butyl rubber ≥14 mils	Nitrile rubber ≥14 mils	Neoprene rubber* ≥14 mils	Natural rubber ≥14 mils	Poly-ethylene	Polyvinyl chloride (PVC) ≥14 mils	Vitron ≥14 mils
A Dry & 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 chemically resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticide at breaks.

Moderate: Moderately chemically resistant. Clean or replace PPE within an hour or two of contact.

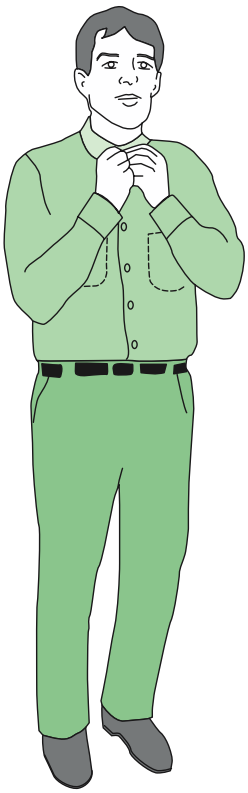
Slight: Slightly chemically resistant. Clean or replace PPE within 10 minutes of contact.

None: Not chemically resistant. Do not wear this type of material as PPE when contact is possible.

For example, if a certain pesticide label states that the user should choose gloves based on the guidelines in Category E, then select only gloves made from barrier laminate, nitrile rubber, neoprene rubber, or vitron. These materials would be expected to give protection for one or more days. Polyethylene gloves and natural and butyl rubber gloves would be expected to provide protection for only 10 minutes or less.

Different materials that are resistant to a particular pesticide do not necessarily provide protection for the same amount of time. Some materials restrict pesticide entry for a fairly long time, while others allow the pesticide to penetrate the PPE fairly quickly. Thin materials, such as disposable plastic gloves, shoe covers, or aprons, may provide the necessary protection for short-term tasks (taking a few minutes), but longer jobs usually require heavier material. Chemical resistance is often stated in exposure time. For example, neoprene is resistant to acetone for 30 minutes or less, and resistant to diesel fuel for more than 4 hours. If you wear neoprene gloves while handling pesticides containing an acetone solvent, change the gloves at least every 30 minutes or the pesticide product (acetone plus active ingredients) might penetrate the gloves and get onto your hands. Check the PPE manufacturer's brochure for information on the allowable length of exposure to specific chemicals.

Another factor to consider is the exposure situation. Chemical-resistant materials do not protect you when they become damaged during the pesticide-handling task. For tasks that involve handling sharp or pointed objects or walking through rough terrain, select a heavy-duty or sturdy material to ensure chemical resistance.



At a minimum wear a long-sleeved shirt, long pants, and socks when working around pesticides.

PROTECT YOUR SKIN

Your skin usually gets the most exposure while handling pesticides. Pay particular attention to covering as much of your skin as possible. Remember that PPE protects you only if the pesticide remains on the outside of the protective clothing. If the pesticide gets inside next to your skin, the protective clothing works against you. It then holds the pesticide tightly against your skin as long as you wear the PPE. This increases the likelihood for contact injury or skin absorption and systemic injury.

Work Clothes

Ordinary shirts, pants, shoes, and other work clothes are usually not considered PPE, even though pesticide labels often indicate that specific items of work clothing should be worn during certain activities. Anytime you handle pesticides or work around pesticide residues, wear, at a minimum, a long-sleeved shirt, long pants, and socks. Make sure the long-sleeved shirt and long pants are made of sturdy material and are free of holes and tears. Fasten the shirt collar completely to protect the lower part of your neck. The tighter the fabric weave, the better the protection. In some instances, the product label requires that you also wear a coverall, a chemical-resistant suit, or a chemical-resistant apron over your work clothes.

Coveralls

The protection offered by chemical-resistant clothing depends on the fabric and design features such as flaps over zippers, elastic at the wrists and ankles, and seams that are bound and sealed. Make sure coveralls are made of sturdy material such as cotton, polyester, a cotton-synthetic blend, denim, or a non-woven fabric such as Tyvek®. When wearing a coverall, close the opening securely so the entire body (except the feet, hands, neck, and head) is covered. When wearing a two-piece outfit, do not tuck the shirt or coat in at the waist—have the shirt extend well below the waist of the pants and fit loosely around the hips. Wear a coverall over a long-sleeved shirt, long

pants, and socks when handling pesticides that exhibit moderate or high dermal toxicity or are skin irritants.

Several factors determine how well a coverall protects you. First, the coverall needs to fit loosely. Each layer of clothing and each layer of air between the pesticide and your skin provide added protection. That is why the coverall needs to fit loosely. If the coverall fits too tightly, there is not a layer of air between it and your skin, and any pesticide that gets through the coverall comes in direct contact with your skin.

The design and structure of the coveralls also affects how well they protect you. Well designed coveralls have tightly constructed, sealed seams and snug, overlapping closures that do not allow gaps and do not unfasten readily. For example, many coveralls have zippers that are covered by flaps for added protection. This type of construction makes it harder for pesticides to get through these areas and come into contact with your inner clothing or skin. Some coveralls, such as those made of Tyvek®, are water resistant and disposable.

Chemical-resistant Suit

Some product labels require the handler to wear a chemical-resistant suit. This usually indicates the pesticide is very hazardous because of either acute or delayed effects. In these instances, take extra care to prevent the pesticide from getting on you.

If you expect that a large amount of pesticide could be deposited on your clothing over an extended period of time, wear a chemical-resistant suit even if the product label does not require it. Under these circumstances, even pesticides that are applied dry, such as dusts or granules, can get through ordinary fabric and may harm you.

Chemical-resistant suits made of rubber or plastic are sold as one-piece coveralls or as two-piece outfits consisting of a jacket worn over overalls. Chemical-resistant suits made of coated non-woven fabric usually are sold as one-piece coveralls.

The biggest drawback to chemical-resistant suits is they may make you uncomfortably warm. Unless you are handling pesticides in cool or climate-controlled environments, heat stress becomes a major concern. Take extra care to avoid heat stress by drinking plenty of water and taking frequent rest breaks to cool down.



Jack Kelly Clark, University of California Statewide IPM Program

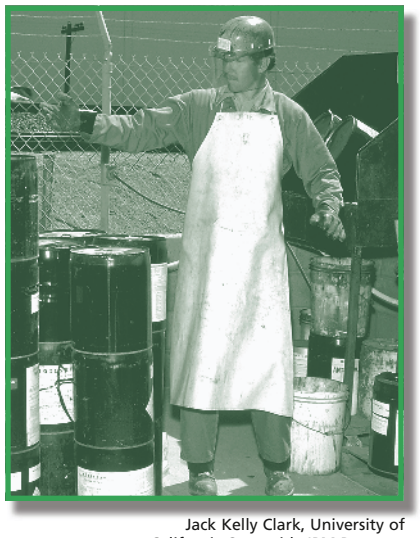
A well-designed coverall makes it hard for pesticides to get through to your inner clothing or skin.

Chemical-resistant Apron

An apron protects you from splashes, spills, and billowing dust, and it protects your coveralls or other clothing. Consider wearing an apron whenever you handle pesticide concentrates. The product label may require that you wear a chemical-resistant apron when mixing or loading a pesticide or cleaning application equipment.

Choose an apron that extends from your neck to at least your knees. Some aprons have attached sleeves and gloves. This style of apron protects your arms and hands and the front of your body by eliminating the potential gap where the sleeve and glove or sleeve and apron meet.

However, an apron can pose a safety hazard when you are working around equipment with moving parts. If an apron can get caught in machinery or get in your way, wear a chemical-resistant suit instead.



Jack Kelly Clark, University of California Statewide IPM Program

Choose a chemical-resistant apron that extends from your neck to at least your knees.

Gloves and Footwear

Pesticide handlers get, by far, the most exposure from pesticides on their hands and forearms. Research has shown that workers mixing pesticides received 85 percent of the total exposure to the hands and 13 percent to the forearms. The same study showed that wearing chemical-resistant gloves reduced exposure by 99 percent. As a result, most product labels require use of waterproof or chemical-resistant gloves during

handling and mixing activities. Do not wear lined gloves because the lining can absorb pesticides. Wear gloves anytime you might get pesticides on your hands, such as when working around contaminated equipment or other contaminated surfaces.

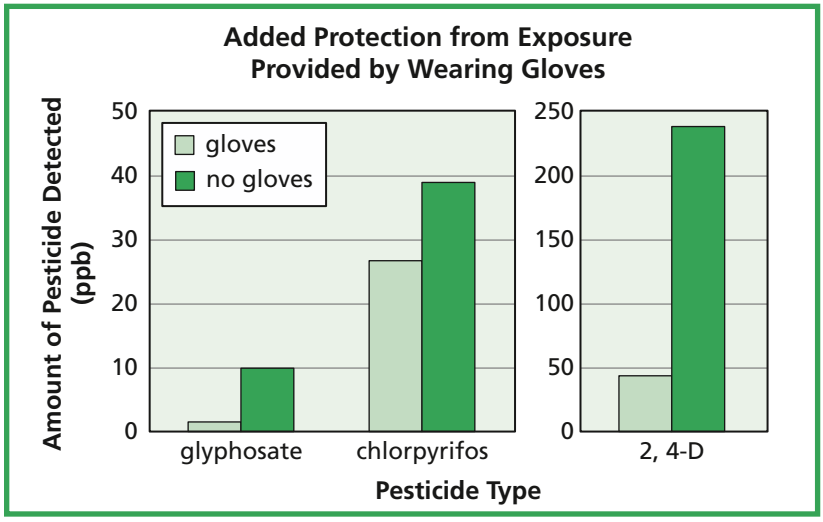


Figure 6.1
*Farmers who wore gloves while applying pesticides reduced their risk of exposure (*The Farm Family Exposure Study, *John Acquavella).*

Pesticide handlers often get pesticides on their feet. Sturdy shoes and socks are sufficient to protect your feet during many handling activities. Canvas and leather shoes are inappropriate when using pesticides because these materials absorb pesticides easily and cannot be decontaminated. Use waterproof or chemical-resistant footwear when handling pesticide concentrates or making applications, or when residues pose a high hazard to your feet. Some product labels require that you wear waterproof or chemical-resistant footwear, which could mean shoe covers or boots. If a pesticide is likely to get on your lower legs or feet, wear chemical-resistant boots that extend past your ankle and at least halfway up to your knee. Wearing waterproof boots is especially important if you enter or walk through treated areas before the spray has dried, such as pesticide applications made to lawns.



Edward Crow, Maryland Department of Agriculture

Nitrile and rubber gloves.

Some formulations may require specific types of gloves and footwear. Do not wear gloves or footwear when handling certain fumigants, such as methyl bromide. The gloves and footwear can trap the fumigant gas near the skin and cause burns. Other fumigants, such as aluminum and magnesium phosphide, specify gloves made of cotton or a similar material be worn when handling the product. Like other pesticides, fumigant labels specify the appropriate PPE required to protect the applicator from exposure.

Wear gloves and footwear correctly. Make sure that you choose gloves and footwear appropriate for the pesticide being handled. Always start out with new or freshly cleaned gloves and footwear that are in good condition. Do not grab a pair just because they are handy—they may not have been properly cleaned and may still have pesticides on or in them. If pesticide gets inside your gloves or footwear, take them off immediately, wash your hands or feet, and put on clean protective equipment. Keep several pairs of gloves and footwear available and change to a clean set whenever they become damaged or you suspect the inside has become contaminated.

Avoid contaminating the inside of gloves and footwear. Contamination often occurs when applicators remove their gloves during an application to adjust the equipment or their PPE, open a pesticide container, or wipe their faces, and then replace the gloves over their contaminated hands. If you must remove your gloves during a handling activity, wash your gloves thoroughly before taking them off, wash your hands thoroughly and dry them before you touch anything, and put the gloves on again when you return to work. Another common mistake is putting on footwear with contaminated hands, thereby transferring pesticides from your hands to your feet and socks.

Be careful not to allow pesticides to run down your sleeves into your gloves. For jobs in which your arms are mostly lowered, place sleeves outside the gloves. Use gloves that go up over your wrist and at least halfway to your elbow. For jobs in which your arms are mostly raised, leave your gloves outside your sleeves. Fold the cuff of

your gloves up 1 or 2 inches toward your fingers to catch the pesticide before it runs down your arm. For many jobs, you will be working some of the time with your arms raised and some of the time with them lowered. In these cases, close the glove cuff tightly outside the sleeve and put heavy-duty tape or an elastic band around the end of the glove where it meets the sleeve (see Figure 6.2). Some gloves have a method of tightening the cuff to your sleeve so the pesticide cannot run down into the glove.

Take care so pesticides do not run down your pant legs and into your footwear. Put your pant legs outside your boots to prevent this from occurring.

Hats

For overhead exposure or exposure to a lot of airborne particles, wear something to protect your head and neck, such as a wide-brimmed hat or chemical-resistant hood. Plastic safari hats with plastic sweatbands are a good choice because they are relatively cool in hot weather. More flexible hats and hoods are also available in chemical-resistant materials. Hats must not contain absorbent material such as cotton, leather, or straw. Many chemical-resistant jackets or coveralls can be purchased with attached protective hoods.

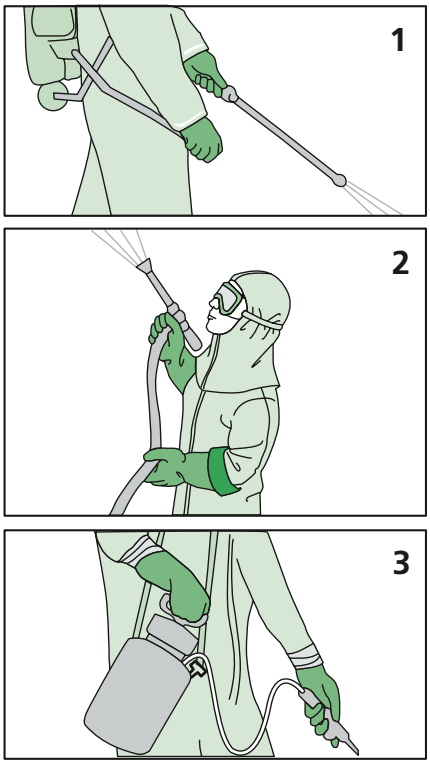


Figure 6.2
Wear gloves according to how you are applying the pesticide: (1) sleeves over gloves for jobs where your hands are mostly lowered, (2) gloves outside your sleeves with cuff folded up 1 or 2 inches when spraying above your head, and (3) cuffed tightly outside the sleeve with heavy-duty tape or an elastic band when working with your arms both raised and lowered.

PROTECT YOUR EYES

Eyes are very sensitive to the chemicals contained in some pesticide formulations, especially concentrates. Eyes readily absorb pesticides. Some product labels require a handler to wear protective eyewear. Goggles, a faceshield, or safety glasses with shields at both the brow and sides are examples of protective eyewear. Some labels specify that a particular type of eye protection must be worn. People who wear contact lenses should consult an eye doctor or their physician before using pesticides.

Shielded safety glasses and full faceshields are good choices in many handling situations because they are comfortable, do not cause fogging or sweating, and give good eye protection. Faceshields that are cupped inward toward your throat give better protection from splashes than straight faceshields. Wear goggles that fit tightly against your face if you will be in an open cab during an air-blast application; flagging directly under an aerial application; applying mists, fogs, or aerosols indoors; or in any other situation in which you will be enveloped in a spray, mist, or dust. Select goggles made of polycarbonate that have protected air baffles to avoid fogging. Either goggles or shielded safety glasses can be worn with a half-face respirator. Full-face respirators are supplied with their own faceshields, so additional eye protection is not required.

Under the agricultural Worker Protection Standard, if the label requires goggles for eye protection, then the handler must have immediate access to an eyewash dispenser at all times. Eyewashes can be portable or set in a fixed location such as an eyewash station in a greenhouse. Any user handling pesticide products that require goggles should have an eyewash readily available. If a pesticide gets past the goggle's protection, you do not have time to look for clean water to flush your eyes. Carrying an eyewash dispenser with you is recommended because some corrosive and irritant products can cause injury within a few seconds.



Chemically resistant splash-proof goggles help protect your eyes from pesticide exposure.

Virginia Tech Pesticide Programs

PROTECT YOUR RESPIRATORY TRACT

The respiratory tract consists of the lungs and other parts of the breathing system. It is much more absorbent than the skin. Even if a pesticide label does not require it, consider wearing a respirator if you are handling any product for which the label states "do not breathe vapors or spray mist" or "harmful or fatal if inhaled." In addition, wear a respirator if you will be exposed to any pesticide that can potentially be inhaled.

Types of Respirators

Air-supplying respirators

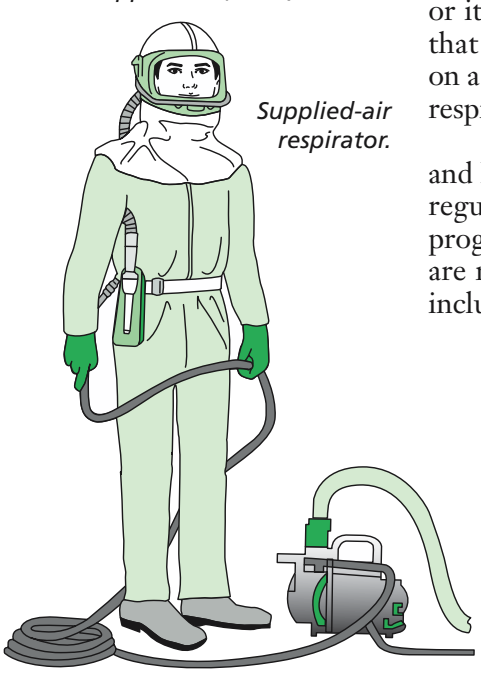
- Supplied-air respirator
- Self-contained breathing apparatus (SCBA)

Air-purifying respirators

- Non-powered particulate respirators (filtering facepiece, dust/mist mask)
- Powered particulate respirators
- Chemical cartridge respirators (half facemask and full facemask)
- Gas masks with canisters



Self-contained breathing apparatus (SCBA).



Supplied-air respirator.

Some fumigants and a few other pesticide formulations contain a chemical warning additive in the product formulation that alerts you when you begin to inhale the pesticide. Such warning agents are often used when the pesticide active ingredient is highly toxic but is not easily detected by smell. The additive may have a characteristic odor or it may be a mild irritant to alert you that you need leave the area or to put on a respirator, or to warn you that your respirator is no longer protecting you.

The federal Occupational Safety and Health Administration (OSHA) has regulations for a respiratory protection program. The following eight elements are required for all users of respirators, including pesticide handlers:

1. Procedures to select the proper respirator for your worksite or job.
2. Medical evaluation to determine ability to use a respirator.
3. Fit testing for tight-fitting respirators.
4. Proper use of respirators.
5. Care and maintenance of respirators.
6. Breathing air quality and use for supplied-air respirators.
7. Training on hazard recognition, dangers, and proper use and care of respirators.
8. Program evaluation on respirator fit, selection, use, and maintenance.

Most states have adopted the OSHA respirator standard into state law.

Respirators

Respirators protect you from breathing pesticide-contaminated air. Various pesticide formulations require different types of respirators. The product label states whether you must use a respirator and, if so, which type.

A respirator is a safety device that covers at least the mouth and nose. Two major groups of respirators are used when dealing with pesticides—air-supplying and air-purifying respirators. **Air-supplying** respirators provide clean, uncontaminated air from an outside source. They are used in low-oxygen environments and are generally more expensive. Often their big and bulky size puts a strain on the worker. **Air-purifying** respirators use physical and chemical filters to trap and remove contaminants as they pass through the respirator with the air being breathed by the wearer. The pesticide label provides guidance on which type of filters or cartridges to use. Adequate oxygen must be present in the air that is being breathed because an air-purifying respirator does not supply oxygen; it only filters the air that is being breathed.

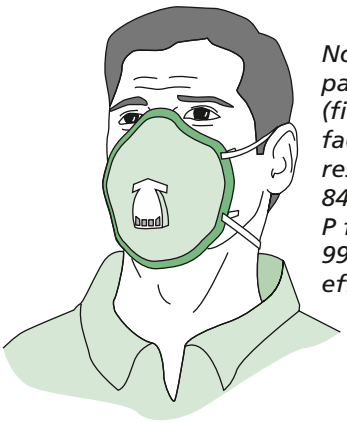
Air-purifying devices may be powered or non-powered. The powered air-purifying respirators use a blower to move the contaminated air through a purifying filter and can be used with either a tight-fitting facepiece or a loose-fitting hood. The non-powered devices can be either half-mask or full-face devices that place a filtration unit

between your breathing passage and the contaminated air source. Filters and cartridges are chemical specific or dust/mist specific. A combination chemical and dust/mist cartridge is also available. When handling some pesticides, an organic (OV) cartridge is required. The components of a typical non-powered air-purifying respirator are a snap-on retainer, a prefilter, an air-purifying cartridge, a facepiece that contains an exhalation valve, and a harness.

The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for testing and certifying respirators used in conjunction with pesticides (and other non-mining respiratory protection). Approval numbers beginning with the letters TC are assigned to all respirators reviewed by the agency and must be on the box containing the facepiece. Pesticide product labels often specify the type of respirator required by listing its TC number. In addition, filters are classified on the basis of oil degradation resistance and filter efficiency. The classification levels for oil degradation resistance are N—not oil resistant; R—oil resistant; and P—oil proof. The filter efficiency for each classification level may be 95, 99, or 100 percent. The following is a list showing several types of respirators and their TC code designations under the NIOSH classification system:

- TC–84A—non-powered particulate respirators (N, P, and R filters).
- TC–21C—powered particulate respirators only (100 series filters).
- TC–23C—chemical cartridge respirators.
- TC–14G—gas masks with canisters.
- TC–19C—supplied-air respirators.
- TC–13F—self-contained breathing apparatus.

The product formulation, toxicity, and type of application influence the type of respirator needed. Manufacturers use criteria approved by the EPA to assign



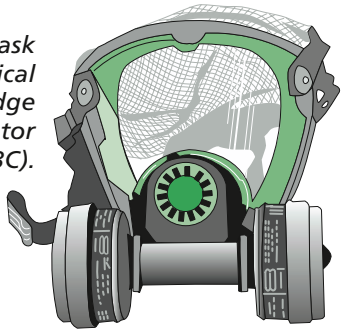
Non-powered particulate (filtering facepiece) respirator (TC-84A; N, R, or P filters; 95, 99, or 100% efficiency).



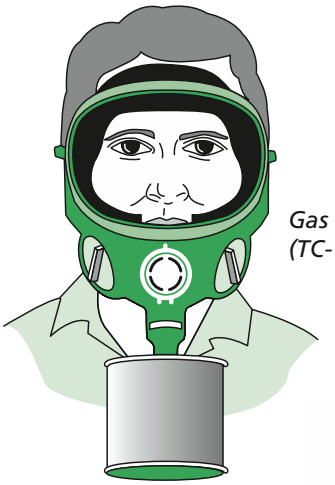
Powered particulate respirator (TC-21C).



Half facemask chemical cartridge respirator (TC-23C).



Full facemask chemical cartridge respirator (TC-23C).



Gas mask with canister (TC-14G).

Adapted from University of Illinois Private Applicator manual



Components of a typical non-powered air-purifying respirator include a snap-on retainer, a prefilter, an air-purifying cartridge, and a facepiece with exhalation valve and harness.

Edward Crow, Maryland Department of Agriculture

Table 6.2 Label Examples Based on the EPA Respiratory Protection Criteria

EPA Criteria	Label Statement for Respiratory Protection
Solid pesticides with Toxicity Class II, III, or IV	Use a NIOSH-approved respirator with any N, R, P, or 100 series prefilter.
Liquid pesticides, Toxicity Class I	Use a NIOSH-approved respirator with an organic vapor (OV) cartridge or canister with any N, R, P, or 100 series prefilter.
Gas applied in enclosed area	Use an air-supplying respirator with NIOSH TC–19C, or use a self-contained breathing apparatus with NIOSH TC–13F.

PPE respirator requirements on labels (see Table 6.2). When a pesticide label requires a respirator, wear a NIOSH-approved respirator for use with that particular pesticide. Remember, a single type of respirator does not adequately protect you from every pesticide or formulation that you may use.

Filtering facepiece respirators or non-powered particulate respirators (TC–84A) are dust/mist-filtering respirators. They offer protection from small particles in the air. They cover the nose and mouth to filter out dusts, mists, powders, and particles. They are to be disposed of after each use.

Chemical cartridge respirators (TC–23C) and gas masks with canisters (TC–14G) absorb harmful vapors or gases. In addition, chemical cartridge respirators and gas masks with canisters usually have an external dust/mist filter. Chemical cartridge respirators come in both half-facemask and full-facemask styles. The cartridge must be appropriate for the particular contaminant (organic vapor, phosphine, etc.).

Powered air-purifying respirators (TC–21C) use a fan to help draw air through an air-purifying cartridge and may reduce respiratory stress and heat stress, but they have a high start-up cost. The cartridge must be appropriate for the particular contaminant (organic vapor, phosphine, etc.).

Supplied-air respirators (TC–19C) use long hoses to supply air to a full facemask. Some but not all supplied-air respirators have a blower or compressor.

The self-contained breathing apparatus (TC–13F) uses a compressed-air tank and provides complete respiratory protection against toxic gases in an oxygen-deficient environment.

If the label recommends a NIOSH/MSHA (Mine Safety and Health Administration) respirator, this reference is to an older classification system. In this system TC–21C designated mist/dusk mask respirators. Under the new NIOSH system this designation is now TC–84A. Be sure to use an appropriate respirator for the pesticides you are using.

Use Respirators Properly

According to OSHA's respiratory protection standard (29 CFR 1910.134), employers must provide a medical evaluation to determine an employee's ability to use a respirator before the employee is fit tested or required to use the respirator in the workplace. Employees must also receive training on the proper use of the respirator for which they have been fit tested.

To work properly and provide the necessary protection, a respirator must fit your face tightly. The **fit test** is a method used to select the right size respirator for the user. OSHA's respiratory protection standard requires a fit test prior to initial use of a respirator, whenever a different respirator facepiece is used, and at least annually thereafter. An additional fit test is required whenever there are changes in the user's physical condition that could affect respirator fit (e.g., facial scarring, dental changes, cosmetic

surgery, or an obvious change in body weight). All employees using either a negative or positive pressure tight-fitting facepiece respirator must pass an appropriate fit test.

The fit test used depends on the type of respirator and the relative workplace exposure level. There are both qualitative and quantitative fit tests. In a **qualitative fit test,** a worker is exposed to an atmosphere containing an odorant, irritant, or taste agent and then asked to breathe normally, breathe deeply, move the head from side to side and up and down, grimace, bend at the waist, and talk. The wearer reports any noticeable odor or taste agent that leaks into the mask.

In a **quantitative fit test,** a particle-counting instrument is used to measure respirator fit by comparing the dust concentration in the surrounding air with the dust concentration inside the respirator. The ratio of these concentrations is called the **fit factor.** A modified filter cartridge (or a modified respirator facepiece) equipped with a sample port is used to collect air from inside the respirator. Having the sampler attached, the wearer is asked to make the same movements as described for the qualitative fit test. During these movements, the particle-counting device measures any leakages.

Every time you put a respirator on, conduct a **fit check,** also referred to as a **user seal check,** to be sure the respirator forms a complete seal around your face and air cannot leak in or out along the edges. To perform the fit check, the respirator must be put on properly. Make sure you have obtained a firm and comfortable fit against the face at all points.

There are two types of fit checks — the positive pressure check and the negative pressure check. "Positive pressure" refers to the user breathing out and exerting positive pressure on the respirator, and "negative pressure" refers to the user breathing in and exerting negative pressure on the respirator. The fit check must be performed before using a respirator in the field and may also be performed periodically while in the field.

- **Positive pressure check** — Cover the exhalation valve with your hand and exhale gently into the facepiece. If a slight positive pressure is built up inside the facepiece without any evidence of leakage, the fit is satisfactory. This test method is the most widely used to check proper fit in the field.

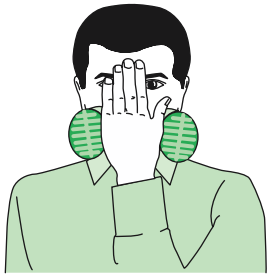


In a quantitative fit test, a particle-counting instrument is used to measure respirator fit.

- **Negative pressure check** — Close off the air inlet valves (i.e., cover the cartridges with your hands), inhale gently to collapse the facepiece slightly, and hold your breath for 10 seconds. If the facepiece remains slightly collapsed and no leakage is detected, the respirator fits properly. It may be difficult to get a good seal when trying to cover the inlet valves (cartridges).

Most respirator styles will not protect you if you have a beard or other facial hair because it does not allow the respirator to seal properly against your face. If you have facial hair, use a loose-fitting hood or helmet-style respirator. Loose-fitting respirators include powered particulate respirators that constantly pump air through a cartridge or canister into a loose-fitting helmetlike or hoodlike head covering. The positive outward pressure caused by the steady outflow of air prevents contaminants from entering the headpiece. The purified air circulating over the user's head, face, and neck also provides some cooling. These loose-fitting respirators do not have to form a seal on your face, so they do not need a medical or a fit test, and people with facial hair can use them.

Not all loose-fitting respirators move the air at the same rate. Most pesticide handling tasks require a minimum airflow rate of 4 cubic feet per minute. If you are doing physically strenuous work, use a respirator with



Positive pressure fit check



Negative pressure fit check

Adapted from University of Illinois *Private Applicator* manual

Be sure to perform a fit check each time you use your respirator.

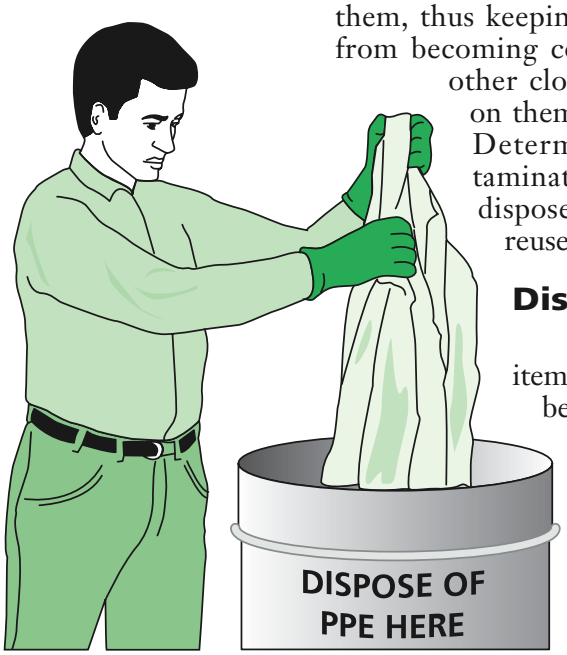
an airflow rate of at least 6 cubic feet per minute. Loose-fitting respirators are not nearly as tiring or as hot as face-sealing respirators.

If you are wearing a respirator that filters out dusts and mists, change the filter or respirator when you find it is getting hard to breathe through the respirator, or if your filter gets torn, damaged, or wet. Do not use a filtering facepiece dust/mist mask if the pesticide soaks the mask. In this case, use a full-face respirator.

If you are wearing a respirator that removes vapors and gases, change the cartridge or canister immediately if you taste or smell pesticide, or if the pesticide burns or stings your nose or throat. Follow the manufacturer's instructions or state regulations on when to replace filters, cartridges, and canisters even if you do not notice a problem. If there are no instructions, replace filters, cartridges, and canisters at the end of each 8-hour work period. To ensure the integrity of the seal between the facemask and the cartridge, make sure the manufacturer of the cartridge is also the manufacturer of the facemask.

MAINTAINING PERSONAL PROTECTIVE EQUIPMENT

When you finish an activity in which you are handling pesticides or are exposed to them, remove your PPE right away. Start by washing the outside of your gloves with detergent and water before removing the rest of your PPE. Wash the outside of other chemical-resistant items before you remove your gloves. This practice helps you avoid contacting the contaminated part of the items while you are removing them, thus keeping the inside surface from becoming contaminated. If any other clothes have pesticides on them, change them also. Determine whether contaminated items should be disposed of or cleaned for reuse.



Discard contaminated PPE in the appropriate container.

Disposables

Disposable PPE items are not designed to be cleaned and reused. Discard them when they become contaminated with pesticides. Place disposable PPE in a separate plastic bag or container prior to disposal.

Chemical-resistant gloves, footwear, and aprons labeled as disposable are designed to be worn only once and then thrown away. These items often are made of thin vinyl, latex, or polyethylene. These inexpensive disposables may be a good choice for brief pesticide handling activities that require dexterity as long as the activity does not tear the thin plastic. For example, you might use disposable gloves, shoe covers, and an apron while pouring pesticide into a hopper or tank, cleaning or adjusting a nozzle, or making minor equipment adjustments.

Non-woven (including coated non-woven) coveralls and hoods, such as Tyvek®, usually are designed to be disposed of after use. Most are intended to be worn for only one workday. The instructions with some coated non-woven suits and hoods permit the user to wear them more than once if each use period is short and not much pesticide gets on them. Pay close attention when reusing these items, and be ready to change them whenever there are signs pesticides could be getting through the material or the inside surface is contaminated.

Dust/mist masks, prefilters, canisters, filtering and vapor-removing cartridges, and a few cartridge respirators are disposables. They cannot be cleaned. Be sure to replace these disposable items often.

Reusables

Some PPE items, such as rubber and plastic suits, gloves, boots, aprons, capes, and headgear, are designed to be cleaned and reused several times.

However, do not make the mistake of continuing to use these items when they no longer offer adequate protection. Wash the reusable items thoroughly between uses, and inspect them for signs of wear or abrasion. Never wash contaminated gloves, boots, respirators, or other PPE in streams, ponds, or other bodies of water. Check for rips and leaks by using the rinse water to form a "balloon" (i.e., filling the PPE item with water) and/or by holding the items up to the light. Even tiny holes or thin places can allow large quantities of pesticide to penetrate the material and reach your skin. Discard any PPE item that shows sign of wear.

Even if you do not see any signs of wear, replace reusable chemical-resistant items regularly—the ability of a chemical-resistant material to resist the pesticide decreases each time an item is worn. A good rule of thumb is to throw out gloves that have been worn for about 5 to 7 workdays. Extra-heavy-duty gloves, such as those made of butyl or nitrile rubber, may last as long as 10 to 14 days. Glove replacement is a high priority because adequate hand protection greatly reduces the pesticide handler's chance for exposure. The cost of frequently replacing your gloves is a wise investment. Footwear, aprons, headgear, and protective suits may last longer than gloves because they generally receive less exposure to the pesticides and less abrasion from rough surfaces. Replace them regularly and at any sign of wear. Most protective eyewear and respirator bodies, facepieces, and helmets are designed to be cleaned and reused. These items can last many years if they are of good quality and are maintained correctly.

Launder fabric coveralls and work clothing after each day's use. Do not attempt to launder clothing made of cotton, polyester, cotton blends, denim, and canvas if these items are drenched or saturated with concentrated pesticides labeled with the signal word DANGER—POISON, DANGER, or WARNING. Always discard any such contaminated clothing or footwear at a household hazardous waste collection site.

Be sure to clean all reusable PPE items between uses, even if they were worn for only a brief period of exposure. Pesticide residues that remain on PPE are likely to penetrate the material. If you wear that PPE again, pesticide may already be on the inside of the material next to your skin. Also, PPE worn several times between launderings may build up pesticide residues. The residues can reach a level that can harm you, even if you are handling pesticides that are not highly toxic. After cleaning reusable items, place them in a plastic bag or clothing hamper away from your personal clothes and away from the family laundry.

Washing PPE

Always wash pesticide-contaminated items separately from the family laundry. Otherwise, pesticide residues may be transferred to the other laundry and may harm you or your family. Be sure that the people who clean and maintain your PPE and other work clothes know they can be harmed by touching these pesticide-contaminated items. Instruct them to wear gloves and an apron and work in a well-ventilated area, if possible, and avoid inhaling steam from the washer or dryer.



Jack Kelly Clark, University of California Statewide IPM Program

Always wash pesticide-contaminated items separately from family laundry.

Follow the manufacturer's instructions for cleaning chemical-resistant items. If the manufacturer instructs you to clean the item but gives no detailed instructions, follow the "Procedure for Washing Contaminated PPE" detailed in this chapter. Some chemical-resistant items that are not flat, such as gloves, footwear, and coveralls, must be washed twice—once to clean the outside of the item and a second time after turning the item inside out. Some chemical-resistant items, such as heavy-duty boots and rigid hats or helmets, can be washed by hand using hot water and a heavy-duty liquid detergent.

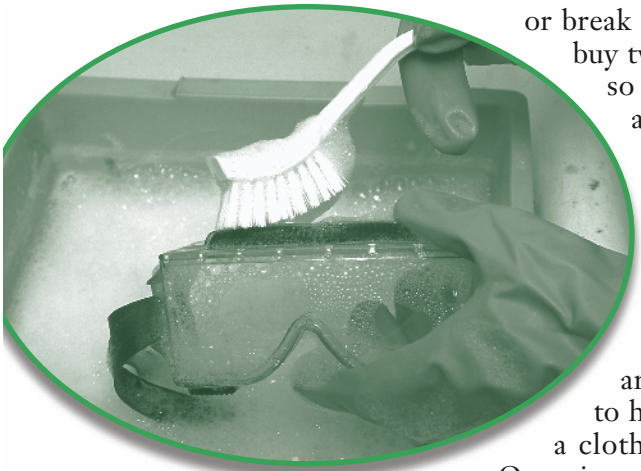
Use the following procedure for washing non-chemical-resistant items such as cotton, cotton/polyester, denim, canvas, and other absorbent materials,

and for most chemical-resistant items.

Hang the washed items to dry, if possible. It is best to let them hang for at least 24 hours in an area with plenty of fresh air. Even after thorough washing, some items still may contain residues. When the items are exposed to clean air and sunlight, most residues move to the surface of the fabric, evaporate, or break down. You may wish to buy two or more sets of PPE so you can leave one set airing while wearing the other set. Do not hang items in enclosed living areas—pesticide residues that remain in the items may evaporate and expose people or animals in the area. If it is not possible to hang fabric items to dry, a clothes dryer may be used. Over time, however, the dryer may become contaminated with pesticide residues.

Procedure for Washing Contaminated PPE

1. Wash only a few items at a time so there is plenty of agitation and water for dilution.
2. Wash in a washing machine, using a heavy-duty liquid detergent and hot water for the wash cycle. Set your washer to the longest wash cycle and two rinse cycles.
3. Use two entire machine cycles to wash items that are moderately to heavily contaminated. (If PPE is too contaminated, bundle it in a plastic bag, label the bag, and take it to a household hazardous waste collection site.)
4. Run the washer through at least one additional entire cycle without clothing, using detergent and hot water, to clean the machine before any other laundry is washed.



Jack Kelly Clark, University of California Statewide IPM Program

Clean goggles, face shields, and respirator bodies and facepieces in detergent and hot water.

Maintaining Eyewear and Respirators

Wash goggles, faceshields, shielded safety glasses, respirator bodies, and facepieces after each day of use. Use a detergent and hot water to wash them thoroughly. Remove any contaminants (such as residual pesticides) under running water with a soft brush. Sanitize them by soaking for at least 2 minutes in a mixture of 2 tablespoons of chlorine bleach in 1 gallon of hot water. Rinse thoroughly to remove the detergent and bleach. After rinsing to remove the detergent and bleach, dry the items thoroughly or hang them in a clean area to dry.

Pay particular attention to headbands. Replace headbands made of absorbent materials with chemical-resistant headbands. After each day of use, inspect all headbands for signs of wear or deterioration, and replace them as needed.

Store respirators and eyewear in an area where they are protected from dust, sunlight, extreme temperatures, excessive moisture, and pesticides or other chemicals. A sturdy plastic bag with a zip closure works well for storage. Store respirator cartridges in an airtight bag or they lose their effectiveness.

Respirator maintenance is especially important. Inspect your respirator before each use. Repair or replace any part that shows signs of wear or deterioration. Maintain an inventory of replacement parts for the respirators you own, and do not use substitutes or incompatible brands. If you keep a respirator for emergency use or as a backup, inspect it at least monthly.

If you remove your respirator between handling activities, follow these guidelines:

- Wipe the respirator body and facepiece with a clean cloth.
- Replace caps, if available, over cartridges, canisters, and prefilters.
- Seal the respirator (*except* for any prefilters) in a sturdy, airtight container, such as a plastic bag with a zip closure. If you do not seal the respirator immediately after each use, the disposable parts will have to be replaced more often because cartridges and canisters continue to collect impurities as long as they are exposed to the air. Prefilters, however, do not lose their effectiveness when exposed to

the air. Remove contaminated prefilters before placing the canisters and cartridges in a zip-closable plastic bag to avoid contaminating the canisters and cartridges.

At the end of every workday that you wear a reusable respirator, be sure to do the following:

- Remove the prefilter. Most filters should be discarded.
- Take off the cartridges or canisters. Discard them or, if they are still usable, replace their caps and seal them in an airtight container, such as a plastic bag with a zip closure.
- Clean and store the respirator as directed above.
- Discard disposable respirators according to manufacturer's instructions. Do not try to clean them.

Remember: Do not store your respirators or other PPE in pesticide storage areas.



Edward Crow, Maryland Department of Agriculture

Keep respirators and cartridges stored in a proper storage bag that has a zip closure.

Handle respirators with the same care that you give your other protective equipment and clothing. Consult labels and MSDS for instructions about protective equipment and clothing, and remember that protective equipment has limitations. A person is never completely protected and must still use caution and common sense to prevent pesticides from contacting the body.

SUMMARY

Proper use and selection of personal protective equipment (PPE) is essential for prevention of pesticide exposures. The PPE items selected for a particular pesticide application depend on the application procedure, the pesticide being applied, and the label requirements. Applicators must be familiar with the various types of PPE available and how well they protect against pesticide exposures.

Choose PPE items to protect the skin, eyes, and lungs from exposure. If there is a risk of pesticides penetrating clothing and contaminating skin, select items made of chemical- resistant materials such as plastics or rubber. Gloves, boots, aprons, suits, and hoods come in chemical-resistant materials such as plastics or rubber. Regular work clothes made of cotton, leather, or canvas are not chemically resistant. Pesticide labels may refer to a chemical resistance category that tells the user how long to expect protection after the pesticide contacts the PPE. Keep a copy of the EPA Chemical Resistance Category Selection Chart on hand for an explanation of how long certain materials provide protection.

In addition to being able to choose the appropriate type of PPE, pesticide users must also know how to wear, clean, and dispose of PPE properly. Wear PPE to prevent pesticides from coming into contact with skin, eyes, or clothing. Clean PPE after each use and wash separately from other clothing to prevent contamination. Dispose of PPE if it has cracks, holes, or rips, or is wearing thin in places. If PPE is contaminated by pesticides that cannot be removed by washing, dispose of it as hazardous waste.

PPE is also available to protect the eyes and lungs. The label often specifies what type of protection to use. Goggles, safety glasses, and faceshields may be worn to protect the eyes. A respirator may be worn to prevent inhalation exposure. The label often lists the type of respirator to use by its "TC" number. Whenever you use an air-purifying, tight-fitting respirator, make sure it has been fit tested specifically for you and understand how to perform the fit check each time you use it. Like other types of PPE, eyewear and respirators must also be worn, cleaned, and stored properly if they are to continue providing protection to the user. Remember, you are legally required to wear all PPE recom-

mended by the label. In many cases, you may want to select additional PPE for added protection. Make sure you are familiar with the level of protection provided by the PPE, and know how to use and wear it properly.



Review Questions

CHAPTER 6: PERSONAL PROTECTIVE EQUIPMENT

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

1. **Which statement is *true* about PPE as required by the label?**
   - **A.** You should not wear more PPE than the label requires.
   - **B.** Sometimes a label has different PPE requirements for pesticide handlers and early-entry workers.
   - **C.** You are not required to wear all the PPE listed on the label.
   - **D.** Wearing the PPE listed on the label ensures that you will not be exposed to pesticides.

2. **Which statement is *true* about PPE chemical resistance?**
   - **A.** The ability of a given material to protect an individual from a pesticide product is largely a function of the type of solvent used to formulate the pesticide product.
   - **B.** Cloth is easy to clean after it becomes contaminated with a pesticide, or it can be inexpensively disposed of after each use.
   - **C.** Cotton, leather, and canvas are chemically resistant to dry formulations.
   - **D.** Gloves, boots, aprons, and suits made of rubber or plastic are the least chemically resistant.

3. **If a pesticide label states that you must wear gloves based on guidelines in Chemical Resistance Category "D", which materials provide the best protection from the pesticide?**
   - **A.** Nitrile rubber or neoprene rubber.
   - **B.** Natural rubber or polyethylene.
   - **C.** Polyvinyl chloride or vitron.
   - **D.** Barrier laminate or butyl rubber.

4. **Which parts of the body are the mostly likely to be exposed to pesticides?**
   - **A.** The hands and forearms.
   - **B.** The feet and legs.
   - **C.** The chest and forearms.
   - **D.** The eyes and lungs.

5. **According to the Worker Protection Standard, what must the pesticide handler have access to if the label requires goggles for eye protection?**
   - **A.** A full faceshield to cover the goggles.
   - **B.** An eyewash dispenser.
   - **C.** A half-face respirator.
   - **D.** A full-face respirator.

6. **According to EPA criteria, what type of respirator must you wear when applying liquid pesticide products from Toxicity Class I?**
   - **A.** Use a NIOSH-approved respirator with any N, R, P, or 100 series prefilter.
   - **B.** Use a NIOSH-approved respirator with an organic vapor (OV) cartridge or canister with any N, R, P, or 100 series prefilter.
   - **C.** Use an air-supplying respirator (NIOSH TC-19C).
   - **D.** Use a self-contained breathing apparatus (NIOSH TC-13F).

7. **What is the purpose of the fit check?**
   - **A.** To select the right size respirator for the user.
   - **B.** To make sure you have a tight-fitting seal with no leakages each time you use the respirator.
   - **C.** To see if you can taste or smell any substance leaking into the mask.
   - **D.** To measure respirator fit by comparing the dust concentration in the surrounding air with the dust concentration inside the respirator.

8. **Which is *true* about disposable PPE?**

   A. Inexpensive disposables may be a good choice for brief pesticide-handling activities.
   B. Non-woven coveralls and hoods are usually designed to be worn for 7 workdays.
   C. Dust/mist masks, prefilters, canisters, and filtering and vapor-removing cartridges can be cleaned and reused three or four times before disposing of them.
   D. Chemical-resistant gloves, footwear, and aprons that are labeled as disposable are designed to be worn three or four times before disposing of them.

9. **Which statement is *true* about washing contaminated PPE?**

   A. Wash a full load of PPE items at a time.
   B. Use cold water and one wash cycle.
   C. Use only very short wash cycles.
   D. After washing the items, run the washer through at least one additional entire cycle without clothing.

10. **Which statement is *true* about respirator maintenance?**

    A. Respirator cartridges must be stored in an airtight bag or they lose their effectiveness.
    B. Inspect respirators twice each year for signs of wear and tear.
    C. After use, prefilters should be stored in a zip-closable bag with canisters and cartridges.
    D. Use a substitute canister or cartridge if you cannot find the replacement part for your respirator.

CHAPTER 7

PESTICIDES IN THE ENVIRONMENT

LEARNING OBJECTIVES

After studying this chapter, you should:

- Understand environmental consequences of pesticide application while considering all relevant factors (e.g., types of terrain, drainage patterns, soil, presence of non-target organisms and endangered species, drift, weather, groundwater and surface water).
- Understand how to prevent pesticide drift, runoff, or loss to unintended areas of the environment.
- Know how to identify potentially sensitive areas that could be adversely affected by pesticide application, mixing and loading, storage, disposal, and equipment washing.
- Understand the importance of implementing procedures to prevent residue accumulation associated with mixing and loading and equipment washing.
- Understand when to adjust or delay an application to minimize environmental impact and maximize effectiveness.



Governmental agencies as well as the general public are becoming increasingly concerned about the harmful effects of pesticides on the environment. Initially, hazards to humans were the primary reason for the EPA to classify a pesticide as a restricted-use product. Now, more and more pesticide labels list environmental effects such as contamination of groundwater or toxicity to birds or aquatic organisms as reasons for restriction. The EPA requires extensive environmental testing when it evaluates pesticide applications submitted by manufacturers for the registration of new pesticides. The agency is also taking a close look at environmental effects when it reevaluates existing pesticide registrations.

THE ENVIRONMENT

The environment comprises everything that is around us. It includes not only the natural elements that the word "environment" most often brings to mind but also people and the manufactured components of our world. Neither is the environment limited to the outdoors—it also includes the indoor areas in which we live and work.

The environment is much more than the oceans and the ozone layer. It is air, soil, water, plants, animals, houses, restaurants, office buildings, and factories, and all that they contain. Anyone who uses a pesticide—indoors or outdoors, in a city or on a farm—must consider how that pesticide affects the environment. The user must ask two questions:

1. Where is the pesticide going to go in the environment after it leaves its container or application equipment?
2. What effects can this pesticide have on those non-target sites it may reach in the environment?

PESTICIDE CHARACTERISTICS

To understand how pesticides move in the environment, you must first understand certain physical and chemical characteristics of pesticides and how they determine a pesticide's interaction with the environment. These characteristics are solubility, adsorption, persistence, and volatilization.

Solubility

Solubility is a measure of the ability of a pesticide to dissolve in a solvent, usually water. Pesticides highly soluble in water dissolve easily. These pesticides are more likely to move with water in surface runoff or by movement through the soil water than are less soluble pesticides.

Adsorption

Adsorption is the process whereby a pesticide binds to soil particles. Adsorption occurs because of an attraction between the chemical and soil particles. Typically oil-soluble pesticides are more attracted to clay particles and organic matter in soil than are water-soluble pesticides. Also, pesticide molecules with positive charges are more tightly adsorbed to negatively charged soil particles. A pesticide that adsorbs to soil particles is less likely to move from the spray site than a chemical that does not adsorb tightly to the soil.

Persistence

Persistence is the ability of a pesticide to remain present and active in its original form for an extended period before breaking down. A chemical's persistence is described in terms of its half-life, a comparative measure of the time needed for the chemical to break down—the longer the half-life, the more persistent the pesticide. These residues are sometimes desirable because they provide long-term pest control and reduce the need for repeated applications. However, some persistent pesticides applied to soil, plants, lumber, and other surfaces or spilled into water or on soil can later harm sensitive plants or animals, including humans. It is especially important to prevent persistent pesticides from moving off-site through improper handling, application, drift, leaching, or runoff.

In addition to presenting a hazard to persons and non-target animals entering a treated area, application of persistent pesticides may lead to the presence of illegal residues on rotational food or feed crops. Check the label for statements about the persistence of the pesticide and for replanting restrictions. The rate of pesticide degradation relates to the persistence of the pesticide.

Pesticide Degradation

Degradation processes break down pesticide compounds into simpler and

often less toxic chemicals. Some pesticides break down very rapidly—in a matter of days or even hours. Others can be detected in the environment for a year or more.

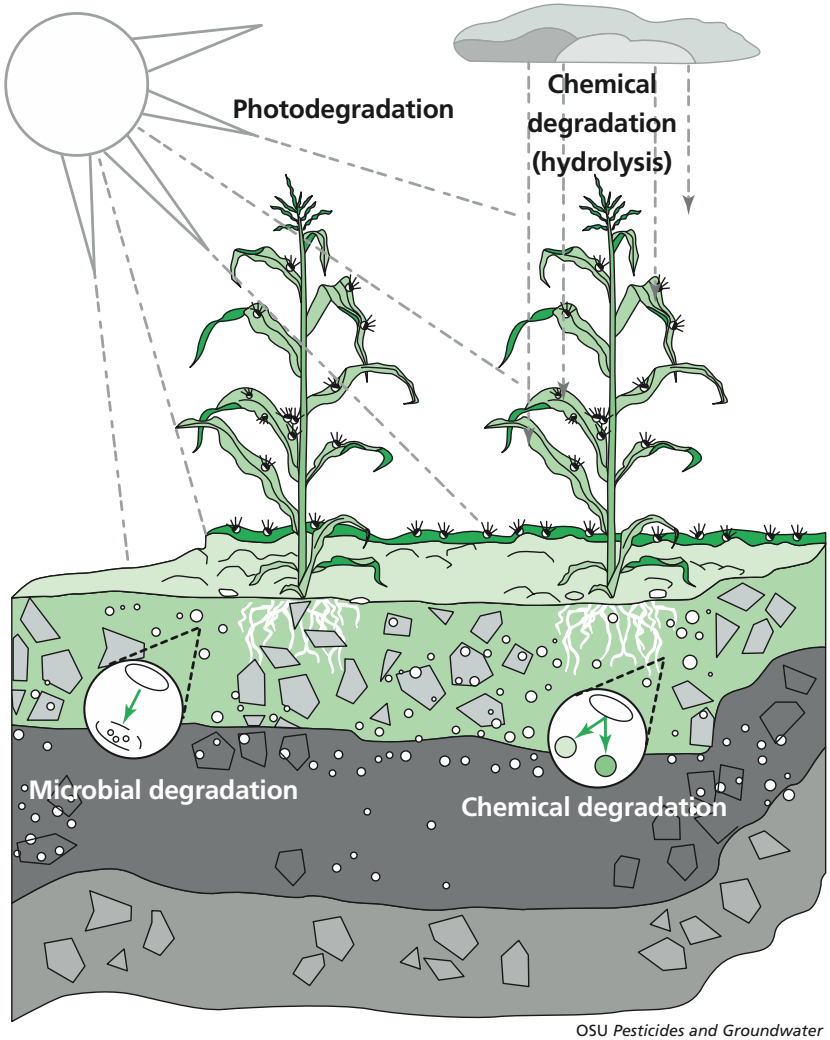
Pesticides are broken down or degraded by the following processes:

- **Chemical degradation**—the breakdown of chemicals by processes that do not involve living organisms, most commonly by **hydrolysis**, a chemical reaction with water.
- **Microbial action**—the process in which chemicals are degraded by soil microorganisms, such as fungi or bacteria.
- **Photodegradation**—the breakdown of chemicals in reaction to sunlight.

Water and temperature both affect the breakdown of pesticides. Warm, wet conditions can increase the speed of pesticide breakdown; cool, dry conditions slow down the degradation process.

Volatility

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. The chance of volatilization increases as temperatures and wind increase. Volatility is also more likely under conditions of low relative humidity.



OSU *Pesticides and Groundwater Contamination*

Figure 7.1
Breakdown of pesticides in the environment.

HOW PESTICIDES MOVE IN THE ENVIRONMENT

Pesticides that move away from the targeted application site, either indoors or outdoors, may cause environmental contamination. Pesticides move in several ways—in water, in air, attached to soil particles, and on or in objects (see Figure 7.2).

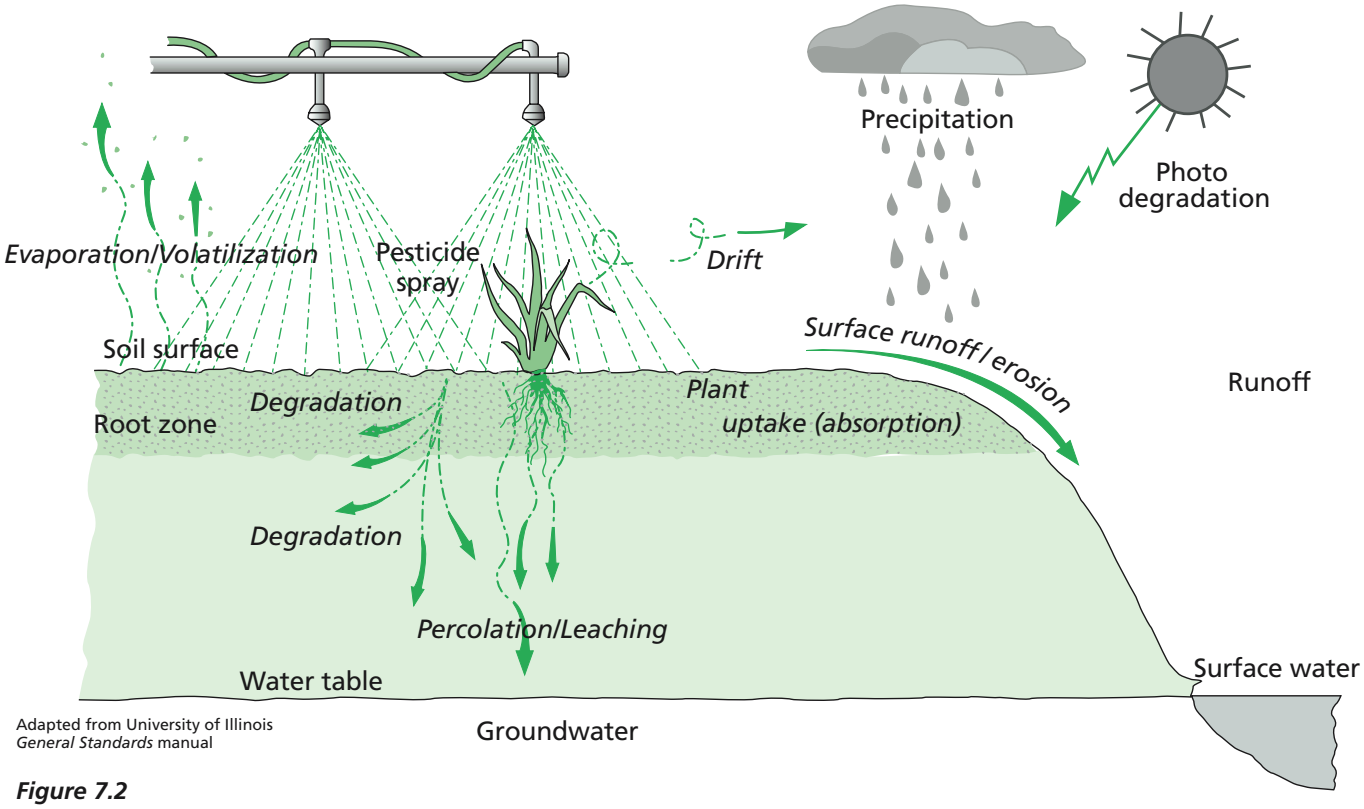
Movement in Air

Pesticide movement away from the application site by wind or air currents is called **drift.** People who mix, load, and apply pesticides outdoors usually are aware of the ease with which pesticides drift off-site. Those who handle pesticides indoors may not realize how easily some pesticides move off-site in the air currents created by ventilation systems and by forced-air heating and cooling systems. Pesticides may be carried off-site in the air as spray droplets, vapors, or solid particles, even on blowing soil particles.

Movement in Water

Most pesticide movement in water is either by surface movement off the treated site (**runoff**) or by downward movement through the soil (**leaching**). Runoff and leaching may occur when:

- Too much pesticide is applied or spilled onto a surface.
- Too much rainwater or irrigation water moves pesticide through the



Adapted from University of Illinois *General Standards* manual

Figure 7.2
Fate of pesticides in the environment.

soil off-site or into groundwater.

- Highly water-soluble or persistent pesticides are used.

Runoff water in an outdoor environment may move into drainage systems, streams, ponds, or other surface water, where the pesticides can be carried great distances. Pesticides that leach downward through the soil may reach groundwater. Besides runoff and leaching, pesticides also can enter water through drift.

In an indoor environment, water containing pesticides can flow into floor drains and contaminate water systems. A careless act such as dumping a pesticide or rinsate down a sink or toilet can contaminate an entire sewage or water-treatment facility.

Some pesticides can leach in indoor environments. In a greenhouse, for example, pesticides may leach through the soil or other planting medium and contaminate other greenhouse surfaces.

Look for special instructions on the label that warn of pesticide hazards caused by the movement of pesticides in water.

Movement on or in Objects, Plants, or Animals

Pesticides can move away from the application site when they are on or in objects or organisms that move (or are moved) off-site. When pesticide handlers bring home or wear home contaminated personal protective equipment, work clothing, or other items, residues can rub off on carpeting, furniture, and laundry items, and onto pets and other people.

Pesticide **residue** is the pesticide that remains in the environment after an application or a spill. Pesticide residues may be on treated crops, feed products, or livestock. The breakdown time ranges from less than a day to many years, depending mostly on the chemical structure of the pesticide's active ingredient.

PREVENTING PESTICIDE DRIFT

Drift can be defined simply as the airborne movement of pesticides to non-target areas. Off-target movement can be in the form of spray droplet drift, vapor drift, or particle (dust) drift. Studies have shown that a significant percentage of pesticides may never reach the intended target site because of drift. It is impossible to eliminate drift totally, but it is possible to reduce it to a tolerable level.

Where significant drift does occur, it can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and contaminate soil and water in adjacent areas. Applicators are legally responsible for the damages resulting from the off-target movement of pesticides. All persons and animals should be removed from the area where pesticides are being applied.

Spray Drift

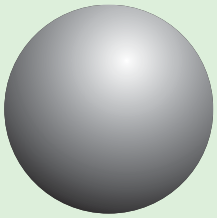
Spray drift refers to the off-target movement of a pesticide during a liquid application. This is the result of small spray droplets being carried off-site by air movement. Spray drift occurs more frequently than the other two types of drift because almost all spray applications result in some off-target movement.

Avoid most problems associated with spray drift by paying close attention to ***spray droplet size*** and the ***wind direction and speed.*** Larger spray droplets are less likely to drift than smaller ones. Typically, larger nozzle orifices and lower pressures produce larger droplets (see Table 7.1). However, some new nozzles, such as the venturi or air-induction nozzles produce larger droplets when used at higher pressures (above 40 psi).

The **viscosity** (thickness) of the liquid affects droplet size. The viscosity of a liquid is a measure of its resistance to flow. For example, mayonnaise is more viscous than water. As the viscosity of the liquid increases, so does the droplet

Table 7.1
American Society of Agricultural Engineers (ASAE) Standard (S-572) characteristics of spray droplets with code, categories, symbols, and approximate micro sizes and relative comparisons.

Table 7.1 Characteristics of Spray Droplets

ASAE[1] Standard				Comparative Size		
Symbol	**Category**	**Code**	**Approx. VMD[2]**	**Relative Size**	**Comparative Size**	**Atomization**
VF	Very Fine	Red	<100		Point of Needle (25 microns)	Fog
F	Fine	Orange	100–175		Human Hair (100 microns)	Fine Mist
M	Medium	Yellow	175–250		Sewing Thread (150 microns)	Fine Drizzle
C	Coarse	Blue	250–375			
VC	Very Coarse	Green	375–450		Staple (420 microns)	Light Rain
EC	Extremely Coarse	White	>450		#2 Pencil Lead (2000 microns)	Thunderstorm

[1]American Society of Agricultural Engineers.
[2]Volume Median Diameter.

size, thus reducing the potential for off-target movement. Formulations such as invert emulsions have a thick consistency that aids in reducing drift. Other formulations produce some spray drift when water droplets begin to evaporate before reaching the intended target. As a result, these droplets become very small and light and may move from the target site. Thus, invert emulsions have less water loss and more of the pesticide reaches the target. Several drift control additives can help reduce the potential for drift. The number of large droplets can be increased by using certain additives and thickeners. Remember, always follow the label directions about using any spray adjuvant intended for minimizing drift.

Air movement is the most important environmental factor influencing the drift of pesticides from target areas. The movement of air is influenced by the temperature at ground level and the temperature of the air above it. Warm air at the soil surface is expected to occur more often when the sun is higher in the sky and shining on the soil. Inversion conditions result when warmer air above traps cooler air located near the surface of the ground (Figure 7.3). These conditions are more likely to occur in the early morning or evening. Except in the case of temperature inversions, the early morning and evening are often the best times to apply pesticides because windy conditions are more likely to occur around midday when the temperature near the ground increases. This causes hot air to rise quickly and mix rapidly with the cooler air above it, favoring drift. The best time to spray is when the spray droplets move slowly upwards in the absence of windy or inversion conditions.

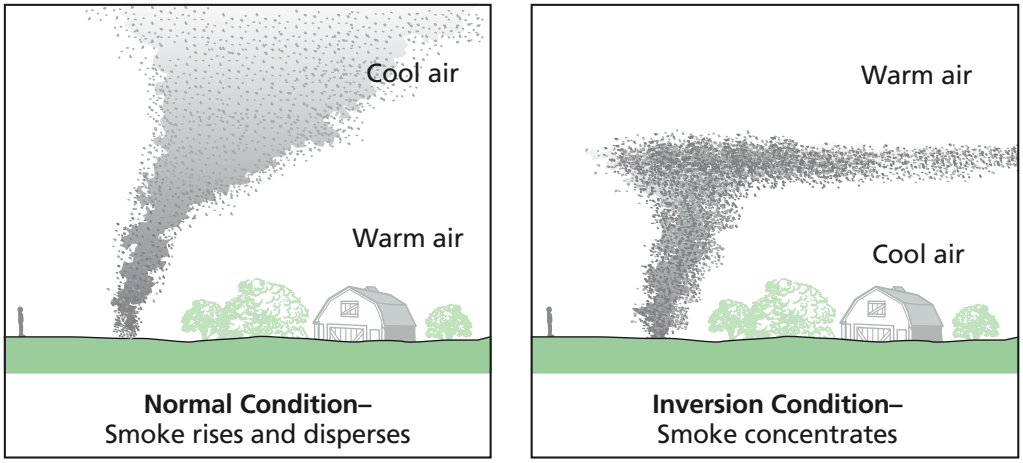
Low relative humidity and/or high temperatures also can increase the potential for spray drift. Under these conditions, the evaporation rate of water increases, resulting in smaller spray droplets that drift more easily. Avoid spraying during these times.

Reduce outdoor drift problems by spraying when the wind speed is low, by leaving an untreated border or buffer area in the downwind target area, and by spraying downwind from sensitive areas such as residential properties, schools, crops, waterways, or beehives. For reducing drift indoors, pest control operators must consider the air circulation patterns inside of buildings. Turn fans and air-conditioners off and close vents where necessary to prevent pesticides from drifting to other areas of the structure. Using low-volatile or non-volatile pesticides and by using only low-pressure treatments can reduce indoor pesticide drift problems.

Temperature Inversions

Applications made under low-wind conditions can sometimes result in more extensive drift than those made under high winds. Drift that occurs over long distances (over a mile) is most often the result of applications made under stable atmospheric conditions such as **temperature inversions.**

A temperature inversion exists when the air at ground level is cooler than the temperature of the air above



Adapted from U. of C. *The Safe and Effective Use of Pesticides*

Figure 7.3
Dispersion of smoke particles under normal and inversion conditions.

it. Under these conditions, the air is considered stable because there is little or no vertical air movement. Almost all air movement associated with inversions is sideways (lateral). This results in a high concentration of small spray droplets suspended in this layer of cool air near the ground. These droplets can then be carried long distances, especially if wind speeds increase. When the spray droplets settle out, they are still concentrated enough to cause potential damage or harm.

Inversions can occur at any time of the day and at any height above the ground, but they most often develop during the early evening hours as the ground temperature begins to cool and the warm air has already risen. They intensify during the night and may persist until midmorning, when the ground has warmed sufficiently to start the vertical mixing of air, causing a dilution and separation of suspended spray droplets. Consequently, applications made during early evening, night or morning hours under what appear to be ideal conditions can result in highly damaging drift that can move long distances. This is especially true if the humidity is high.

These stable air conditions (inversions) can be recognized by observing the movement of dust or smoke. If the dust or smoke rises little from its source and tends to hang in the air, an inversion is probably present or in the process of developing (see Figure 7.3). Another method of detecting inversions is to place a thermometer at ground level and a second thermometer high above the ground and compare the difference in temperature. If the temperature at ground level is below that found at the elevated thermometer, a temperature inversion exists. Do not apply pesticides under such conditions.

Vapor Drift

Vapor drift refers to the movement of pesticides as gaseous vapors from the target area. Some pesticides are volatile and can change readily from a solid or liquid form into a gas under the right conditions. This most often occurs with high air temperatures. Pesticides that have volatilized into a vapor or gas may drift farther and for a longer time than they would have as spray droplets. Only those pesticides that are able to volatilize are susceptible to vapor drift. As air temperatures increase, the likelihood that these pesticides will volatilize and drift also increases.

Whenever possible, choose a pesticide formulated as a low-volatility product. Avoid applying volatile pesticides on hot days. Some products can even volatilize several hours after application, so beware if high temperatures are predicted for later in the day (Figure 7.4). Many products carry precautions against applying these products when temperatures are above 85 degrees F or expected to reach 85 degrees. Remember to check label precautions for product-specific concerns about vapor drift.

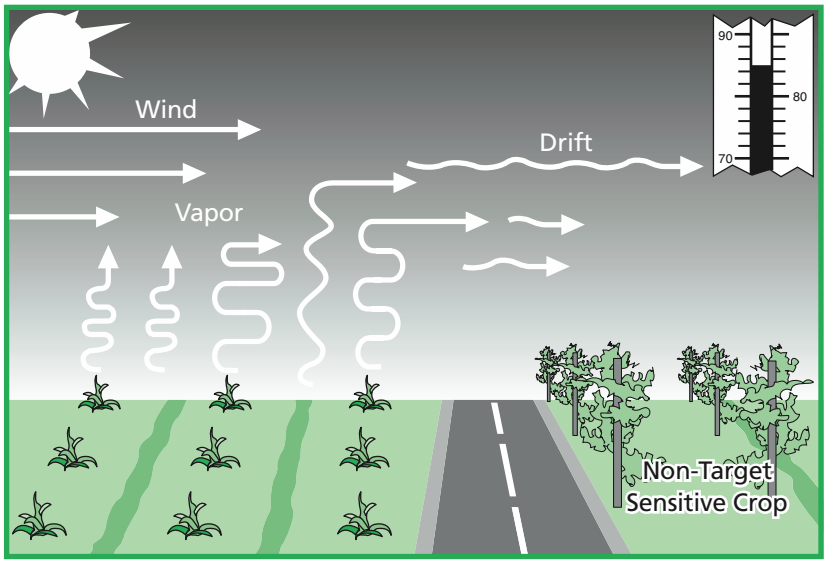


Figure 7.4
Vapor drift of pesticides is more likely to occur as heat and wind increase and the relative humidity decreases.

Particle Drift (Dust Drift)

Particle drift refers to the movement of solid particles from the target area by air during or just after an application. These solid particles may include pesticides formulated as dust or soil particles to which pesticides are attached. Some pesticides can remain active on soil particles for long periods after they are applied. If particles are blown off the target area, contamination or damage to sensitive areas can occur. To prevent particle drift from nearby outdoor pesticide applications from entering a building, be

sure to close all windows, vents, and turn off all circulating fans, forced-air heating systems, and air-conditioning units.



Univeristy of California Statewide IPM Porgram

Particle drift in a field.

For indoor applications of pesticides, reduce particle drift by turning off fans, forced-air heating systems, and other air-circulating equipment. Check pesticide labels for statements related to these concerns.

Applicator Responsibility

The applicator is ultimately responsible for managing drift. Applicators must assess the vulnerability of neighboring properties and those areas downwind of the application site. Evaluate weather conditions for temperature inversions, wind direction, and wind speed before making the all-important decision about whether to spray. The applicator may have to make adjustments to the application equipment to reduce spray drift. Consider using low-volatile formulations or adding a drift-control additive or thickener to help minimize drift. (For further discussion on equipment designed to minimize drift, see Chapter 11.) A good drift management program includes a combination of all drift-reducing techniques available for a particular application.

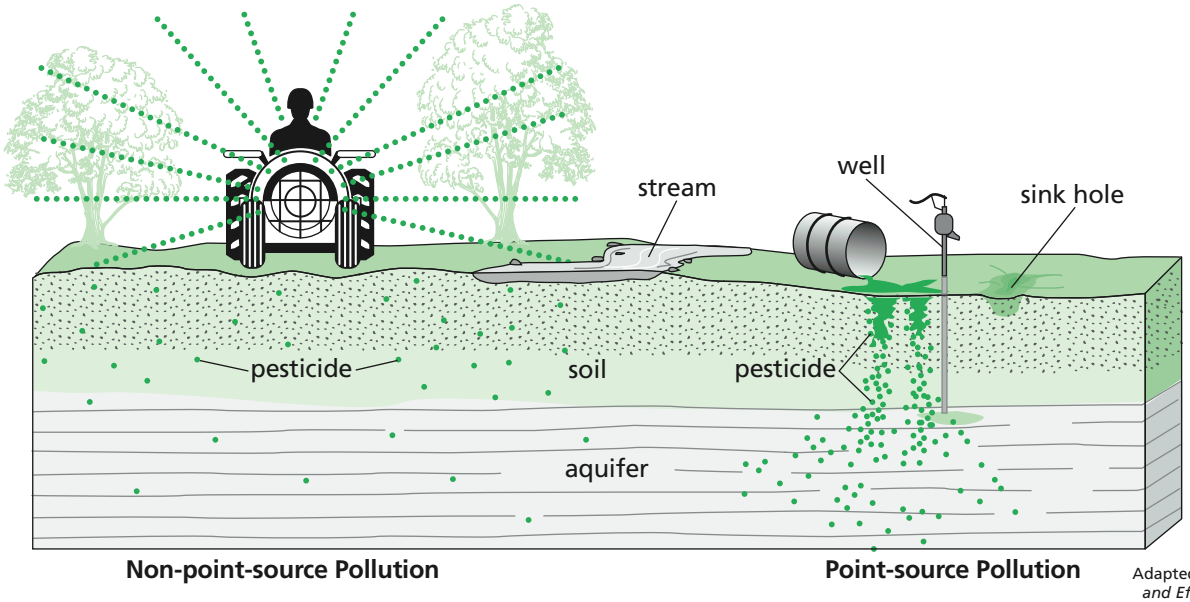
Applicators who apply pesticides indoors are also responsible for preventing drift. They must ensure pesticides do not move beyond the target site and that all people and animals are kept out of the treatment area according to label instructions.

SOURCES OF WATER CONTAMINATION

Surface water or groundwater contamination results from either **point-source** or **non-point-source** pollution (see Figure 7.5). Non-point-source pollution from pesticide applications has most commonly been blamed for pesticide contamination in the outdoor environment, but studies are revealing that water contamination also results from point-source pollution. Point-source pollution comes from a specific, identifiable place or location, such as:

- A pesticide spill entering a storm sewer.
- Back-siphoning of pesticides.
- Contaminated surface water entering sinkholes.
- Repeated spilling of pesticides at mixing and loading sites.
- Careless spilling of wash water at equipment cleanup sites.
- Improper handling of spills and leaks at storage sites.
- Improper disposal of containers, rinsate from containers, and excess pesticides.

Non-point-source pollution comes from a widespread area. The movement of pesticides into streams or groundwater following a broadcast application to an agricultural field, large turf area, or right-of-way is an example of non-point-source pollution. Indirect or non-point-source contamination of groundwater can occur when contaminated surface streams interact with shallow groundwater through subsurface flow. Normally, surface water becomes contaminated when water runs off treated fields. Runoff risk is the greatest when heavy rains immediately follow a pesticide application.



Adapted from U. of C. *The Safe and Effective Use of Pesticides*

Figure 7.5
Non-point-source pollution comes from a widespread area and point-source pollution comes from a specific identifiable place or location.

Pesticide Contamination of Surface Water

Surface water is often a source of drinking water. Therefore, pesticide contamination of surface water (ditches, streams, rivers, ponds, and lakes) is a health concern. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and may reach sources of surface water.

Factors affecting runoff and erosion rates include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. These factors influence how much water runs off and how much moves into the soil (infiltration).

Runoff may be a problem for most outdoor application sites. In areas treated with any type of pesticide, it is critical that runoff does not carry the pesticide into water sources or other vulnerable areas.

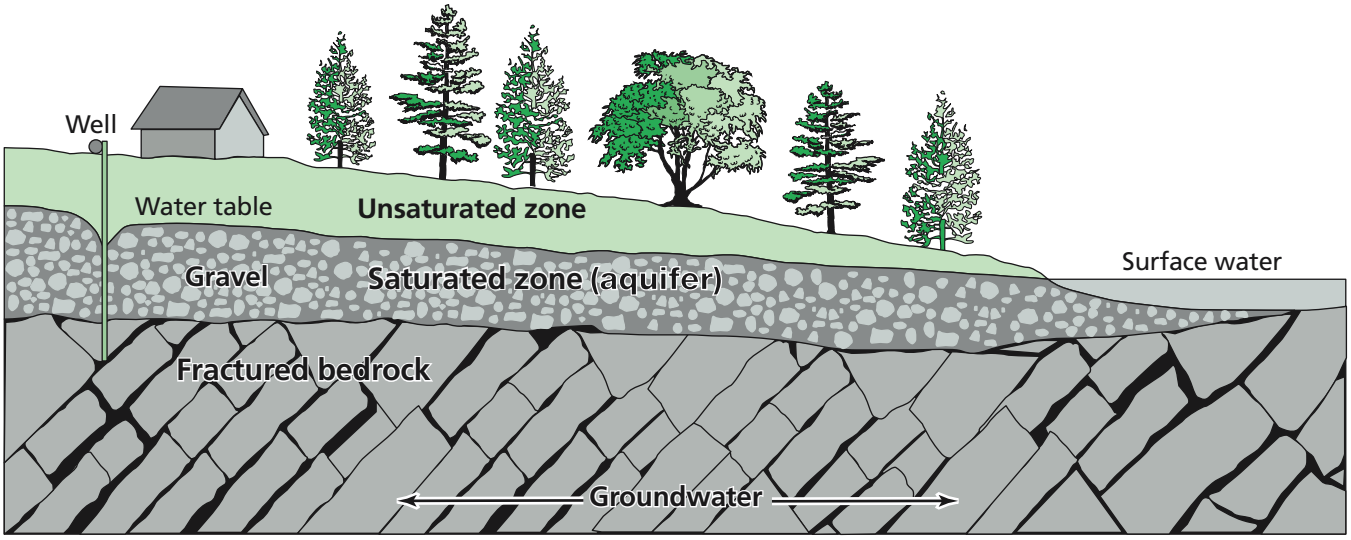
Pesticide Contamination of Groundwater

Groundwater provides 70 percent of the water used for public and private water supplies, irrigation, and industry. Like surface water, groundwater needs to be protected from contamination. Once groundwater is contaminated, correcting the problem is difficult or even impossible. Groundwater is found underground in cracks in the bedrock and in the spaces between soil particles, gravel, and rocks, and is the source of water for wells and springs.

The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water is the **saturated zone.** The boundary between the saturated zone and the overlying unsaturated rock and soil is known as the **water table.** The overall geologic formation from which groundwater can be drawn is called an **aquifer** (see Figure 7.6).

Leaching

Some pesticides reach groundwater by moving through the soil in a process called **leaching.** For a pesticide to leach into groundwater, it must move down through the soil in water and resist binding to soil particles and breaking down into non-toxic compounds. A pesticide's chemical and physical characteristics influence its ability to leach into groundwater. A pesticide soluble in water can move in water into surface water or groundwater. Persistent pesticides are likely to leach and contaminate groundwater. Pesticides having high solubility, low adsorption, and/or persistence typically have a label statement informing the applicator of leaching concerns. A pesticide that adsorbs or binds itself strongly to soil particles will not leach as easily. In addition to the characteristics of the pesticide, soil properties and environmental conditions also affect the



Adapted from Penn State *Pesticide Education Manual*

Figure 7.6
Where groundwater occurs.

likelihood and extent that a pesticide will leach.

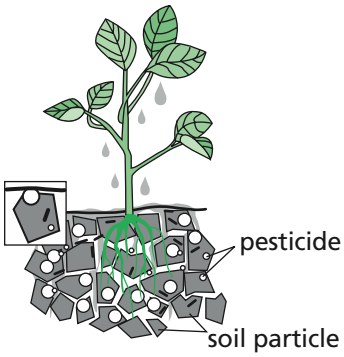
Soil Properties

Four soil properties influence a pesticide's potential for leaching—texture and structure, organic matter, depth to groundwater, and geology.

Texture and Structure

Soil texture is the relative proportions of sand, silt, and clay-sized particles. Percolating water moves faster in sandy soils, and fewer binding sites are available for the adsorption of dissolved chemicals when compared to clay or silt soils. Though sandy soils are more prone to pesticide movement, leaching may also occur in clay or silt soils.

Soil structure is the shape or arrangement of soil particles. It plays a big role in determining the size and shape of the pores through which water moves. Small amounts of pesticides may also move through soil cracks,



sandy soil (large pores)



clay soil (small pores)

Table 7.2 Soil Properties

TEXTURE (affects movement of water particles)	ORGANIC CONTENT (measures volume of water and soil's ability to adsorb pesticides)	PERMEABILITY (measures speed of water's downward movement)
coarse (sand)	**low organic content=** faster water flow and little adsorption of pesticides	↓ **high permeability** (fast flow)
smooth (clay, silt)	**high organic content=** higher water retention and greater adsorption of pesticides	↓ **low permeability** (slow flow)

OSU *Pesticides and Groundwater Contamination*

worm holes, and root channels. These features are referred to as macropores.

Organic Matter

Organic matter consists of decaying plant material. The higher the soil organic matter content, the greater the soil's ability to hold both water and adsorbed pesticides. Pesticides held in the root zone are less likely to leach into groundwater and may be taken up by plants.

Depth to Groundwater

Areas with a shallow water table have a greater chance for groundwater contamination because less soil is available to act as a filter, resulting in fewer opportunities for the pesticide to be degraded or adsorbed. When you musts use pesticides in areas where the groundwater is close to the surface, select a pesticide having a low leaching potential and take extra precautions during mixing, application, and cleanup.

Geology

The **permeability** of the geologic layers lying between the surface of the soil and the groundwater is also an important factor. Highly permeable materials such as gravel deposits allow water and dissolved pesticides to move downward to groundwater freely. Layers of clay, which are much less permeable, can inhibit and slow the downward movement of water.

PREVENTING SURFACE WATER AND GROUNDWATER CONTAMINATION

To help prevent surface water and groundwater contamination, the EPA requires that all pesticide products with directions for outdoor uses must include the environmental hazard statement on the label: "Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water supplies when cleaning equipment or disposing of equipment washwaters." Labels of pesticides, which have been found in groundwater, must bear groundwater warning statements. Groundwater statements on labels help applicators choose appropriate pesticides where soils are sandy or where extra precautions are needed to reduce contamination risk.

You can reduce the risk of point- or non-point-source contamination greatly by following best management practices (BMPs). BMPs are effective, commonsense practices that emphasize proper mixing, loading, application, and disposal of pesticides. Following these procedures greatly reduces the potential for pesticides to cause adverse effects on the environment.

Use IPM principles—Apply pesticides only when and where necessary, and only in amounts adequate to control pests. Following IPM principles, use non-chemical control methods whenever possible. When using pesticides:

- Determine the type of pest and the density of the pest population and the proper control method.
- If a pesticide is necessary, select the least toxic product that will provide adequate control.
- Calibrate pesticide application equipment regularly.
- Use spot treatments or band applications, if possible, to reduce pesticide use.

Identify vulnerable areas—The presence of sandy soil, sinkholes, wells, streams, ponds, and shallow groundwater increases the chance of groundwater contamination. Avoid pesticide application in these locations, if at all possible. Never dispose of empty pesticide containers in sinkholes or dump or rinse sprayers into or near sinkholes (see Chapter 10). Also exercise care to avoid contamination of streets, storm sewers, drainage ditches, and other potential sources of runoff to streams and waterways. Do not under

any circumstances clean tanks or intentionally discharge water from a tank of any vehicle into a street, along a road, or into a storm drain.

Do not mix and load near water— Carry out mixing and loading as far as possible (at least 50 feet) from wells, lakes, streams, rivers, and storm drains. When possible, mix and load the pesticides at the site of application. Consider using a sealed permanent or portable mixing and loading pad to prevent seepage into soil.



M.J. Weaver, Virginia Tech Pesticide Programs

Maintain an air gap between the discharge end of the water supply line and the spray tank to prevent backflow of pesticides.

Keep pesticides away from wells— Do not store or mix pesticides around wells. Poorly constructed or improperly capped or abandoned wells can allow surface water containing pesticides and other contaminants direct entry into groundwater. These wells are sometimes located in or near treated fields and other application sites.

Avoid back-siphoning— Back-siphoning is the reverse flow of liquids into a fill hose. It sucks tank contents back into the water supply. Back-siphoning starts with a reduction in water pressure and can draw very large quantities of pesticide directly into the water source. This happens when the end of the water hose is allowed to extend below the surface of the spray mixture when filling a spray tank. The simplest method of preventing backflow is to maintain an air gap between the discharge end of the water supply line and the pesticide solution in the spray tank. Keep the air gap at least twice the diameter of the discharge pipe. Another method for preventing back-siphoning is to use an anti-backflow device or check valve (see Chapter 10).



Ed Crow, Maryland Department of Agriculture

Use an anti-back flow device (check valve) to prevent back-siphoning.

Improve land use and application methods— Terraces and conservation tillage practices can reduce water runoff and soil erosion. Ideally, leave as much plant residue as possible on the soil surface to lessen erosion. Where conservation tillage is not possible, reduce runoff potential by incorporating pesticides into the soil to lower the concentration of product on the soil surface. In ornamental plantings, consider using mulches to reduce water runoff and soil erosion.

Grass buffer strips are very effective in reducing pesticide runoff because they trap sediment containing pesticides and slow runoff water, allowing more runoff water to infiltrate the soil. Leaving untreated grass strips next to streams, ponds, and other sensitive areas can trap much of the pesticide running off of treated areas.

Time pesticide applications according to the weather forecast— Pesticides are most susceptible to runoff from heavy rains or irrigation during the first several hours after application. To avoid overspraying an area and causing drift, check the pesticide label for application precautions or restrictions during windy conditions. Wind speed, temperature, and humidity all affect the off-target movement of pesticides.

Select products wisely— Whenever possible, use pesticides that are less likely to leach. Read labels for leaching warnings.

Handle pesticides safely— Follow these guidelines to prevent surface or groundwater contamination:

- Immediately contain and control pesticide spills.
- Check application equipment regularly for leaks or damage.
- Mix and load pesticides away from water sources.
- After the pesticide application is complete, follow label directions for proper equipment cleanup and container disposal.
- After applying granular pesticides, sweep or blow any granules from sidewalks, driveways, or patios onto the treatment area.

Clean sprayers at the application

site, whenever possible, and at a safe distance from wells, ponds, streams, and storm drains. Spray the rinsate on the treated area or on another site listed on the pesticide label, or use in the next tank mix. Be sure not to exceed label rates.

PREVENTING PESTICIDE EFFECTS TO SENSITIVE AREAS AND NON-TARGET ORGANISMS

To prevent adverse effects on the environment, pesticide users must be aware of sensitive areas, non-target plants and animals (especially endangered species), and harmful effects on habitat.

Sensitive Areas

In addition to water sources, sensitive areas include sites where living things could easily be injured by a pesticide. Outdoor sensitive areas include:

- Schools, playgrounds, recreational areas, hospitals, and similar institutions.
- Habitats of endangered species.
- Apiaries (honeybee sites), wildlife refuges, and parks.
- Areas where domestic animals and livestock are kept.
- Ornamental plantings, public gardens, and sensitive food or feed crops.

Sensitive areas indoors include:

- Where people live, work, shop, or are cared for.
- Where food or feed is processed, prepared, stored, or served.
- Where domestic or confined animals live, eat, or are otherwise cared for.
- Where ornamental or other sensitive plants are grown or maintained, such as in malls and buildings.

Sometimes pesticides must be deliberately applied to a sensitive area to control a pest. Only applicators who are competent in handling pesticides should perform these applications.

At other times, the sensitive area may be part of a larger target site. Whenever possible, take special precautions to avoid application to the sensitive area. Leaving an untreated buffer zone around a sensitive area is a practical way to avoid contaminating it.

In still other instances, the sensitive area may be near a site used for mixing and loading, storage, disposal, or equipment washing. The pesticide user must take precautions to avoid accidental contamination of the sensitive area. Check the label for statements that alert you to special restrictions around sensitive areas.



Scott Bauer, USDA ARS

Sensitive area—apiary.

Pesticide Effects on Non-target Organisms

Pesticides may affect non-target organisms directly causing immediate injury, or may produce long-term consequences through environmental pollution. When pesticides build up in the bodies of animals or in the soil, they accumulate. If you use the same mixing and loading site or equipment cleaning site over a long period, pesticides are likely to accumulate in the soil. When this occurs, plants and animals that come into contact with the soil may be harmed. The following sections discuss the effects of pesticides on non-target plants; bees and other beneficial insects; and fish, wildlife, and livestock.



USFWS

Sensitive area—wildlife habitat.



C. Randall, MSU

Sensitive area—playground.

Non-target Plants

Nearly all pesticides can cause plant injury due to chemical exposure (**phototoxicity**), particularly if they are applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. Phytotoxicity can occur on any part of a plant—roots, stems, leaves, flowers, or fruits. Most phytotoxic injury is due to herbicides. Damage to crops or other plants in



Edward Crow, Maryland Department of Agriculture

Avoid pesticide effects to non-target plants.



USDA

Avoid spraying when bees are actively foraging.



Craig Koppie, USFWS

Pesticides can be harmful to all kinds of animals.

adjacent areas is primarily caused by drift, though it may sometimes be a consequence of surface runoff.

Bees and other Beneficial Insects

Bees pollinate many fruit, seed, vegetable, and field crops. Applicators must be aware of bee activity when planning pesticide applications. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper. Before applying pesticides toxic to bees, notify beekeepers in the area so they can protect or move their bee colonies. Minimize losses of bees to insecticide poisoning by following a few basic principles:

- Read the label and follow label directions.
- Determine whether bees are foraging in the target area so you can take protective measures.
- Whenever possible, use pesticides and formulations least hazardous to bees. Emulsifiable concentrates are safer than powders and dust formulations. Granules are the safest and least likely to harm bees. Microencapsulated pesticides pose the greatest risk to bees.
- Choose the least hazardous application method. Ground applications are less hazardous to bees than aerial applications.
- Apply chemicals in the evening or during early morning hours before bees forage. Evening applications are generally safer to bees than morning applications. If unusually warm evening temperatures cause bees to forage later than usual, delay the pesticide application.
- Do not spray crops in bloom except when necessary.
- Do not spray when weeds or other plants around the treatment site are in bloom.
- Do not treat an entire field or area if spot treatments will control the pest.

Pesticides can harm other beneficial insects in addition to bees. Often these beneficial insects are valuable allies in keeping pest populations below damaging levels. A pesticide application often harms the beneficial insect population as much as the target pest, so do not spray when beneficial insects are in the target area except when absolutely necessary.

Fish, Wildlife, and Livestock

Pesticides can be harmful to all kinds of animals. Most injuries occur from the direct effects of acute poisoning. Fish kills often result from water pollution by a pesticide. Fish kills are most likely to be caused by insecticides, especially when small ponds or streams are under conditions of low water flow or volume.

Bird kills resulting from pesticide exposure can occur in a number of ways. Birds may ingest pesticide granules, baits, or treated seeds; they may be exposed directly to sprays; they may consume treated crops or drink contaminated water; or they may feed on pesticide-contaminated insects and other prey. Granular or pelleted formulations are a particular concern because birds and other animals often mistake them for food. Other formulations (liquid) may be safer when birds and other wildlife are in or near the treated area. Place baits properly so they are inaccessible to pets, birds, and other wildlife.

Animals can also be harmed when they feed on plants or animals carrying pesticide residues. Predatory birds or mammals feeding on animals killed by pesticides are a special concern. Pesticide residues remaining on or in the bodies of the dead animal may harm predators. This is called **secondary poisoning.** Check the pesticide label for statements about secondary poisoning.

The less obvious effects that occur from long-term exposure to pesticides

are a major concern. For example, certain pesticides have been banned because of fish and bird kills and reproductive failures of several bird species.

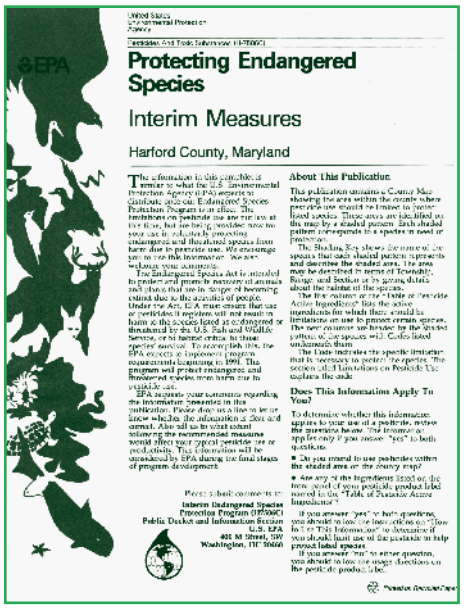
The most important source of livestock poisoning by pesticides has been introduced to contaminated feed, forage, and drinking water. Contamination often occurs as a result of improper or careless transportation, storage, handling, application, or disposal of pesticides.

PROTECTING ENDANGERED SPECIES

Certain plants and animals have been identified as endangered or threatened species. Make every effort to avoid causing harm to these populations. Because all living things are part of a complex, delicately balanced network, the removal of a single species can set off a chain reaction that affects many others. The full significance of an extinction is not always readily apparent, and the long-term effects are often difficult to predict.

An **endangered species** is one on the brink of extinction throughout all or a significant portion of its range. A **threatened species** is one likely to become endangered in the foreseeable future. The reasons for a species' decline are usually complex, and thus recovery is difficult. A major problem for most wildlife is the destruction of habitat, usually the result of industrial, agricultural, residential, or recreational development.

Each state is responsible for implementing the federal Endangered Species Protection Program in cooperation with the EPA to protect endangered and threatened species from the harmful effects of pesticides. Under this program, pesticide products that might adversely affect an endangered species carry a label statement instructing applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product. The EPA develops these bulletins, which identify precautionary measures required in each county where one or more pesticides could affect an endangered or threatened species. Precautionary measures may include buffer strips, reduced application rates or timing restrictions, or an applicator might be prohibited from using the pesticide within the identified habitat altogether. Check with your state lead agency, local Extension Service, or the EPA web site (www.epa.gov) to find out the status of available county bulletins.


EPA

Protecting Endangered Species

Interim Measures

Harford County, Maryland

About This Publication

Does This Information Apply To You?

Consulting a county bulletin is necessary for pesticides that might adversely affect endangered species.

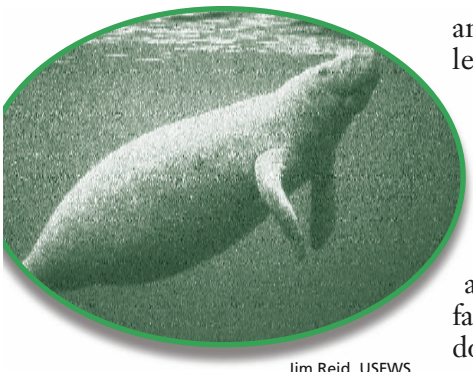
SUMMARY

Regulation is necessary in the use and classification of pesticides are regulated because of their potential hazard to humans and the environment. An important part of using pesticides responsibly is considering where the pesticide is going once it leaves the container and whether there might be any adverse effects on non-target sites, plants, or animals. The user must understand the characteristics of the pesticide (its solubility, volatility, adsorption, and persistence) and how the pesticide might move in the environment (as in the air by drift or through water by leaching and runoff) to know how to prevent unwanted effects.

If pesticides are applied correctly at the right time, in the right location, and with the proper application technique, the user can do a lot to prevent drift, runoff, and leaching. You can reduce or prevent drift by considering the method of application, the spray droplet size, and the speed and direction of the wind. In general, applying pesticides closer to the ground and using larger droplets reduces drift potential. Other factors to consider for preventing drift include the physical

properties of the liquid, air stability, humidity, and temperature, and the volatility of the pesticide formulation.

Pesticides that enter groundwater and surface water through runoff and leaching present a hazard to aquatic organisms, plants, and wildlife, and they may enter drinking water. Factors affecting runoff include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. Some of these factors also affect leaching of pesticides as do soil properties: texture and structure, organic matter content, the depth to groundwater, and the geology of the area. Consider these factors before applying pesticides in an area. Several techniques or "best management practices" can prevent groundwater and surface water contamination from pesticides, such as identifying vulnerable areas, not mixing or loading near water, keeping pesticides away from wells, and avoiding backsiphoning.



Jim Reid, USFWS

Endangered species need to be protected from pesticides.

Other important environmental considerations arise in sensitive areas. These are areas where pesticides present a greater risk of injury, such as to schools, playgrounds, endangered species habitats, and ornamental plantings. If it is necessary to make an application in these areas, make sure the pesticide applicator is well trained and knows how to apply the pesticide properly to reduce risk to people, plants, or animals in the area. Non-target organisms include plants, bees and other beneficial insects, fish, wildlife, and livestock. To avoid exposing non-target organisms to pesticides, applicators must know when and how exposures might occur and adjust their application practices accordingly. To prevent harmful effects on habitats, pesticide handlers also must avoid the buildup of pesticides at a site. For example, using the same mixing, loading, and cleanup site over a long time will result in the accumulation of pesticides in the soil. Pesticide handlers need to alternate locations for these activities or use some kind of containment system such as a mixing and loading pad to prevent pesticide buildup.

Pesticide handlers must be aware of any endangered or threatened species inhabiting the area to be treated. Always check the label for statements on endangered and threatened species. It may be necessary to consult a county bulletin that details the procedures for protecting them. It is the pesticide handler's responsibility not only to follow label directions but also to use the best management practices that present the least risk to the environment while achieving effective pest control.



Review Questions

CHAPTER 7: 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. **Which property of a pesticide would make it more likely to move with water in surface runoff?**
   - **A.** High solubility.
   - **B.** High adsorption.
   - **C.** High volatility.
   - **D.** A tendency to evaporate quickly.

2. **Which statement is *true* about groundwater or surface water contamination by pesticides?**
   - **A.** Pesticides cannot reach groundwater by runoff.
   - **B.** Runoff and erosion are sources of surface water contamination by pesticides.
   - **C.** Pesticide-contaminated surface water will not reach groundwater.
   - **D.** Groundwater or surface water contamination risk is low when a heavy rain immediately follows a herbicide application.

3. **Which is an example of non-point-source contamination of groundwater?**
   - **A.** Back-siphoning of pesticide spills at a wellhead.
   - **B.** Leaching from a pesticide mixing area.
   - **C.** Pesticides that dissolve and leach through soil after it rains.
   - **D.** Dumping leftover pesticide products down a well.

4. **Under what soil conditions are pesticides more likely to leach through soil?**
   - **A.** A heavy clay soil, low in organic matter, where groundwater is shallow.
   - **B.** A heavy clay soil, high in organic matter, where groundwater is deep.
   - **C.** A sandy soil, high in organic matter, where groundwater is deep.
   - **D.** A sandy soil, low in organic matter, where groundwater is shallow.

5. **Which is a recommended best management practice for preventing contamination of surface and groundwater by pesticides?**
   - **A.** Use pesticides that are highly water soluble.
   - **B.** Use terrace and conservation tillage practices.
   - **C.** Clean sprayers near sinkholes.
   - **D.** Select persistent pesticides.

6. **What two things should pesticide applicators be *most* aware of to avoid spray drift?**
   - **A.** Droplet size and wind direction and speed.
   - **B.** Air stability and temperature.
   - **C.** Viscosity of liquid pesticides and air turbulence.
   - **D.** Temperature and pesticide volatility.

7. **What two things should pesticide applicators be *most* aware of to avoid vapor drift?**
   - **A.** Droplet size and wind direction and speed.
   - **B.** Air stability and temperature.
   - **C.** Viscosity of liquid pesticides and air turbulence.
   - **D.** Temperature and pesticide volatility.

8. **Which statement about sensitive areas is *true*?**
   - **A.** Never spray a sensitive area to control a pest for any reason.
   - **B.** Do not spray a larger target site if it contains a sensitive area.
   - **C.** Pesticide labels may contain statements that list special precautions around sensitive areas.
   - **D.** Endangered species habitats are not considered sensitive areas.

9. Which statement is *true* about protecting bees from pesticide injury?

A. Wettable powders are the safest formulation for preventing bee injury.
B. It is best to spray crops when they are in bloom.
C. Aerial applications are less hazardous to bees than ground applications.
D. Applying pesticides in the evening or during early morning is recommended.

CHAPTER 8

TRANSPORTATION, STORAGE, AND SECURITY

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to identify components of a proper (e.g., secured, ventilated) storage area.
- Know how to store pesticides according to label directions and regulations and how to post warning signs around storage areas.
- Know how to practice inventory control methods to prevent excess storage.
- Know how to maintain pesticide containers (e.g., protect labels, inspect for damage, keep containers closed, discard expired products).
- Know how to prepare for potential spills (e.g., maintain spill kit, maintain accessible material safety data sheets).
- Know how to dispose of pesticide wastes according to label directions.
- Know how to restrict access to pesticides by unauthorized personnel.

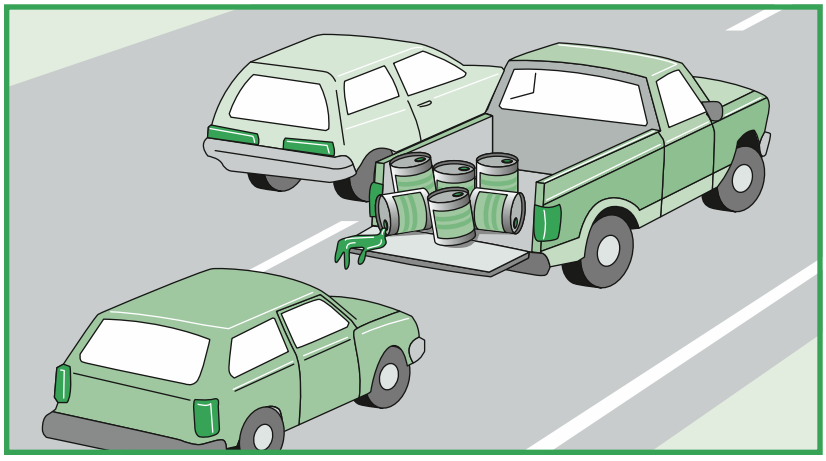


This chapter discusses safety and security issues while pesticides are in transit or in storage. Accidents involving pesticides are more likely to occur while they are being transported. Properly maintain and design storage sites to prevent damage and unauthorized access to pesticides. Pesticide safety practices include securing pesticides in the cargo area of the transport vehicle and preventing water damage in storage areas to prevent the accidental discharge of pesticides. In addition, appropriate security measures, such as locking pesticides inside cargo boxes and storage areas, prevent pesticide theft and vandalism. You can reduce the potential for pesticide problems by being aware of the conditions that leave pesticides open to security risks and by initiating good safety practices.

TRANSPORTATION

It is important for every pesticide user to understand possible hazards and the procedures for minimizing the risks associated with transporting pesticides. Careless handling of containers, incorrectly maintained equipment, and unforeseen accidents can all lead to pesticide leaks and spills during transport. The fact that some pesticides are highly flammable increases the danger (fire and toxic fumes) while they are in transit. Another concern is that other vehicles could scatter pesticide products that are spilled on public roads. Such events have the potential to injure bystanders and animals. In addition, transportation-related pesticide spills and leaks can contaminate the environment, endanger residential areas, and lead to financial losses and legal actions.

Pesticides are transported from manufacturers to distributors and dealers, from retailers to end users, and from storage sites and mixing locations to application sites. Accidents can happen at any point in the distribution chain, even when transport distances are short. The first line of defense is knowing how to prevent transportation mishaps. When mishaps occur, however, initiating the appropriate response could mean the difference between a minor inconvenience and a communitywide disaster.

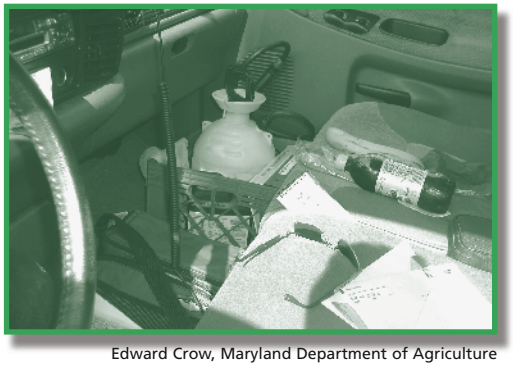


Secure pesticides while transporting them even for short distances.

Transport Vehicle

Transport vehicles should be in good mechanical condition, including power train, chassis, and any onboard bulk tanks and associated fittings. In particular, make sure safety and control components such as brakes, tires, and steering are in good working order. A poorly maintained vehicle is, by itself, a safety risk; adding pesticides to the picture increases the potential risk of injury or contamination should a mishap occur. Regularly inspect application equipment being transported. Look for structural defects in the equipment such as cracks, punctures, and other causes of leaks or failure. Always carry equipment needed to make repairs in case a problem occurs while the vehicle is in transit.

Never carry pesticides in the passenger compartment of a vehicle because spilled chemicals and hazardous fumes



Edward Crow, Maryland Department of Agriculture

Never carry pesticides in the passenger compartment of a vehicle.

can seriously injure the occupants. Spilled pesticides can be difficult or impossible to remove completely from the vehicle's interior, leading to long-term exposures. If pesticides must be carried in a station wagon, utility van, or similarly enclosed vehicle, ventilate the cargo and passenger compartments, and keep passengers and pets away from pesticides during transport. Remember, cargo can shift during collisions and other sudden stops, placing a safety barrier between the passengers and the cargo area is advisable.

The cargo area must be able to securely hold containers and provide protection from tears, punctures, or impacts that could lead to container damage. Enclosed cargo boxes provide the greatest protection but are not

always practical. Cargo boxes also offer the added benefit of security from curious children, careless adults, or vandals. Open truck beds are convenient for loading and unloading, but take precautions to minimize the possibility of theft or losing containers on sharp turns or bumpy roads. Never stack pesticide containers higher than the sides of the vehicle. Make sure flatbed trucks have side and tail racks, and tie-down rings, cleats or racks to simplify the job of securing the load. Before loading, inspect every cargo area for nails, stones, or sharp edges/objects that could damage containers. Steel beds are preferable to wood because they are more easily cleaned if a spill should occur.



Jack Kelly Clark, Univ. of California Statewide IPM Program

Cargo boxes allow for secure transport of pesticides and help prevent theft and vandalism.

Vehicle Operator

Both the owner and the operator of the transport vehicle can be held accountable for any injuries, contamination, or damage resulting from a chemical release that may occur. The vehicle operator may be the only person capable of reacting to a spill and, in some instances, may need to assist first response emergency personnel as they arrive on the scene. At a bare minimum, the vehicle operator must understand the nature and hazards of the pesticides being transported. Train the operator in basic emergency response procedures, including spill control and emergency notification procedures. Refer to Chapter 9, "Emergency or Incident Response," for specific information on how to respond to a fire, spill, or leak involving agricultural chemicals.

Special motor vehicle training and licensing, in addition to pesticide training or certification, may be required for operators of pesticide transport vehicles. If a load meets the U.S. Department of Transportation (DOT) definition of a hazardous material or substance, then special driver training and, in some instances, commercial driver licensing is required.

Other Safety Precautions

Before departing, make sure that the technical data for all pesticide products and emergency information for spill response are in the vehicle. A shipping paper, also called a vehicle manifest, may be required for certain products regulated as hazardous materials under DOT regulations. The regulatory section of a MSDS lists whether or not the pesticide product is a DOT-regulated product.

Product labels and material safety data sheets contain information about the proper storage and handling of products, including acceptable storage temperatures, human and environmental hazards, personal protective equipment, and emergency telephone numbers. Provide this information in the vehicle to help the driver or emergency personnel properly respond to a pesticide release. It is also a good idea to have a phone number in the vehicle for 24-hour emergency assistance.

A mobile phone is strongly recommended for anyone routinely involved in the transport of pesticides or working alone in remote locations. Always carry a spill kit including a shovel and broom and personal protective equipment appropriate for the pesticides in transit and know how to use these items. Be familiar with the travel route so you can anticipate and avoid problems such as construction delays. If a pesticide release occurs, a major traffic jam only further complicates cleanup.

Inspect containers before loading to be certain they are in good condition. Look for legible and attached labels, tight closures, and pesticide-free outside surfaces. Handle containers

carefully during loading to avoid rips and punctures. Use packing or shipping containers to provide extra protection and secondary containment. Where practical, using a synthetic liner or tarpaulin large enough to cover the floor and sides of the cargo area (especially truck beds) can provide containment and easier cleanup of spilled materials. Organize the load to maximize stability while at the same time maintaining access to containers for ease of unloading. The less containers are handled, the less likely they are to be damaged. Secure the load with tarps, ropes, brace bars, or other appropriate devices to prevent containers from shifting. Also, stabilize anything else that could move and damage a container during transport. Also secure application equipment such as hand sprayers, backpack sprayers, spreaders, and spray tanks during transport.

Protect pesticides from temperature extremes and moisture during transit. Extremely low or high temperatures (below 40 degrees F or above 110 degrees F) can alter the stability or effectiveness of some pesticide formulations. Moisture can destroy paper and cardboard pesticide containers. Placing a waterproof cover over the load can provide protection from the elements, including the hot summer sun.

Never allow people, pets, or livestock to ride in a cargo area loaded with pesticides. Separate food, livestock feed, seed, veterinary supplies, and plant materials from pesticides because contamination may render them unusable or result in a poisoning incident. Keep herbicides separate from other pesticides and fertilizers because of the potential for cross-contamination.

Always secure the load and carry in the truck a spill kit that includes a broom and shovel.



Adapted from University of Illinois *Privte Applicator* manual

Transportation Security

Whenever possible, transport pesticides in a locked compartment or container. If you must use an open vehicle to transport pesticides, never leave it unattended. Always secure your spray tank or mini-bulk container



NC Dept. of Agriculture & Consumer Services

Pesticides stored incorrectly with feed, seed, and fertilizers increase the risk of contaminating non-pesticide products.

when it contains a pesticide mixture. Remember, you will be held responsible if a curious child or careless adult is poisoned or if environmental contamination occurs because of your negligence. Take all appropriate steps to reduce the chance of vandalism or theft.

The DOT requires diamond-shaped signs called **placards** on vehicles that transport certain types and quantities of hazardous materials. Though few pesticides require placarding, it is important to ask distributors whether what you are buying requires placarding. Most distributors furnish these to you if you need to place them on your transportation vehicles. Hazardous materials include some pesticides; fertilizers such as anhydrous ammonia or ammonium nitrate; fuels such as gasoline, diesel, and propane; and explosives such as dynamite and detonators. Placards

provide emergency responders with the information necessary to quickly assess an accident situation from a distance, reducing the possibility of someone approaching the accident site without wearing the proper protective clothing or equipment.

Persons, including farmers, who ship or transport materials in quantities that require placards are now required to develop and implement a **transportation security plan.** Vehicles must be placarded when transporting pesticides bearing a DOT poison label being transported in containers larger than 119 gallons or in quantities greater than 1,000 pounds. Therefore, all operations that transport pesticides that meet these conditions must have a security plan. The security plan must include protection against unauthorized access, a security check of employees that pick up and transport placarded hazardous materials, and a security plan for the intended travel route. For further details on the transportation security plan, contact the Hazardous Materials Information Center (see box below).

Hazardous Materials Information Center

1-800-HMR-4922

http://hazmat.dot.gov/infocent.htm

Applicators may need to become familiar with many other DOT state and federal requirements. The DOT guidebook, *Guide to Developing an Effective Security Plan for the Highway Transportation of Hazardous Materials*, is a useful reference for transporters of pesticides *(http://www.fmcsa.dot.gov/safety-security/hazmat/security-plan-guide.htm).*



Examples of placards placed on vehicles that transport certain types of hazardous materials.

PESTICIDE STORAGE

Although many pesticide handlers use existing buildings or areas within existing buildings for pesticide storage, it is always best to build a separate storage facility just for pesticides.

A well-designed and maintained pesticide storage site:

- Protects people and animals from exposure.
- Reduces the chance of environmental contamination.
- Prevents damage to pesticides from temperature extremes and excess moisture.
- Safeguards the pesticides from theft, vandalism, and unauthorized use.
- Reduces the likelihood of liability.

Secure the Site

Keeping out unauthorized people, pets, and stray animals is an important function of the pesticide storage site. Whether the designated area is as small as a cabinet or closet or as large as an entire room or building, keep it securely locked. Post highly visible warning signs on doors and windows to alert people that pesticides are stored inside. In addition, post "No Smoking" warnings—many pesticides are highly flammable. Security of pesticides is covered in much more detail at the end of this chapter.

Prevent Water Damage

Locate the pesticide storage facility where water damage is unlikely to occur. Carefully consider soil and land surface characteristics when selecting a storage site to prevent potential contamination of surface water or groundwater. Avoid locating the storage facility near a stream likely to flood or where runoff water can be a potential problem, such as at the base of a slope. In extreme cases of flooding, all the pesticides from the storage site can move into surrounding areas. In certain situations, consider diking or constructing some other con-



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Maintain a well designed, secure pesticide storage facility with highly visible warning signs. Keep it well ventilated and located where water damage is not likely to occur.



Do not store pesticides in locations that can become damp or wet.

tainment structure around the storage facility. A common recommendation is to set storage areas back at least 50 feet from a well to prevent groundwater contamination, but requirements may vary by state.

Water or excess moisture can damage pesticide containers and their contents. Moisture causes:

- Metal containers to rust.
- Paper and cardboard containers to split or crumble.
- Pesticide labeling to peel, smear, or otherwise become unreadable.
- Dry pesticides to clump, degrade, or dissolve.
- Slow-release products to release their active ingredients.

Control the Temperature

Choose a cool, well-ventilated room or building that is insulated or temperature-controlled. Exhaust fans directed to the outside of the building reduce temperatures and remove dust and vapors from the storage facility. Ventilation of the air from a pesticide storage area into other rooms is an unsafe practice. The pesticide labeling often specifies the temperature limits for storing a product. Temperature extremes can decrease the effectiveness of some pesticides. In addition, freezing temperatures can result in breakage of glass, metal, and plastic containers. Excessive heat can cause plastic containers to melt, some glass containers to explode, and a few pesticides to volatilize and drift from the storage site. Always store pesticide containers out of direct sunlight to prevent overheating.

Provide Adequate Lighting

Be sure the pesticide storage facility is well lighted. Pesticide handlers using the facility must be able to see well enough to read the pesticide label and notice whether containers are leaking or corroding. Without adequate lighting, the pesticide handler can have difficulty cleaning up spills and leaks.



Paul Love, Michigan State University

Provide adequate lighting inside of pesticide storage areas.

Because of the volatility of some pesticide formulations, use only spark-proof lighting fixtures and switches.

Use Non-porous Materials

Construct the floor of the pesticide storage area using sealed cement, glazed ceramic tile, no-wax sheet flooring, or other material that is free of cracks and easy to clean and decontaminate in the event of a spill or leak. Carpeting, wood, soil, and other absorbent floors are not suitable because they are difficult or impossible to decontaminate. A floor that slopes into a containment system or recessed below the level of the doors helps to keep spilled or leaking pesticides within a confined area. For ease



USDA

Be sure the floor of the pesticide containment site is made of non-porous materials such as sealed cement. A recessed floor helps control spills or leaking pesticides.

of cleanup, choose shelving and pallets made of non-absorbent materials such as plastic or metal.

Maintain the Storage Site

Store only pesticide containers, pesticide equipment, and a spill cleanup kit at the storage site. Never keep food, drinks, tobacco, feed, medication, medical or veterinary supplies, seeds, clothing, or personal protective equipment (other than that necessary for emergency response) at the site. These items could become contaminated by pesticide vapors, dusts, or spills, resulting in accidental exposure to people or animals. Have water available for decontamination.

Keep Labels Legible

Store pesticide containers with the labels in plain sight. Costly errors can result if the wrong pesticide is chosen. Be sure labels are always legible. If the label is destroyed or damaged, immediately mark the container with some basic labeling information such as the trade name and common name of the product, the EPA registration number, the percentage of each active ingredient, the signal word, and the use classification. Then request a replacement label from the pesticide dealer or the distributor.

Store Pesticide Containers Safely

Store pesticides only in their original containers or an acceptable service container. At a minimum, write the trade and common names, EPA registration number, and signal word on the container. Never use milk jugs, soft drink bottles, fruit jars, medicine bottles, fuel cans, or other types of non-pesticide containers. Besides being illegal, switching containers has resulted in serious poisonings because children, as well as most adults, associate the shape, size, and color of a container with its usual contents. Never lend or borrow any pesticide product in an unmarked or unlabelled container.

Keep containers securely closed when not in use. Dry formulations tend to cake when wet or subjected to high humidity. Opened bags of wettable and soluble powders, dry flowables, dusts, and granules can be placed into sealable plastic bags or other suitable containers to reduce moisture absorption and to prevent a spill, should a tear or break occur.

Place large drums and heavy bags on plastic pallets. Store other pesticides on metal shelving, placing the heaviest containers and liquids on the lower shelves. Do not allow containers to extend beyond the edge of shelving because they could easily be bumped or knocked off. Be sure the shelving is sturdy enough to handle the quantity and weight involved.



D. Brown-Rytlewski, MSU

Do not store pesticides in food containers.

Store volatile pesticides separately to avoid possible cross-contamination of other pesticides, fertilizers, and seeds.

Place bulk or mini-bulk tanks on a reinforced concrete pad or other impermeable surface. Diking around a tank keeps spilled or leaking pesticides inside a restricted area and also helps prevent damage to the tanks from vehicles and equipment. Construct the area inside a dike large enough to contain the volume of the liquid in the tank plus at least an additional 10 percent. Keep valves and pumps within the diked area. Make sure all drains within the dike connect to a holding tank. Outside, use fencing to prevent tampering or unauthorized access to any bulk tanks.



Store pesticides on metal shelving, with the heaviest containers and liquids stored on the lower shelves. Never extend beyond the edge of the shelving.

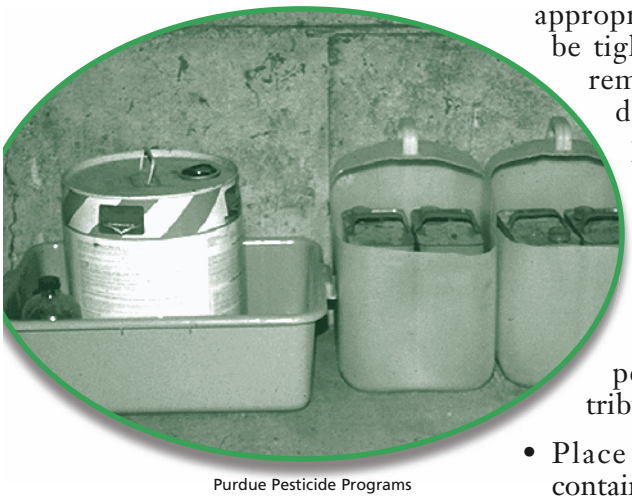
Look for Damage

Inspect pesticide containers regularly for tears, splits, breaks, leaks, rust, or corrosion. If you find a damaged container, immediately put on appropriate personal protective equipment and take immediate action to prevent the pesticide from leaking or spreading into its surroundings. If a container is already leaking, take corrective action to prevent further leaking and immediately clean up any spilled pesticide. Be especially careful if the damaged container is an aerosol can or fumigant

cylinder that contains pesticides under pressure.

Depending on the specific situation, consider the following actions:

- Use the pesticide immediately at a site and at a rate allowed by the label.
- Transfer the pesticide into another pesticide container that originally held the same pesticide and has an intact label.
- Transfer the contents to an appropriate container that can be tightly closed. If possible, remove the label from the damaged container and place it on the new container. Otherwise, temporarily mark the new container with basic labeling information and get a copy of the label from the pesticide dealer or distributor as soon as possible.
- Place the entire damaged container and its contents into a suitable larger container (overpack container for subsequent disposal).



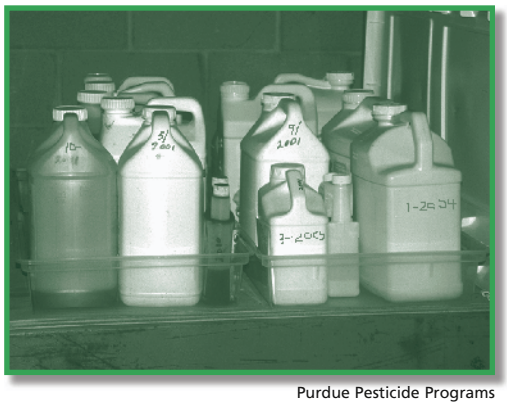
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Place damaged pesticide containers in secondary containment.

Note Shelf Life of Pesticides

Keep an inventory of all pesticides in storage and mark each container with its purchase date. Be sure to note if the product has an effective shelf life listed on its label. If you have questions about the shelf life of a product, contact the dealer or manufacturer. Signs of pesticide deterioration from age or poor storage conditions may appear during mixing. Watch for excessive clumping, poor suspension, layering, or abnormal coloration during mixing. Other times, however, the first indication of pesticide deterioration from age or poor storage conditions may be poor pest control and/or damage to the treated crop or surface.

To minimize storage problems, avoid storing large quantities of pesticides for long periods. Keep records of previous usage to make good estimates



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Mark each container with its purchase date.

of future needs. Buy only as much as you need for the season.

Follow These Safety Tips

The following safety tips help prevent pesticide accidents and exposures in storage areas and help people respond appropriately to pesticide spills and emergencies:

- Have duplicate copies of labels available in case of an emergency. Keep a material safety data sheet available for every chemical in the storage facility. The Internet or the pesticide dealer is a good source for MSDS and labels.
- Wear the appropriate protective clothing when handling pesticide containers.
- Label all items used for handling pesticides (measuring utensils, protective equipment, etc.) to prevent their use for other purposes.
- Have clay, pet litter, fine sand, activated charcoal, vermiculite, or similar absorbent materials readily available in case of spills or leaks. In addition, keep a shovel, broom, and heavy duty plastic bags on hand.
- Check the MSDS for the types of materials that may be needed to deactivate spills.
- Treated seed is usually colored with a bright dye to serve as a warning that the seed has

been treated with a pesticide. Unfortunately, the bright colors may be attractive to children. Never use treated seed for feed or mixed with untreated seed. Handle it with the same care as the pesticide itself and store in a locked storage facility away from feed, veterinary supplies, pesticides, other chemicals, equipment, pets, wildlife, and children.

Keep clean water for decontamination, an eyewash station, personal protective equipment, a fire extinguisher rated for chemical fires, first-aid equipment, and emergency telephone numbers easily accessible at all times. In addition, keep plenty of soap, water, and paper towels available near the storage facility.

Isolate Waste Products

Do not accumulate outdated or cancelled pesticide products. Make every effort to use up what you purchase because leftover pesticides may become hazardous waste. All of these materials could be subject to additional federal regulations on the storage, disposal, and reporting of hazardous materials (see SARA Title III and RCRA in Appendix D). Outdated products—those whose shelf life has expired—may no longer be effective. Cancelled products often have a specified period beyond which they cannot be legally used. Use time-limited products according to the label directions before the expiration date to avoid generating hazardous wastes. Follow the status of products on the verge of cancellation, and use these products before the deadline.



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Have a designated area for properly rinsed containers.

If you are holding pesticides or pesticide containers for disposal or recycling, store them in a special section of the storage site. Be sure to follow label directions for disposal of any excess or leftover product. Accidental use of pesticides meant for disposal can be a costly mistake. Make sure all empty containers are **triple-rinsed** or **pressure-rinsed** before storing for disposal or recycling. Refer to Chapter 10 for an explanation of triple-rinsing and pressure-rinsing procedures. Clearly mark properly rinsed containers. If possible, recycle these containers through a program supported by the Ag Container Recycling Council (ACRC) or by your state pesticide regulatory agency.

PESTICIDE SITE SECURITY

Businesses that manufacture, reformulate, sell, distribute, or transport pesticides have long known the importance of taking risk mitigation steps for the safety of their workers, their customers, and their communities. Those who distribute pesticides have emphasized safe storage and accurate labeling of their products. For the pesticide user, safety efforts have centered on reading and following all label directions. Now these efforts are no longer enough. Every pesticide handling and storage facility must now focus on its security efforts and plan for any possible situation.

Pesticide establishments and applicators need to review their security and emergency management plans to determine if there are additional ways to minimize risks. Lacking effective security procedures, a business may be vulnerable to both internal (employee theft) and external risks (theft and vandalism), putting employees, buildings and machinery, and even sensitive business information in jeopardy. If the business has mobile pesticide application equipment, particularly aerial application equipment, take special precautions to secure the equipment.

Benefits of Security Efforts

By developing a strong security plan, managers and individual pesticide applicators can reduce the likelihood of adverse effects on employees, the public,



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Be sure to guard against unauthorized entry.

and the environment. In addition, good security helps avoid costly losses. An incident of any magnitude can seriously disrupt business operations, resulting in lawsuits, costly remediation activities, employee fear and uncertainty, and damage to the company's or applicator's reputation. Benefits of a good security program include:

- Safeguarding employees, the community, and the environment.
- Maintaining the integrity and effectiveness of operations.
- Reducing legal risk, insurance costs, and theft.
- Reducing the risk of vandalism and sabotage.
- Protecting confidential business information.
- Improving relationships with local authorities and the community.
- Providing a mechanism for conducting employee background checks and identification.

Risk Assessment

The first step in developing a solid security program is to conduct a risk assessment. In other words, make a list of those assets that need to be protected, the types of possible threats against those assets, and the likelihood and consequences of an attack against those assets.

Any business that involves pesticides, no matter how large or small, has the same assets, which are broadly defined as people, information, and property. "People" includes employees, visitors, customers, contractors, and those engaged in transporting pesticide products. "Information" includes all business information. The "Property" that a security program might wish to protect could include the following:

- Pesticide storage facilities.
- Vehicles.
- Application equipment.
- Bulk storage tanks.
- Mixing and loading sites.
- Waste pesticide collection and containment facilities.
- All utilities, such as telephone, water, gas, and electric.
- All other potentially hazardous materials.

Several pesticides currently in use today have acute toxicities or environmental hazards that could make them attractive as potential weapons. However, any pesticide product has the potential to be misused and cause human, environmental, psychological, and/or economic injury. Make sure security measures are in place when transporting, storing, applying, or disposing of any pesticide.

Employee Training and Security Awareness

The first line of defense in any security program is to remind all employees, contractors, and customers they can serve as the eyes and ears of a companywide security effort. They notice much of what occurs in and around a pesticide storage facility or pesticide application business and can provide an early warning when something does not seem quite right or someone is acting suspiciously. Proper security training and awareness can transform these individuals into an alert surveillance system. At a minimum instruct all employees on pesticide inventory control, security of storage facilities and application equipment, and emergency preparedness and response. Individuals must be alert to unusual purchases, threats, or suspicious behavior by other employees or customers.

Evaluating Pesticide Security

The security needs and critical control points differ for each pesticide business and facility. However, some

of the fundamental security items to consider include:

Securing buildings, manufacturing facilities, storage areas, and surrounding property—One of the most fundamental security needs is preventing the unauthorized entry of persons into areas used to manufacture or store pesticides. Elements of an effective security plan can range from basic fencing, lighting, and locks to detection systems, cameras, and trained guards.

Securing pesticide application equipment and vehicles—All facilities, whether family-owned farms or custom application businesses, need appropriate security protections to prevent intruders from having access to equipment used in mixing, loading, and applying pesticides. Secure and disable equipment in the field to prevent unauthorized use. Before allowing operation of pesticide application equipment and vehicles, check handlers for proper authorization and identification. The Federal Bureau of Investigation (FBI) cautions that any suspicious activity related to the use, training, or acquisition of pesticides should be immediately reported to the authorities.

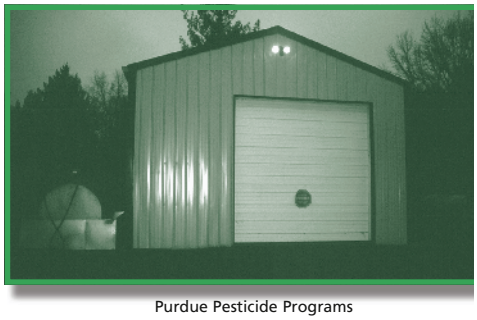
Protecting confidential information—As business, safety, and security systems become more reliant on computer and communications technology, the need to secure these systems has grown. Such efforts include contingency planning for power losses, effective monitoring of access ports, adherence to password and backup procedures, and other mechanisms to ensure only authorized personnel have access to these systems.

Developing procedures and policies that support security needs—These include effective hiring and labor policies, inventory management, and planning for emergency response. Effective hiring and labor policies are necessary to obtain and retain good employees who support and follow safety precautions. For example, the hiring process must ensure employees have all the training necessary to handle pesticides safely. Background checks of staff members who have access to secure areas where pesticides may be stored are also necessary. Inventory management is necessary to help limit the amount of potentially hazardous pesticides stored on site and to reduce the risks of accidental or intentional release or theft. Buy no more of a product than you need for a specific job or a growing season. Finally, planning for emergency response is critical and helps to ensure that business officials and employees understand how to respond and whom to contact in the case of an emergency. In addition to accidents, such plans must also now consider vandalism, bomb threats, and terrorist activity.



Purdue Pesticide Programs

Lock backpack sprayers securely onto the transport vehicle.



Purdue Pesticide Programs

Outside lights on a pesticide storage building help prevent theft and vandalism.

Coordinating with authorities in a timely manner— If a breach of security or suspicious activity does occur, contact the appropriate authorities immediately. In addition to alerting the local police department and other emergency response agencies, individuals must immediately report any threats or suspicious behavior to the local FBI field office. These agencies also must be informed of incidents involving pesticide exposures that occur under circumstances incon-sistent with a product's normal use pattern. Information on the location of the appropriate FBI office is available at www.fbi.gov.

Steps for Preventing Security Problems

- Adopt security measures that deter tampering with your chemicals, equipment, or the facility itself.
- Work with local authorities (police, fire) in developing your security plan.

- Keep an updated and accurate inventory of all chemicals in your possession.
- Keep the chemical storage area secure and locked during non-business hours and after inventory is removed.
- Routinely review, update, and practice your emergency response plan and procedures.
- Post current telephone numbers of all relevant law enforcement and emergency response agencies in a prominent location.
- Be cautious of unknown persons who are interested in purchasing large amounts of pesticides with cash.
- Ask employees to report any incidents of strangers expressing unusual interest in and/or asking questions about the toxicity of various pesticides.
- Similarly, ask employees to report anyone who shows an unusual curiosity and/or interest in pesticide application equipment.
- Report unauthorized persons loitering near pesticide storage areas to local authorities.
- Require photo identification from purchasers. Check credentials carefully to determine if they have been altered or forged.
- Restrict access of non-employees to your pesticide storage facilities.

SUMMARY

It is essential that good safety and security practices be in place for pesticides in transit and in storage. Spills and accidents are more likely to occur while transporting pesticides. The transport vehicle must be in good mechanical condition, and the owner/operator of the vehicle must be trained in emergency and spill response procedures. It is also important to have the pesticide label and MSDS for each pesticide being carried in the vehicle to assist the driver or emergency personnel should a pesticide release occur.

Design and maintain pesticide storage sites to prevent unauthorized access and damage to pesticide containers. Keeping pesticides in a cool, dry, well-ventilated room with adequate lighting protects pesticide containers and their contents from damage. Lock the storage area and post it with highly visible signs to warn others that pesticides are stored inside. Store pesticides in their original containers and out of direct sunlight. Make sure labels can be read easily. If damage to pesticide containers occurs, take appropriate steps to prevent the pesticide from leaking into surrounding areas and clean up any spill carefully. Keep an inventory of all pesticides in storage, and note if the product has an effective shelf life on its label to minimize storage and disposal problems. Follow label directions for disposing of any excess or leftover pesticide products.

Attention to pesticide site security has been on the increase. Develop security and emergency management plans for every pesticide handling and storage facility to safeguard employees and the community. Design security plans to reduce the risk of theft, vandalism, and the deliberate misuse of pesticides to harm others or the environment. Pesticide-related businesses must train their employees in appropriate security and emergency response procedures and coordinate their efforts with local police, emergency response personnel, and the FBI.



Review Questions

CHAPTER 8: TRANSPORTATION, STORAGE, AND SECURITY

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

1. **Which statement about transporting pesticides is *true*?**
   - **A.** Carry hazardous pesticides in the passenger compartment of a vehicle to prevent unauthorized access.
   - **B.** Enclosed cargo boxes offer the greatest protection but are not always practical.
   - **C.** Operators of vehicles that transport hazardous materials are not required to have any special training, only a commercial driver's license.
   - **D.** The operator is not held responsible if a pesticide spill or accident occurs because the vehicle was left unattended.

2. **Which statement about pesticide storage facilities is *true*?**
   - **A.** If pesticides are stored in a small, locked cabinet or closet, it is not necessary to post warning signs.
   - **B.** Carefully consider soil and land surface characteristics when selecting a storage site to prevent potential contamination of water sources.
   - **C.** Store pesticides in a warm, airtight environment.
   - **D.** The floor of the pesticide storage site should consist of materials such as carpeting or wood.

3. **To prevent damage to pesticide labels, you may use transparent tape or a coating of lacquer or polyurethane to protect them.**
   - **A.** True.
   - **B.** False.

4. **What is the *first* thing you should do if you notice a damaged pesticide container?**
   - **A.** Put on appropriate personal protective equipment.
   - **B.** Transfer the contents into another sturdy container that can be tightly closed.
   - **C.** Use the pesticide immediately at a site and at a rate allowed by the label.
   - **D.** Clean up any spilled chemical.

5. **Which practice for minimizing storage problems is *not* recommended?**
   - **A.** Buy large quantities of pesticides to reduce costs and ensure that the chemicals you use are available when you need them.
   - **B.** Keep records of previous usage to make good estimates of future needs.
   - **C.** Mark each pesticide container with the purchase date, and keep an inventory of all pesticides in storage.
   - **D.** Be sure to note if the product has an effective shelf life listed on the label.

6. **What is the *first* step a business should take to develop a sound pesticide security program?**
   - **A.** Coordination with authorities.
   - **B.** Risk assessment.
   - **C.** Employee training in security awareness.
   - **D.** Evaluation of pesticide security.

7. **Which would *not* be considered a good security practice?**
   - **A.** Instructing employees on pesticide inventory control.
   - **B.** Preventing access to equipment used in mixing, loading, or applying pesticides.
   - **C.** Replacing employees often with new personnel.
   - **D.** Reporting suspicious behavior to the FBI.

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CHAPTER 9

EMERGENCY OR INCIDENT RESPONSE

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to implement emergency response procedures as necessary and to execute an emergency response plan (e.g., contact agencies, administer first aid, clean up spills).
- Know how to identify how unintended pesticide releases (e.g., spills, fires) can have harmful effects on humans and the environment.
- Understand how to use emergency response equipment properly.
- Understand how to plan and implement cleanup activities or procedures to mitigate environmental impact.
- Know how to dispose of contaminated materials from a spill according to regulations.
- Know how to identify components of emergency response equipment (e.g., spill cleanup kit, first-aid kit, personal protective equipment).
- Know how to restrict access to authorized personnel only.



Although accidents and emergencies involving pesticides are rare; unfortunately, they do occur. Many pesticide accidents can be traced to applicator carelessness or misuse. Pesticide accidents or fires can result in water, soil, and air contamination; damage plants, injure livestock, wildlife, or pets; and endanger the health of the applicator and other people. In addition, personal financial losses can occur from cleanup costs, liability claims, and fines and penalties.

Manufacturers, transporters, dealers, and users of pesticides must treat all pesticide leaks, spills, and fires as emergencies and be prepared to respond to these emergencies promptly and correctly. Do all that you can to prevent accidents, but be prepared in case an emergency should arise.

EMERGENCY RESPONSE PLANNING

A carefully thought-out emergency response or contingency plan is one of the most important tools you can have to prevent an emergency situation from becoming a catastrophic event. An emergency response plan

can help protect the health and welfare of employees and the community, minimize environmental damage, and potentially reduce liability in the event of an accident. The importance of planning for emergencies cannot be overemphasized. Undertake this planning with painstaking attention.

Do you know what to do in a pesticide emergency?

An emergency may take the form of a severe weather event such as a tornado or flood or, more likely, an accident or fire. Serious public health and environmental consequences can occur when a tank truck overturns or a hose ruptures, spilling pesticides. An explosion and subsequent fire in a pesticide storage facility could result in serious injuries and environmental contamination, requiring the evacuation of persons downwind from the site of the fire. How you respond to a pesticide emergency may determine whether the incident becomes nothing more than a minor mishap or results in a major chemical release.



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Be prepared for emergency situations.

Consider the following guidelines when developing an emergency response plan:

- Designate an emergency coordinator. This person must have the knowledge and authority to direct and manage employee responses to a pesticide emergency, and to coordinate the efforts of local emergency response agencies such as fire, police, and paramedics.
- Maintain a list of emergency response agencies. Include names and telephone numbers of all response agencies you may have to call to assist in an emergency. Organize the list in the order to be called.

Emergency Response Agency Contacts

- Persons/agencies required to be notified by local, state, and federal requirements.
- Local emergency planning committees.
- Police and fire units.
- Paramedics and area hospitals.
- Appropriate chemical manufacturers and dealers.
- Containment and hazardous waste cleanup contractors.
- Your attorney, to protect your rights and the rights of others.

- Include an outline with your calling list of the information to be passed along during an emergency notification call; include the following:
  - Name and callback number of the person reporting the incident.
  - Precise location of the incident.
  - General description of what has occurred.
  - The exact name, quantity, and classification of each chemical involved.
  - The extent of any injuries.
  - Potential danger to the environment and persons living in the area.
- Prepare a map of your facility to include with your emergency response plan. Show a layout of all chemical storage buildings and bulk storage tanks; access roads; main shutoffs for electricity, water, and gas; perimeter fencing that could hinder access to the pesticide storage facility; the location of fire alarms, firefighting equipment, and protective clothing; and

drainage easements on the site. Provide emergency response agencies an updated copy of this map whenever changes are made at the facility (Figure 9.1).

- Provide your emergency response agencies with an area map that shows your facility in relation to the surrounding area. Fire, police, and paramedics cannot waste time trying to determine where your facility is located.

  - Equipment that can be used for diking, trenching, pumping, and vacuuming.
  - Containment and cleanup materials such as absorbent materials and neutralizing agents.
  - Location and inventory of fire extinguishers and protective equipment.
  - Any specialized equipment such as self-contained breathing apparatus.

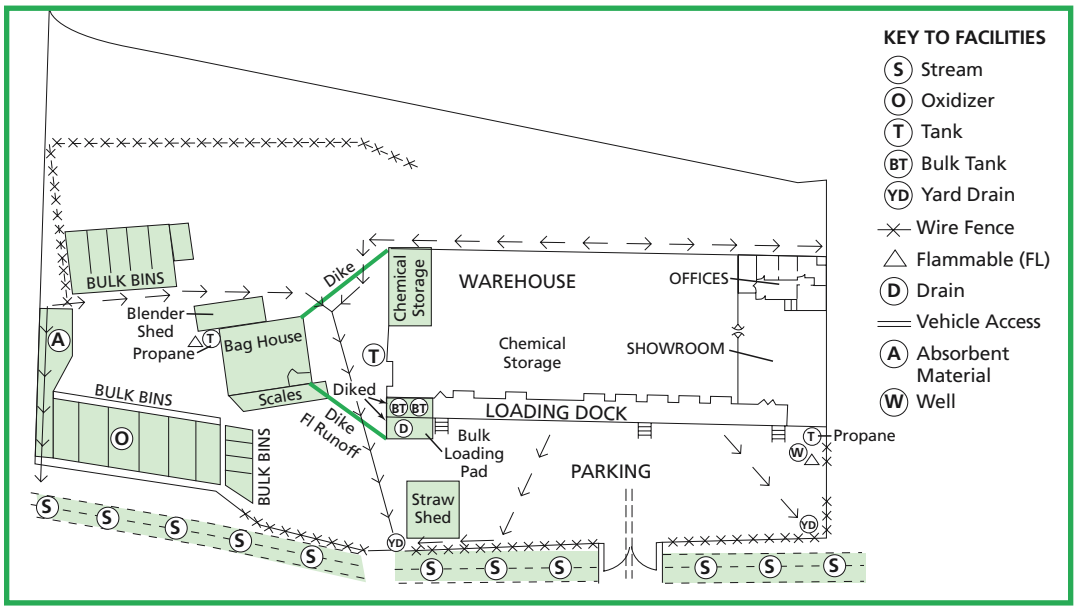


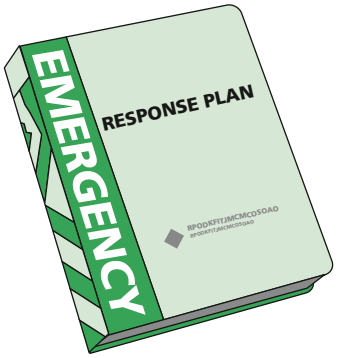
Figure 9.1
Include a facility map as part of the emergency response plan.

- Keep a product inventory of the types and quantities of chemicals stored at your facility. Let your emergency response plan reflect peak season storage. The primary information in the product inventory includes the product names, container volumes, and locations of containers in the storage facility. Also, keep copies of pesticide labels, MSDS, and a description of protective equipment that may be required for the chemicals in storage. Keep a set of these documents at a separate site away from the storage area.
- Keep an inventory of emergency equipment and supplies you have available on site, including:

Do you know where your emergency equipment is?

Maintain an updated list of suppliers who can provide additional equipment and materials that may be needed in the event of an emergency.

The backbone of any emergency response plan is an outline of the exact sequence of actions to take in a crisis. Determine which situations you can handle on your own and which require outside help. Plan step-by-step procedures to respond to various emergencies, such as fires, spills, ammonia leaks, and transport accidents. Determine who is responsible for each specific task in the event of an



Develop a written emergency response plan.

emergency. Specify in writing every activity from sounding the alarm to directing the response agencies. Once internal emergency procedures have been established, be sure to share this information with local response agencies. Always keep a current plan on file with local response authorities.

Emergency response or contingency planning is the key to protecting every facility and the surrounding community from a potentially catastrophic situation.

FIRES

Pesticide products vary significantly in their flammability and storage hazard. Those requiring extra precautions usually include the label statement "Do not use or store near heat or open flame." Pesticides containing oils or petroleum solvents are the ones most likely to have these warnings, although certain dry formulations also present fire and explosion hazards.

A number of potential problems may be associated with pesticide fires:

- The pesticides may be highly flammable or explosive.
- The pesticides may give off highly toxic vapors or smoke that may harm firefighters, nearby residents, animals, or plants.
- Pesticide residues may be present in the debris and soil following a fire at a pesticide storage facility.
- Runoff from the fire site may contain highly toxic chemicals.

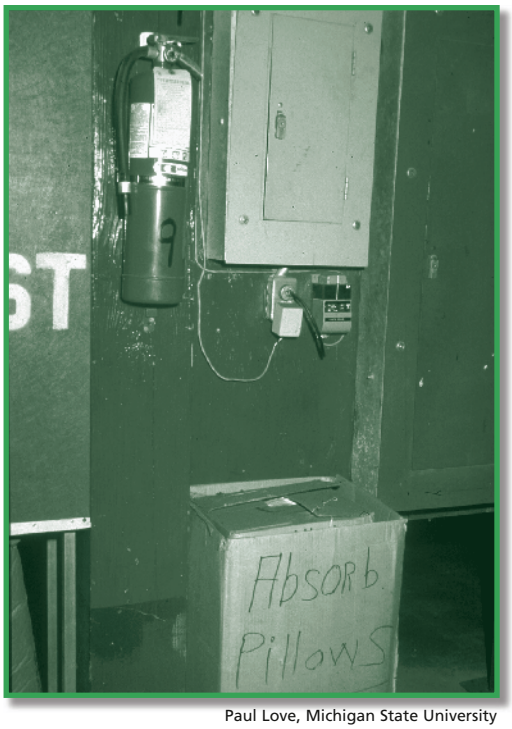
Precautions to Reduce Fire Hazards

- Locate the storage facility as far as possible from places where people and animals live.
- Keep the storage facility locked at all times.
- Post signs that indicate pesticides are stored in the facility.
- Store combustible pesticides away from steam lines and other heating systems.
- Do not store glass or pressurized containers in sunlight where they can concentrate heat and possibly explode or ignite.
- Install fire detection systems in large storage areas.
- Keep foam-type fire extinguishers approved for chemical fires in all storage areas.



Paul Love, Michigan State University

Install fire detection systems such as this sprinkler system with a sensor.



Paul Love, Michigan State University

Have a fire extinguisher approved for chemical fires readily available.



Edward Crow, Maryland Department of Agriculture

Post signs that indicate pesticides are stored in the facility.

- Notify the local fire company of the location and contents of the storage facility.
- Develop an emergency plan and train all workers in its execution.
- Keep a written inventory of the pesticides held in storage and file the list away from the storage facility.

Prompt and responsible action is essential in the event of a chemical fire. Emergency or contingency planning is the cornerstone of a responsible action plan. Coordinate all details on responding to a fire with local emergency response officials and review at least annually. Take the following actions in the event of a chemical fire:

- Evacuate the premises.
- Notify the fire department and inform the firefighters of the nature of the pesticides involved.
- Provide emergency response personnel with MSDS, which include technical and emergency information.
- Keep people away. Establish a security perimeter to discourage onlookers.
- If significant smoke is generated, evacuate all people and animals in the vicinity, especially those downwind.
- Contain small fires with fog, foam, or dry powder. If only water is available, use it as a fine spray or fog. Use only as much water as absolutely necessary. Do not use water jets because they can break bags and glass containers. Water used to fight pesticide fires may spread the contamination to the surrounding area.
- Check that water and spilled chemicals are being contained.
- For larger fires, consider withdrawing and allowing the fire to burn out. This option is preferred over using water to fight the fire, which can lead to widespread environmental contamination. If runoff water cannot be avoided, build dikes to contain the contaminated water.
- Clean and dispose of equipment and all clothing. All personnel involved should shower after fighting the fire.

After the fire, do not attempt cleanup and salvage operations until the area has cooled, and then, under expert supervision only.



J. Ples Spradley, University of Arkansas

A National Fire Protection Association (NFPA) warning on a storage box for fumigants. The strikeover on the letter W in the white diamond alerts firefighters not to use water to put out a fire.



Purdue Pesticide Programs

Emergency responders conducting a mock emergency drill at a facility.



Pat Hipkins, Virginia Tech Pesticide Programs

Cleanup and salvage operations after a fire must be done under expert supervision after everything has cooled.

PESTICIDE SPILLS

A spill is any accidental release of a pesticide. The spill may be a minor one involving only a few leaking containers, or it may be a major accident in which a piece of equipment malfunctions and releases its contents, or a tank truck or rail car overturns and spills its cargo. All users of pesticides must be thoroughly familiar with the laws and guidelines governing chemical spills. The inability to respond properly to such an emergency, no matter how minor the problem, could seriously endanger public health and environmental quality.

The suggested guidelines in the event of a chemical spill are known as the three Cs: **CONTROL** the spill, **CONTAIN** it, and **CLEAN** it up.



Tom Bowman, Virginia Tech Pesticide Programs

Clean up all spills immediately.

The Three Cs

Control
Contain
Clean up the Spill

Control the Spill

Take immediate steps to control the release of the products being spilled. If a sprayer has tipped over, if a pesticide is leaking from a damaged tank truck, or if a container on a storage shelf is leaking, do whatever you can to stop the leak or spill at once. For instance, smaller containers can be put into larger containers to prevent further release of the chemical. For larger leaks, try to plug the leak, if possible. Outside assistance often is required to control large leaks.

Never expose yourself unnecessarily to leaking chemicals—always wear protective equipment when attempting to control a leak. Never charge in blindly if someone is injured; first, make sure you are properly protected.

A cellular phone must be standard equipment on every vehicle transporting pesticides. Alert the state and local police if the spill occurs on a public highway. Contact the appropriate state regulatory agency (or agencies) if the chemical is a pesticide. In certain cases, it may be necessary to alert the fire department, public health officials, and/or the nearest hospital emergency room. Be sure to have the product label and MSDS available for emergency responders.



Adapted from OSU *Applying Pesticides Correctly*

Wear appropriate PPE when cleaning up a spill.

If the spill is large or dangerous, have someone get help. Do not leave the site unattended. Operators need radio or telephone communication available in the vehicle in case they need to call for assistance. The first contact you make in case of a spill is to your county emergency management office, which can help coordinate the emergency response. In addition, CHEMTREC provides access to emergency response information and technical assistance from chemical industry experts. CHEMTREC's emergency phone number is 1-800-424-9300. ***This number is for emergency assistance only.***

A very important number is the emergency telephone number found on many product labels and on transportation or shipping papers. The lines are answered 24 hours per day by people who are prepared to handle pesticide emergencies involving the company's products.

For emergency response information call:

CHEMTREC

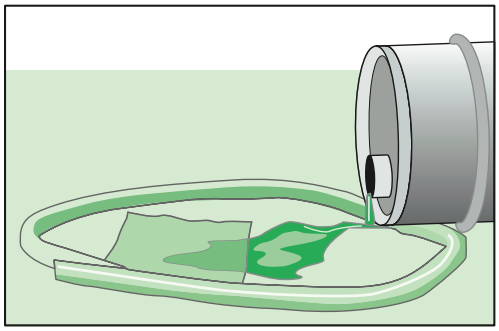
1-800-424-9300

Rope off the contaminated area; keep people at least 30 feet away from the spill. Avoid contact with any drift or fumes that may be released. Do not use road flares if you suspect the leaking material is flammable. At times it may be necessary to evacuate people downwind from the spill.

Contain the Spill or Leak

At the same time the leak is being controlled, contain the spilled material in as small an area as possible. Do everything possible to keep it from spreading or getting worse. In some situations, you may need to use a shovel or power equipment to construct a dike or dam. The important thing to remember is ***do not let the spilled material get into any body of water,*** including storm sewers or drains.

If the chemical does contaminate a stream, pond, or any other waterway, immediately contact the state agency responsible for streams and fisheries and the agency for pesticide regulation. Also notify the local emergency planning coordinator if the pesticide spilled is listed as an extremely hazardous substance and exceeds the reportable quantity (RQ) (see SARA Title III, Appendix D). Do not delay in notifying authorities because they must alert downstream users as soon as possible to prevent accidental poisoning of livestock and to avoid contamination of irrigated crops and soil.



Take action to prevent spills from spreading. In this case, an absorbent spill tube is used to contain the spill.

You can further contain liquid spills can be further contained by spreading absorbent materials such as fine sand, vermiculite, clay, or pet litter over the entire spill. Avoid using sawdust or sweeping compounds if the pesticide is a strong **oxidizer** (see label or MSDS) because such a combination presents a possible fire hazard. In addition, nonspecific absorbent materials packed in pillows, tubes, or pads can be placed directly on the spill or used to dike around the spill area. Waste disposal is then simplified because the contaminated pillows, tubes, or pads can be placed into heavy-duty disposal bags without dust or spillage. Keep adding absorbent material to the contaminated area until all the liquid is soaked up.

National Fire Protection Association

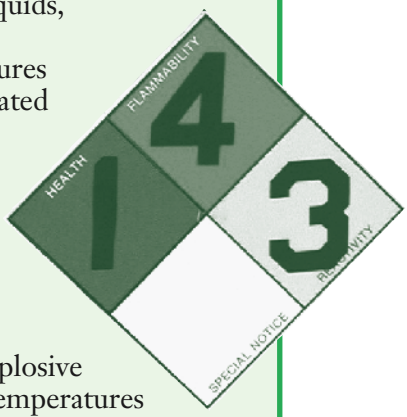
A hazardous rating system used to assist emergency response personnel is the NFPA Hazard Identification System. This system uses a diamond-shaped warning symbol. The top, left and right boxes refer to flammability, health, and instability hazards, respectively, and each contains a number from 0 to 4. 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 temperatures
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



Adapted from OSU *Applying Pesticides Correctly*

Use an absorbent material to help clean up a spill.

In the case of dust, wettable powder, or granular spills, you can reduce spreading by lightly misting the material with water or covering the spill using some type of plastic cover. Discard the cover after use. Disposal of all hazardous wastes must be done in strict accordance with state and federal laws (see RCRA, Appendix D).

Clean Up the Spill

Once the spill has been contained, sweep it up and place it in a steel or fiber drum lined with a heavy-duty plastic bag. It may then be necessary to decontaminate or neutralize the area. Use ordinary household bleach in water (approximately 30 percent bleach), hydrated lime, or a commercial decontamination preparation to help neutralize the spill area. Remember to wear protective equipment. ***Do not use bleach and lime together.*** Work this cleaning material into the spill area using a coarse broom. Then add fresh absorbent material to soak up the now contaminated cleaning solution. Sweep up this material and place it in a plastic bag or drum for disposal. It will be necessary to repeat this procedure several times to ensure that the area has been thoroughly decontaminated.

The only effective way to decontaminate soil saturated with a pesticide is to remove the top 2 to 3 inches of soil. This contaminated soil is now considered hazardous waste and must be disposed of according to state guidelines. Once the contamination has been removed, cover the area with at least 2 inches of lime, and finally, cover the lime with fresh topsoil. Soils contaminated as the result of application errors or minor spills can sometimes be cleaned up by applying activated charcoal to the contaminated surface immediately after the spill or misapplication. The charcoal may adsorb or tie up enough chemical to avoid significant plant injury and long-term contamination. However, application of activated charcoal to areas where large spills have occurred does little to reduce soil contamination and subsequent plant damage.

Clean any vehicles and equipment that were contaminated either as a result of the original accident or during the cleanup and disposal procedures. Before you begin, be sure you are properly clothed and protected to avoid contact with the chemical. Use ordinary household bleach in water (approximately 30 percent bleach) or an alkaline detergent (dishwashing soap) solution to clean your equipment. ***Do not mix bleach and alkaline detergent together.*** Equipment such as brooms, leather shoes, and cloth hats cannot be effectively decontaminated and must be discarded. Also, do not save disposable garments and gloves or badly contaminated clothing. As soon as you are



Purdue Pesticide Programs

Keep emergency supplies and a shovel on hand.

finished with the spill and equipment cleanup, wash yourself thoroughly with soap and water. Wash any part of your skin that might have been exposed, and always wash your face, neck, hands, and forearms.

For legal protection, it is advisable to keep records of your activities and conversations with regulatory authorities, emergency response personnel, and the general public when dealing with a pesticide spill. Photographs help document any damage as well as the cleanup process.

Prevent Spills

A key to preventing pesticide spills is to maintain all vehicles and application equipment properly. Leaks and drips from cracks or loose fittings in equipment are indications of potential trouble. An understanding of how spray equipment works, especially a pumping system, is often essential to controlling the flow of a product and minimizing equipment damage. Safe driving and other good operating habits further reduce the likelihood of a spill.

Keep a spill cleanup kit readily available whenever you handle pesticides or their containers. Also maintain a spill kit at the business location where pesticides are mixed, loaded, and stored, and on each vehicle that transports pesticides. If a spill occurs, you will not have the time or the opportunity to find all of the items.

Include the following in a kit:

- Telephone numbers for emergency assistance.
- Sturdy gloves, footwear, and apron chemically resistant to most pesticides.
- Protective eyewear.
- An appropriate respirator, if any of the pesticides require the use of one.
- Containment tubes or pads to confine the leak or spill.
- Absorbent materials, such as spill pillows, absorbent clay, sawdust, pet litter, activated charcoal, vermiculite, or paper for liquid spills.
- Sweeping compound for dry spills.
- A shovel, broom, and dustpan.
- Heavy-duty detergent.
- A fire extinguisher rated for all types of fires.
- Any other spill cleanup items specified on the labeling of any products you use regularly.
- A sturdy plastic container that holds the quantity of pesticide from the largest pesticide container being handled and that can be tightly closed.

Store spill kit items in a plastic container and keep them clean and in working order until needed.

The faster you can contain, absorb, and dispose of a spilled or leaking chemical, the less chance that it will cause harm.

Do not leave the spill site until someone relieves you. Have someone present at the spill site continuously until the chemical is cleaned up and the danger removed. If the spill is indoors, get out of the building. Open doors and windows and set up a portable fan.

SUMMARY

To prepare for a pesticide emergency or incident, have a well-thought-out emergency response plan. Make sure the plan includes designating an emergency response coordinator, maintaining a list of emergency response agencies, preparing a map of the facility, keeping a product inventory of the types and quantities of stored chemicals, and knowing what emergency equipment and supplies are available. Be sure all employees at the facility are familiar with the emergency response plan and know the sequence of actions to take in a crisis.

Pesticide fires are of particular

concern because of the variable nature of pesticide products in a storage facility. Some products are more flammable than others and may even be explosive. The pesticides may give off vapors or smoke highly toxic to people, animals, and the surrounding environment. Actions to take in the event of a pesticide fire are a key component of any emergency response plan. It is important to know what products are stored and where. Emergency response personnel must be notified of the kind of pesticides involved so they can take appropriate action to protect themselves and the surrounding environment. In some cases it may be better to let a pesticide fire burn out rather than spreading the contamination by spraying the fire with water. Smaller pesticide fires can often be dealt with by using fog, foam, or dry powder.

When dealing with pesticide spills, it is important to remember **the three Cs—control, contain,** and **clean up** the spill. Immediate steps must be taken to control the release of products being spilled. Have emergency telephone numbers readily available in the case of a large or dangerous spill. It is important to try to contain the spilled material in as small an area as possible. This may involve constructing a dike or a dam around the spill area. It is critical to prevent the spill from entering any water source. Use absorbent materials such as fine sand, vermiculite, clay, pet litter, or absorbent materials packed in pillows, tubes, or pads to clean up liquid spills. Once the spill is absorbed, it can be swept up and placed in a steel or fiber drum lined with a heavy-duty plastic bag. Dry pesticide spills can be contained initially by lightly misting the pesticide with water and covering it with a plastic cover. The dry spill then can be swept up and discarded in the same manner as a liquid spill.

The best way to manage pesticide spills is to prevent them from happening in the first place. Always keep a spill cleanup kit available wherever pesticides are handled. All persons using or transporting pesticides and other hazardous chemicals have a responsibility to protect the public and the environment. Doing everything possible to avoid spills and adhering to a few basic guidelines when handling spills and leaks can go a long way toward fulfilling that responsibility.

Review Questions

CHAPTER 9: EMERGENCY OR INCIDENT RESPONSE

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

1. **Which statement about emergency response planning is *true*?**
   - **A.** Your emergency response plan should reflect only the off-season inventory of pesticides stored at your facility.
   - **B.** As long as you have an emergency response plan at your facility, it is not necessary to designate an emergency response coordinator.
   - **C.** In the event of an emergency, the first person to contact would be your attorney.
   - **D.** It is important to keep with your emergency list an outline of the information that should be passed along during an emergency notification call.

2. **What is the backbone of any emergency response plan?**
   - **A.** Outlining the sequence of actions to take in a crisis.
   - **B.** Having a pesticide inventory readily available.
   - **C.** Knowing where copies of labels and material safety data sheets are kept.
   - **D.** Keeping an inventory of emergency equipment and supplies on site.

3. **Which is *not* a recommended action to take in the event of a fire involving pesticides?**
   - **A.** Construct dikes to contain contaminated runoff water.
   - **B.** Notify the fire department and inform the firefighters of the nature of the pesticides involved.
   - **C.** Contain small fires with fog, foam, or dry powder.
   - **D.** Use water jets to put out the pesticide fire.

4. **Which would *not* be an action to take in the case of a pesticide spill?**
   - **A.** Rope off the contaminated area, keeping people at least 30 feet from the spill.
   - **B.** Contain liquid spills by spreading absorbent materials such as fine sand, vermiculite, clay, or pet litter over the entire spill.
   - **C.** Use sawdust or sweeping compounds to control pesticides that are strong oxidizers.
   - **D.** Use absorbent pillows or tubes to dike around the spill area.

5. **Which statement is *true* about proper cleanup procedures for pesticide spills?**
   - **A.** Remove the top 1 inch of soil to decontaminate soil saturated with a pesticide.
   - **B.** Sweep up the absorbed chemical and place it in a steel or fiber drum lined with a heavy-duty plastic bag.
   - **C.** Use bleach and lime together to clean up spill areas.
   - **D.** Use charcoal briquets to reduce soil contamination and subsequent plant damage.

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CHAPTER 10

PLANNING THE PESTICIDE APPLICATION

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to select appropriate pesticides and additives.
- Know how to review pesticide label information and understand the legal restrictions pertaining to an application, including avoiding non-target organisms and surfaces.
- Know how to determine if two or more pesticides may be tank mixed.
- Know how to follow the label for safe mixing and loading.
- Understand how to prevent contamination of groundwater, surface water, or irrigation water by pesticides during mixing, loading, and cleaning.
- Know what PPE to wear during mixing, loading, and cleaning.
- Know how to measure pesticides accurately using the proper measuring device.
- Know how to open pesticide containers and transfer contents safely.
- Know how to rinse and dispose of pesticide containers properly.
- Know how to ensure that the pesticide is being applied correctly.
- Know how to clean and properly store application equipment after use.



Careful planning and consideration of all details are necessary before starting a pesticide application. Planning the pesticide application requires knowing how to select the appropriate pesticide for the job and then carefully reviewing the label. Other factors involved in correct pesticide application procedures include knowing how to test for pesticide compatibility prior to mixing; what PPE to wear during mixing, loading, and cleaning; how to transfer pesticide contents safely; and how to clean up after an application.

SELECTING THE PESTICIDE



Tom Bowman, Virginia Tech Pesticide Programs

Always read the label before applying the pesticide.

Before selecting a pesticide for a particular application, you need to know whether it is the right pesticide for your particular pest management needs, whether the pesticide can be used safely under your application conditions, and how much product you need for the area you are treating.

Before applying the pesticide, read the label to determine:

- What safety measures must be followed.
- Where you can legally use the pesticide (e.g., target sites).
- When to apply the pesticide. Consider such factors as the life cycle of the pest, weather conditions, the preharvest and grazing interval, and the rotational or replanting interval.
- How to apply the pesticide properly (including selecting equipment and following label directions).
- If any special use restrictions apply, such as reentry into a treated area or prohibitions against certain types of application methods or equipment.
- Whether restrictions apply on the use of the pesticide, such as environmental conditions, setbacks or buffers, and drift warnings.

Some labels call for the addition of an adjuvant (or additive) to the spray mixture. This may be an **emulsifier,** which allows two unlike liquids (such as oil and water) to be uniformly mixed; a **spreader** or **surfactant** to allow for more thorough coverage over the target plant or insect; a **sticker** to help keep the pesticide on the treated site longer; or a **penetrant** to help the pesticide pass through the outer surfaces of plant leaves and stems or insect cuticle. **Drift control additives** increase the size of the spray droplets. **Defoaming agents** eliminate foam in the spray tank. Other types of additives include **invert emulsifiers** and **buffers.** (See Chapter 4 for a more detailed discussion of spray adjuvants.)

REVIEWING THE PESTICIDE LABEL

It is important to review the label carefully. Immediately under the heading ***Directions for Use*** is the statement: ***It is a violation of federal law to use this product in a manner inconsistent with its labeling.*** This statement, which must appear on all EPA-registered pesticide products, emphasizes that the pesticide must be used as directed on the product label.

The directions for use indicate the various crops, animals, or sites on which you may legally use the pesticide. It is important to follow the use instructions on the label for the specific crop, animal, or site being treated. Under the subheading for specific crops, sites, or animals to be treated, the label lists the target pests, application rates, and general application methods. Also consult the label on proper storage and disposal of the pesticide and empty containers.

COMPATIBILITY OF PESTICIDES

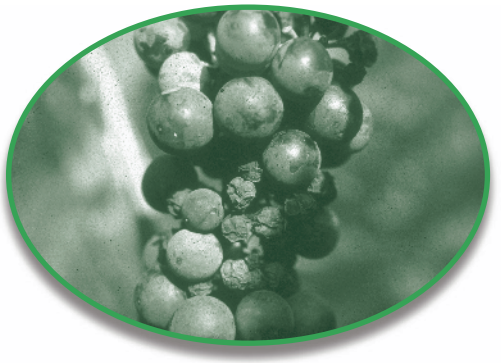
Tank mixing two or more pesticides saves time and labor and reduces equipment and application costs. In some cases, however, it can alter the effectiveness of one or more of the products.

Two or more pesticides are considered **compatible** when they can

be mixed and applied in combination without adversely affecting the effectiveness or the physical and chemical properties of the mixture, or causing undesirable damage to the application site. When problems develop from mixing two or more products together, the chemicals are considered **incompatible.** Incompatibility can be a matter of timing or placement of the pesticides. Chemical or physical incompatibility may occur between the pesticides.

Timing incompatibility occurs when two or more pesticides are not equally effective in controlling pests at the time of application. For example, a preemergence herbicide applied to control germinating weed seeds would be incompatible with a herbicide best applied just after the emergence of weeds later in the season.

Placement incompatibility occurs when two or more pesticides need to be handled by different application methods, even though the timing is the same. For example, some herbicides must be incorporated into the soil, while others must remain on the soil surface.



In this example of timing incompatibility, a mixture of a fungicide and insecticide was applied at the same time. The insecticide was applied at the right stage of development to control a moth pest but the fungicide was applied too early to control the fungal disease on grapes.

Physical incompatibility is the failure of the products to stay uniformly mixed in the spray tank. Physical incompatibility may result in a putty or paste formation, a separation into layers, or a cottage cheese-looking mixture (precipitates) that may clog screens and nozzles and be useless in controlling target pests.

Physical incompatibility may be caused by improper mixing procedures, inadequate agitation, lack of stable emulsifiers in some emulsifiable concentrates (EC), or the combination of incompatible products. Physical incompatibility problems may also occur when mixing combinations of pesticides with liquid fertilizers. Some ECs are not stable in saline solutions such as fluid fertilizers. A few pesticides are available in special fertilizer-grade formulations that reduce compatibility problems. Other physical incompatibility problems may occur when pesticides are mixed with hard water (water with a pH greater than 7.0). When wettable powders (WPs) and ECs are improperly mixed in a tank, a putty or paste may form at the bottom, or an oily layer may float to the top of the mixture.



Physical incompatibility results in an unsprayable mixture, in this case, excessive foaming.

Chemical incompatibility occurs when mixing certain pesticides in the spray tank alters the activity of one or more of them. In other words, a chemical reaction takes place. The resulting mixture is different from the products applied separately. There are two types of chemical incompatibility. In the first type, the pesticidal activity of at least one of the components is reduced when two or more products are mixed. This is more likely to occur when the applicator is using hard water, chlorinated water, or fertilizers in the mixture. Before using a new water source or adding fertilizer, check the compatibility with the pesticides you are using (see "Conducting a Physical Compatibility Test"). In the second type, the activity of two or more products applied together may be greater than if the individual pesticides were applied separately. This added effectiveness can result in losing the selective nature of the individual products and may cause undesirable damage.



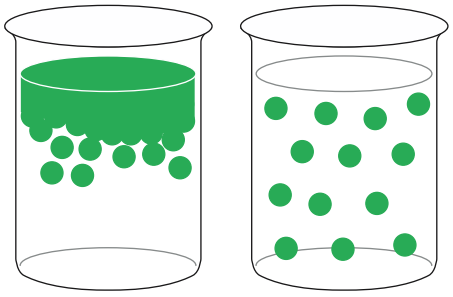
In this case of chemical incompatibility, mixing pesticides reduced their effectiveness, allowing weeds to grow along with the corn.

Pesticide labels may provide directions for avoiding chemical incompatibility in the spray tank. If product mixtures are known to tank mix without concern, the

label may specifically mention this. When mixing chemicals that are not listed as compatible products on the label, determine whether the products are chemically and physically compatible before mixing them in the spray tank. Remember, it is illegal to mix pesticides with other products (for example, other pesticides, adjuvants, or carriers) when such mixtures are expressly prohibited on the label.

Conducting a Compatibility Test

The best way to determine if products can be tank mixed is to read the label. Most labels, however, do not indicate whether products can be safely mixed. In this case, use a jar test to test for chemical and physical incompatibility. To conduct a jar test, use a small glass or plastic container and mix proportionate amounts of all the carrier and products you intend to mix in the spray tank. Start by filling the jar one-fifth to one-half full with the carrier (water or liquid fertilizer). Then add proportionate amounts of each of the products, one at a time, in the order suggested under "Making Tank Mixes." Shake the jar thoroughly after each product is added. Allow the mixture to stand for 10 to 15 minutes. If flakes, sludge, gel, precipitates, or other solids form, if the products separate into layers, or if heat is given off, the products cannot be safely tank-mixed. In some cases, adding compatibility agents may improve the mixing of the ingredients.



Adapted from *The Safe and Effective Use of Pesticides,* University of California

A jar test indicates whether two or more pesticides can be safely mixed.

Making Tank Mixes

To minimize compatibility problems with tank mixes, follow correct mixing procedures. The usual method for tank mixing pesticides is to fill the spray tank one-fifth to one-half full with the carrier (usually water or liquid fertilizer) before adding any pesticide or adjuvant. Then begin agitation. If the label calls for a compatibility agent like a buffer, add it before other products. Add and thoroughly mix the products, one at a time, beginning with those hardest to mix. Generally, dry products such as wettable powders (WP), dry flowables (DF), or water-dispersible granules (WDG) are added first to produce a suspension in the tank. Then add liquid suspensions such as flowables (F)/liquids (L), and microencapsulated (ME) formulations. Next, add the solution (S) and soluble powder (SP) formulations. Add any surfactant or other adjuvant after the suspension and solution products. Be careful and always add the emulsion products (EC) last.

Thoroughly mix each product before adding the next one. To ensure thorough mixing of dry formulations before adding them to the mixture, make a preslurry—mix them with a little water to form a paste before adding them to the tank mix. To make certain you have a uniform spray mixture at all times, keep the mixture agitated during the entire application until the tank is empty.

Tank Mixing Order

1. Fill tank one-fifth to one-half full with carrier (water or liquid fertilizer). Start agitation.
2. Add compatibility agent (if needed).
3. Add suspension products: first, dry formulations—wettable powders (WP), dry flowables (DF), water-dispersible granules (WDG) (as a preslurry, if necessary), then liquids—flowables (F), liquids (L), microencapsulated (ME).
4. Add solution products—solutions (S), soluble powders (SP).
5. Add surfactants or other adjuvants (if needed).
6. Last, add emulsion products—emulsifiable concentrates (EC).

SAFE MIXING AND LOADING PRACTICES

Handlers who mix and load concentrated pesticides have an especially high risk of accidental exposure and poisoning. Observe the following simple precautions to reduce the risks involved with this part of the job.

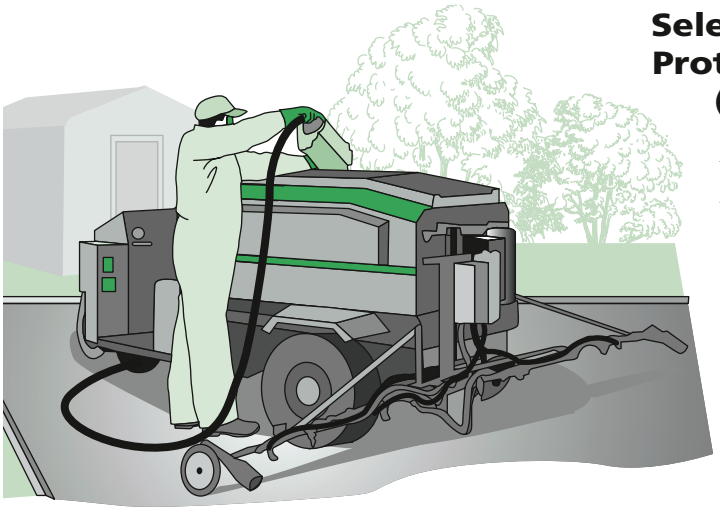


Jack Kelly Clark, University of California Statewide IPM Program

Observe all precautions when mixing and loading pesticides.

Select an Appropriate Mixing/Loading Area

Locate the pesticide mixing and loading area outdoors or indoors in a well-ventilated, well-lighted area away from unprotected people, animals, food, and other items that might be contaminated.



Locate the pesticide mixing and loading site outdoors or in a well ventilated area.

Protect Water Sources

When mixing, ensure that no tank mixture can back-siphon into a water source. When filling using a water pipe or hose, place the pipe or hose end well above the surface of the pesticide mixture, leaving a distinct air gap between the two. An air gap prevents contamination of the hose and keeps pesticides from back-siphoning into the water source if a drop or loss of water pressure occurs. 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. The backflow preventer has a mechanism that automatically closes if a drop or loss of water pressure occurs. Check valves are crucial for **chemigation** and similar systems where pesticides are injected into irrigation water.

Mix pesticides in areas where any spills, leaks, and overflows cannot flow toward a drain or into water sources. It may be necessary to use a containment pad (see Chapter 11). If using a permanent mixing and loading site, use a mixing/loading pad. When possible, mix and load the pesticides at the application site, being careful not to use the same site repeatedly and not to contaminate any water sources.



Purdue Pesticide Programs

Leave a distinct air gap between the hose and the surface of the pesticide mixture to prevent back-siphoning.



Purdue Pesticide Programs

Use a backflow device when water is pumped directly from the source.

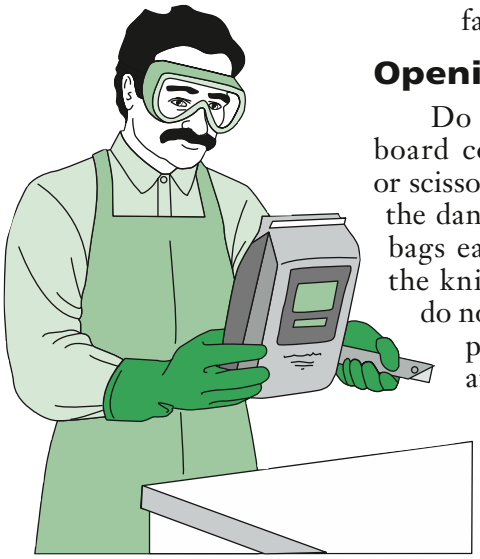
Select Personal Protective Equipment (PPE)

Put on the appropriate PPE before opening a pesticide container. Pesticide handlers must use all PPE that the pesticide labeling requires.

- **Body protection**—If splashing may occur during mixing or loading tasks, or if you come in direct contact with 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**— When pouring liquid pesticides or adding dry pesticides to a liquid, consider wearing a faceshield to keep splashes and dusts off the face, nose, and mouth.

- **Respiratory protection**— When handling pesticides, choose the appropriate respirator with the NIOSH code specified on the label. Also wear eye protection, such as shielded safety glasses, goggles, or a faceshield.



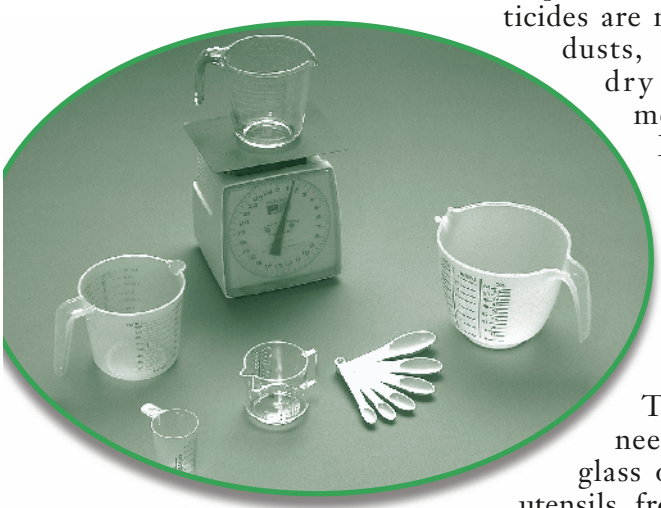
Use a sharp knife to open pesticide bags and wear appropriate PPE.

Opening Containers

Do not tear open paper or cardboard containers. Use a sharp knife or scissors to open them. This reduces the danger of spilling and also makes bags easier to close after use. 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 of the same pesticide, close the container tightly each time. Be sure to wear the appropriate PPE when handling pesticide containers.

Measuring

Liquids and some granular pesticides are measured by volume; dusts, powders, and most dry formulations are measured by weight. Pesticide labels use the English system of measurement—i.e., fluid ounces, pints, quarts, and gallons for liquids, and pounds and ounces for dry materials. The pesticide handler needs an assortment of glass or plastic measuring utensils, from 1 cup to 1 gallon, for accurately measuring liquids. Some pesticides react with metal, especially aluminum and iron, so avoid using metal measuring utensils. Use an eyedropper to measure small quantities of liquids. Use an accurate scale and a set of measuring cups and spoons for measuring and weighing dry pesticides. Mark each pesticide measuring item clearly to avoid using it for other purposes. To avoid accidental poisonings, paint handles with brightly colored waterproof paint or attach waterproof warning labels. When you are not using them, keep all measuring and weighing equipment and utensils locked in the pesticide storage area. After each use, clean and wash utensils before storing them to prevent contaminating future mixtures.



Jack Kelly Clark, University of California Statewide IPM Program

Accurately measure pesticides.

Transferring Pesticides

After measuring or weighing the correct amount of pesticide, carefully add it to the partially filled spray tank. When pouring any pesticide from its container, keep the container and pesticide below face level. If there is a breeze outdoors or strong air currents indoors, stand so the pesticide cannot blow back on you. Rinse the measuring container thoroughly and pour the rinsate into the spray tank. Use caution while rinsing to prevent splashing. Never leave the spray tank unattended while it is being filled.

When transferring wettable powders, dusts, or other dry formulations, avoid spillage and inhalation of dusts.



Virginia Tech Pesticide Programs

When transferring wettable powders, dusts, or other dry formulations, avoid inhalation of dusts.

CLEANING AND DISPOSING OF PESTICIDE CONTAINERS

There are two types of pesticide containers: **rinsable** and **non-rinsable.** Rinse empty rinsable plastic containers immediately because the residues can dry quickly and become difficult to remove. When rinsing, add the rinsate to the spray tank as part of the pesticide mixing process. **Triple-rinsing** 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 recycling or disposal.



Triple-rinse containers.

Adapted from Penn State *Pesticide Education Manual*

Non-rinsable containers include bags and boxes of dry pesticides and aerosol cans and cylinders. Empty them as completely as possible. Some containers are designed to be returned to the pesticide dealer or manufacturer for refilling.

If empty pesticide containers cannot be refilled, reconditioned, recycled, or returned to the manufacturer, crush, break, or puncture them to make them unusable except in the case of aerosol cans. Do not leave pesticide containers unattended at the mixing, loading, or application site—return them to a secured storage area until they can be recycled or disposed of properly. Dispose of containers in accordance with label directions and with federal, state, and local laws and regulations. Do not reuse pesticide containers or tamper with containers designed to be returned and refilled. Check with your state, territorial, or tribal pesticide regulatory agency to determine if your area has a container recycling program.



Larry Schulze, University of Nebraska

A pesticide container recycling center.

Container Rinsing Procedures

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 water under high pressure into the container. Check with your chemical dealer for availability of these nozzles. Studies have indicated that pressure-rinsing is as effective as triple-rinsing and it can take less time. Puncturing the container with the rinse nozzle also renders the container unusable.



Purdue Pesticide Programs

Pressure rinsing directs high-pressure water into the container.

To pressure rinse a container, wear

protective clothing, especially gloves and goggles or a faceshield, and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.
2. While holding the container over the spray tank in a draining position, push the pointed pressure-rinse nozzle through the side of the pesticide container.
3. Pressure-rinse the container for at least 30 seconds, draining the rinse water directly into the spray tank.
4. Thoroughly rinse the container cap with a slower flow of water, capturing the rinse water in the spray tank.

APPLYING PESTICIDES CORRECTLY

Applicators have several important responsibilities when applying pesticides—protecting themselves, others, the environment, and making sure the pesticide is applied correctly. Applicators must be sure to use the proper PPE and follow the correct application procedures.

Personal Protective Equipment (PPE)

By law, applicators must wear the PPE and other clothing the pesticide labeling requires. Consider using additional protection for some types of pesticide application tasks.

Hand-carried and backpack applications—Exposure is quite likely to occur when pesticides are applied using hand-held application equipment or dust shakers. Dripping or partially clogged nozzles, leaky hoses, or loose equipment connections are other potential sources of exposure. Consider wearing extra PPE to protect the areas of your body that will be in contact with the equipment.

Many applications performed while on foot cause the applicator to walk into the path of the pesticide being applied. Whenever possible, apply pesticides so 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 rubber boots, or other protective footwear with chemical-resistant pants. Wear appropriate protective clothing and equipment when entering treated areas to fix clogged nozzles or other malfunctioning equipment parts.



M.J. Weaver, Virginia Tech Pesticide Programs

Wear appropriate protective PPE whenever you must walk into the path of a pesticide application.

High-exposure applications—Certain types of pesticide applications pose a special risk because they may expose the applicator to large amounts of pesticide. These include:

- Mist blower or airblast sprayers.
- Aerosol and fog generators.
- High-pressure sprayers and power dusters.
- Equipment that directs applications over your head, such as to tree canopies or roof eaves.



Tom Bowman, Virginia Tech Pesticide Programs

This high pressure spray application in a Christmas tree plantation requires more PPE than the label has listed.

Pesticide exposure is quite likely whenever you are working in these situations. Therefore, consider wearing more PPE than the pesticide label requires. A chemical-resistant suit with a hood and gloves, footwear with sealed cuffs, and a full-face respirator or half-face respirator with sealed goggles can provide adequate protection for these high-exposure applications.

Pesticides are sometimes applied in enclosed spaces such as warehouses, factories, restaurants, and homes; railcars, and ship and truck cargo areas; silos, elevators, and other grain storage areas; and greenhouses. Applying pesticides in enclosed spaces increases the risk of inhalation and dermal exposure. Consider using a respirator and additional protective clothing even if you would not need it for the same application outdoors.

Application Procedures

To ensure pesticides are being applied properly, follow these basic procedures:

1. Before applying a pesticide, clear all people and pets from the area. Remove toys and pet dishes from the application area, and cover garden furniture, swimming pools, and birdbaths. 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 label to find out when they can go back into the application area. If the label does not include specific restricted-entry statements, keep people and non-target animals out of the treated area until the spray has dried or the dust has settled.
2. Take the time to be sure that the pesticide is reaching the surface or area toward which you are directing it. In the case of granules, make sure they are removed from non-target areas such as sidewalks.
3. Apply the pesticide evenly and in the correct amounts. Do not allow liquid pesticides to form puddles or dry pesticides to pile up in the application area. Be especially careful in areas where you turn or pause your equipment. You may have to shut off your equipment in these areas. After the pesticide is applied to the first part of the target site, check to be sure the correct amount of pesticide has been used.
4. Ensure that the pesticide maintains a uniform mix or appearance during the application. Several pesticide formulations mixed with liquid require agitation to remain in suspension. Granules and dusts should appear dry and not form clumps on the target site.
5. Check hoses, valves, nozzles, hoppers, and other equipment parts often during the application.
6. Turn equipment off when you pause for any reason. Agitation must be maintained if the spray mix is a suspension of particles (such as wettable powders, flowables, or dry flowable formulations). When you stop an application for any reason, depressurize spray tanks. Turn off the main pressure valve on the tank and release the pressure remaining at the nozzles.
7. Check the label for any postapplication requirements, such as incorporating the pesticide into the soil.

AFTER MIXING, LOADING, AND APPLICATION

After mixing, loading, or applying a pesticide, you need to perform a few important follow-up tasks. Take the time to clean the pesticide equipment and yourself properly. While the facts of the application are still fresh in your

mind, record all information about the application for future reference needs and to comply with all federal and state pesticide record-keeping laws.

Always clean all mixing, loading, and application equipment as soon as you finish. Do not leave equipment containing pesticides 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.

Instruct persons who clean pesticide-contaminated equipment on proper safety procedures. 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 same PPE that the labeling requires for making applications, plus a chemical-resistant apron or other appropriate protective equipment. Also consider wearing eye protection even if not required by the label.



USDA

Be sure to wear appropriate PPE when cleaning application equipment.

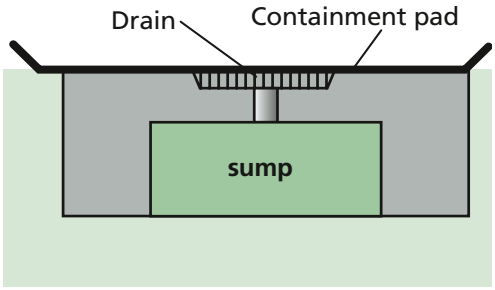
Cleaning Procedures

After the equipment is empty, clean both the inside and the outside thoroughly, including nozzles or hopper openings. Certain pesticides use a carrier (e.g., petroleum-based products) that may require special cleaning agents or high water pressure to get the equipment clean.

Collect rinsate and apply to a labeled site at or below labeled rates.

Rinsates—Rinsates from equipment that has been cleaned 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, storm sewers, wells, streams, lakes, or rivers. Collect rinsates and apply them to labeled sites at or below labeled rates. If possible, consider rinsing your equipment at the application site and applying the rinsate to the labeled site.

Equipment rinsate may also be used as a diluent for future mixtures of pesticides if:



A mixing and washing pad may require a sump that can be pumped out to collect rinsate after each use.

- 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 label rate for the target site.
- The rinsate is used to dilute a mixture containing the same or a compatible 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.

If rinsates cannot be used, dispose of them as you would waste pesticides.

Equipment cleanup—Clean your equipment thoroughly after each use or when changing chemicals. Pesticide residues in a spray tank may corrode metal, plug hoses, or damage pumps and valves unless they are removed immediately after use. Sometimes residues react with pesticides used later, reducing the effectiveness of the pesticides. Special tank-cleaning nozzles are available for cleaning the interior walls of spray tanks.

Thoroughly rinse equipment with a water-detergent solution (8 to 16 ounces of detergent in 30 to 40 gallons of water). Allow the water-detergent solution to circulate through the system for several minutes. Remove the nozzles and screens, and flush the sprayer system twice with clean water.

Sloppy cleanup practices are one of the main causes of equipment failure or malfunction. Pesticides allowed to dry in the application equipment tend to clump and stick and cannot be easily removed.

Several commercial compounds are available to aid in tank cleaning. These can neutralize and remove pesticide residues, remove mineral deposits and rust, and leave a protective film on tank walls to help prevent corrosion.

When preparing to store your sprayer, add 1 to 5 gallons of lightweight oil (how much depends on the size of the tank) before the final flushing. As water is pumped from the sprayer, the oil leaves a protective coating on the inside of the tank, pump, and plumbing. To prevent corrosion, remove nozzle tips and screens and store them in a can of light oil such as diesel fuel or kerosene. In addition, add a small amount of oil and rotate the pump four or five revolutions by hand to coat interior surfaces completely. Engines, whether air- or water-cooled, require additional servicing. Follow the directions in the owner's manual.

After thoroughly cleaning and draining the equipment, store it in a dry, clean building. Replace worn-out, deteriorated, or broken parts. If you store the sprayer outside, remove the hoses, wipe them clean of oil, and store them inside where they will not become damaged. When using trailer sprayers, you may want to put blocks under the frame or axle to reduce tire pressure during storage.

As with any procedure involving pesticides, remove contaminated clothes and take a shower immediately after cleaning equipment. Waiting until the end of the day to clean up can allow additional absorption of the pesticide through the skin. Never wear contaminated clothing under any circumstances. Keep contaminated clothing separate from other laundry and tell the person who washes the clothes of the possible hazards. Encourage him/her to wear protective gloves while doing the laundry. Dispose of contaminated clothing as hazardous waste if it cannot be decontaminated.



Take a shower immediately after using pesticides.

SUMMARY

Applying pesticides correctly requires careful planning. The user must be able to review and understand the label information to select the appropriate pesticide for the job. By law, the applicator must adhere to the label directions. Making tank mixes of pesticides can save time, labor, and costs. Labels do not always specify whether products can be tank mixed. Therefore, it is important that applicators know how to conduct a compatibility test to determine which products can be safely mixed. Following the appropriate tank mixing order can also help reduce compatibility problems.

Safe mixing and loading practices include selecting an appropriate mixing/loading area, protecting water sources, and selecting appropriate PPE. Be sure to open, measure, and transfer the pesticide as safely as possible and adhere to all label directions on mixing and loading. Pesticide users must also properly dispose of empty pesticide containers. Rinsable containers must be triple- or pressure-rinsed, disposed of, or recycled. Empty non-rinsable containers as completely as possible before disposing, recycling, or refilling.

Procedures must be in place to ensure pesticides are being applied properly. Remember, to protect yourself and the surrounding environment, wear the appropriate PPE and remove all people and pets from the area. Wear all the PPE required by the label. Consider wearing additional PPE under high exposure applications.

After mixing, loading, and applying pesticides, be sure to clean equipment and yourself properly.

Poor equipment cleanup practices may lead to equipment failures. To avoid environmental contamination, reuse application equipment rinsates used to clean as a diluent in a spray mixture containing the same or a compatible pesticide. Apply these rinsates to a labeled site at or below the label rate. Following these safety practices reduces exposure risks to the applicator and the surrounding environment.

Review Questions

CHAPTER 10: PLANNING THE PESTICIDE APPLICATION

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

1. **Determining *when* to apply a pesticide includes consideration of:**
   - **A.** The life cycle of the pest and weather conditions.
   - **B.** The percent active ingredient.
   - **C.** The need for additives or adjuvants.
   - **D.** What safety measures you should follow.

2. **The directions for use on a pesticide label indicate:**
   - **A.** The various crops or areas on which the pesticide may be legally used.
   - **B.** The disposal of pesticide waste.
   - **C.** The environmental, physical, and chemical hazards.
   - **D.** Treatment procedures in case of exposure.

3. **When two or more pesticides mixed together form a putty or paste, separate into layers, or look like cottage cheese, it is an example of:**
   - **A.** Timing incompatibility.
   - **B.** Placement incompatibility.
   - **C.** Chemical incompatibility.
   - **D.** Physical incompatibility.

4. **What is the usual order for tank mixing pesticides?**
   - **A.** Fill tank one-fifth to one-half full with carrier, add suspension products, add emulsion products, add solution products, add surfactants (if needed), add compatibility agent (if needed).
   - **B.** Fill tank one-fifth to one-half full with carrier, add compatibility agent (if needed), add suspension products, add solution products, add surfactants (if needed), add emulsion products.
   - **C.** Fill tank one-fifth to one-half full with carrier, add surfactants (if needed), add suspension products, add emulsion products, add solution products, add compatibility agent (if needed).
   - **D.** Fill tank one-fifth to one-half full with carrier, add suspension products, add emulsion products, add solution products, add compatibility agent (if needed), add surfactants (if needed).

5. **Which statement about the proper technique for opening pesticide containers is *true*?**
   - **A.** You should tear open paper or cardboard containers carefully.
   - **B.** Put on the appropriate PPE after the containers have been opened.
   - **C.** Use a sharp knife or scissors to open paper or cardboard containers.
   - **D.** Leave the container open until you are done mixing pesticides for the day.

6. **Which statement about measuring and transferring pesticides is *true*?**

   A. When pouring any pesticide from its container, keep the container and pesticide above face level.
   B. Metal measuring utensils are recommended over plastic.
   C. Most dusts, powders, and dry formulations are measured by volume.
   D. After adding the pesticide to the partially filled spray tank, the measuring container should be rinsed and the rinse solution poured into the tank.

7. **Which statement about cleaning and disposing of pesticide containers is *true*?**

   A. Do not puncture rinsed pesticide containers.
   B. When rinsing pesticide containers, pour the rinsate down the drain.
   C. Pesticide containers that cannot be recycled or returned to the manufacturer should be reused.
   D. Containers must be disposed of in accordance with label directions and federal, state, and local laws and regulations.

8. **Which statement about triple-rinsing and pressure-rinsing pesticide containers is *true*?**

   A. You must wear protective clothing for triple-rinsing but not for pressure-rinsing.
   B. Triple-rinsing requires the use of a special nozzle.
   C. Both triple-rinsed and pressure-rinsed containers are considered non-hazardous waste.
   D. Triple-rinsing is more effective than pressure-rinsing.

9. **Which statement about pesticide rinsates is *true*?**

   A. Rinsates may be applied to labeled target sites at or below labeled rates.
   B. Dispose of rinsates by pouring them down a sink or drain.
   C. Rinsates containing strong cleaning agents may be reused in pesticide mixtures.
   D. The amount of pesticide in the rinsate plus the amount of pesticide product in the new mixture may exceed the label rate for the target site.

10. **Which statement about pesticide equipment cleanup is *false*?**

    A. Several commercial pesticide tank-cleaning compounds are available.
    B. Sprayers should be thoroughly rinsed with a water-detergent solution for several minutes.
    C. When getting ready to store your sprayer, add some lightweight oil to the tank before the final flushing.
    D. Leave pesticide residues in the spray tank when changing products.

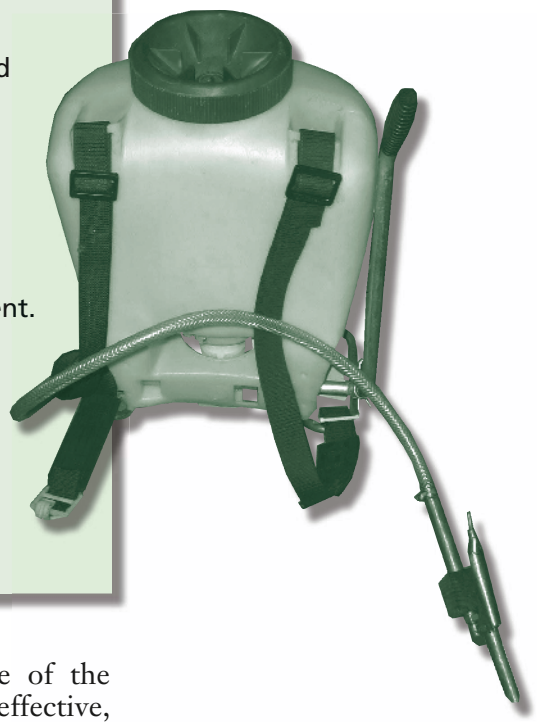
CHAPTER 11

PESTICIDE APPLICATION PROCEDURES

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to select the application procedure, equipment, and pesticide formulation appropriate to the situation.
- Know how to use appropriate safety systems (e.g., closed mixing and loading, enclosed cab, pesticide containment).
- Understand the factors (e.g., nozzles, volumes, pressures) that affect calibration.
- Understand the importance of calibrating application equipment.
- Know how to calculate the size of the application area.
- Know how to determine the pesticide application rate.
- Know how to determine the amount of pesticide concentrate and diluent to use.
- Know how to choose appropriate drift reduction practices.

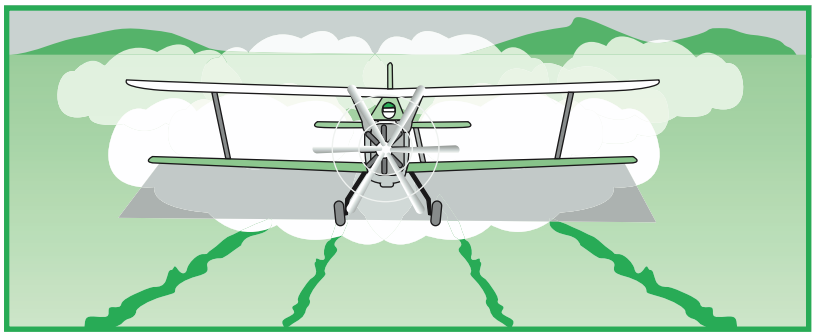


Today's pest management practices require modern equipment to apply a variety of pesticides. Pesticides may be applied as sprays, dusts, granules, gases (vapors), fogs, baits, rubs, or dips. The vast array of equipment on the market must be matched to the pesticide as well as to the size and type of the job to be done. To make an effective, safe, and efficient application, ***read the label first.*** In addition, the equipment must be properly selected, operated, calibrated, and maintained.

APPLICATION METHODS

The pesticide application method you choose depends on the nature and habits of the target pest, the characteristics of the target site, the properties of the pesticide, the suitability of the application equipment, and the cost and efficiency of alternative methods. Your choice is often predetermined by one or more of these factors. Following are some common application methods.

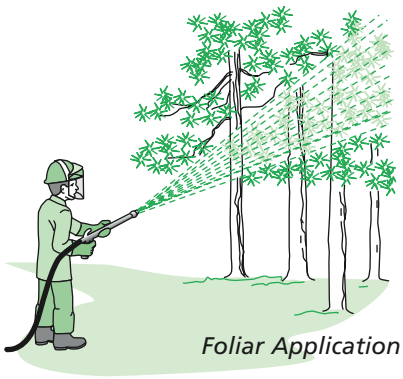
Band application involves applying a pesticide in parallel strips or bands such as between rows of crops rather than uniformly over the entire field.



Broadcast application



Crack and crevice application



Foliar Application

Basal application directs herbicides to the lower portions of brush or small trees to control vegetation.

Broadcast application is the uniform application of a pesticide to an entire area or field.

Crack and crevice application is the placement of small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets, where insects or other pests commonly hide or enter a structure.

Directed-spray application specifically targets the pests to minimize pesticide contact with non-target plants and animals.

Foliar application directs pesticide to the leafy portions of a plant.

Rope-wick or wiper treatments release pesticides onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds in an ornamental planting bed.

Soil application places pesticide directly on or in the soil rather than on a growing plant.

Soil incorporation is the use of tillage, rainfall, or irrigation equipment to move the pesticide into the soil.

Soil injection is the application of a pesticide under pressure beneath the soil surface.

Space treatment is the application of a pesticide in an enclosed area.

Spot treatment is the application of a pesticide to small, distinct areas.

Tree injection is the application of pesticides under the bark of trees.

SAFETY SYSTEMS

Closed systems...

- Increase handler safety.
- Reduce the need for some personal protective equipment.
- Decrease the occurrence of spills.
- Provide a more accurate measurement of pesticide concentrate, which reduces overdosing or underdosing.

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 handle pesticides that are very hazardous to humans or to the environment. These systems may be required for certain pesticides or for pesticide use in or near sensitive areas.

Closed Mixing and Loading Systems

Closed mixing and loading systems are designed to prevent pesticides 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 human health effects, may require the use of a closed mixing and loading system.

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 water-soluble packaging.

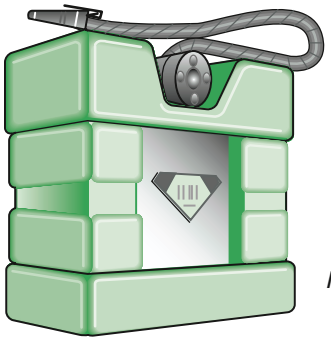
Mechanical Systems

Mechanical systems often consist of a series of interconnected equipment parts that allow for the safe removal of a pesticide from its original container. These systems minimize exposure when rinsing the empty container and transferring the pesticide and rinsate to the application equipment.

Closed mixing and loading systems are often custom-made with

components from several commercial sources. Because pesticide container openings vary in shape and size, no single closed system can be used with all containers. Closed systems are available for containers as small as 2.5 gallons. Mechanical systems are now available to remove the pesticide concentrate from the original container either by gravity or by suction.

A mechanical loading system is often used with **mini-bulk containers.** Mini-bulk containers range in volume from 40 to 600 gallons and are adapted to closed systems. The applicator can use the closed system to attach the mini-bulk tanks to the sprayer without exposure to the chemical. Typically, pump and drive units deliver the product, and a meter allows accurate measuring from the mini-bulk tank to the sprayer. These meters require frequent calibration to be accurate. Mini-bulks must be returned to the dealer for refilling. This process eliminates the need to triple- or pressure-rinse multiple small containers and reduces the volume of used plastic containers.



Mini-bulk tank.



Jack Kelly Clark, Univ. of California Statewide IPM Program

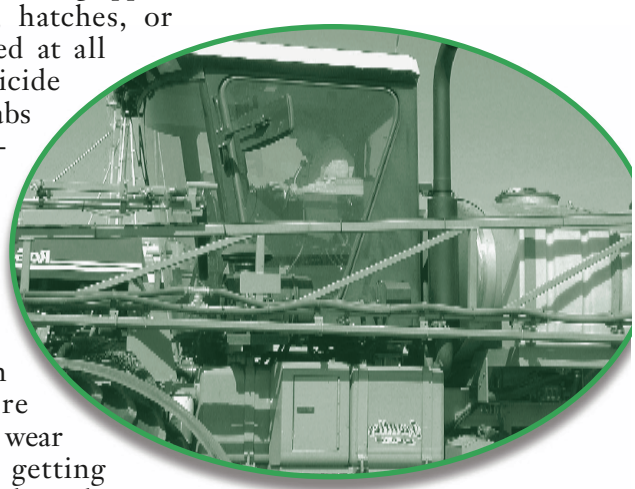
A closed loading system.

Water-soluble Packaging

Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or package. The pesticide bag is placed unopened into the mixing tank and dissolves in water or liquid fertilizer. Few manufacturers, however, provide water-soluble bags for small-volume applications.

Enclosed Cabs

An **enclosed cab**—such as a tractor cab, cockpit, or truck/vehicle cab—surrounds the occupant(s) and may prevent exposure to the pesticides being applied as long as any doors, hatches, or windows are kept closed at all times during the pesticide application. Enclosed cabs are considered a supplement to PPE, not a replacement for it. Wear all PPE specified on the label while working inside the enclosed cab. Remember, outside surfaces of the application equipment and cab are contaminated. Be sure to wear appropriate PPE when getting in and out of the cab and conducting maintenance.



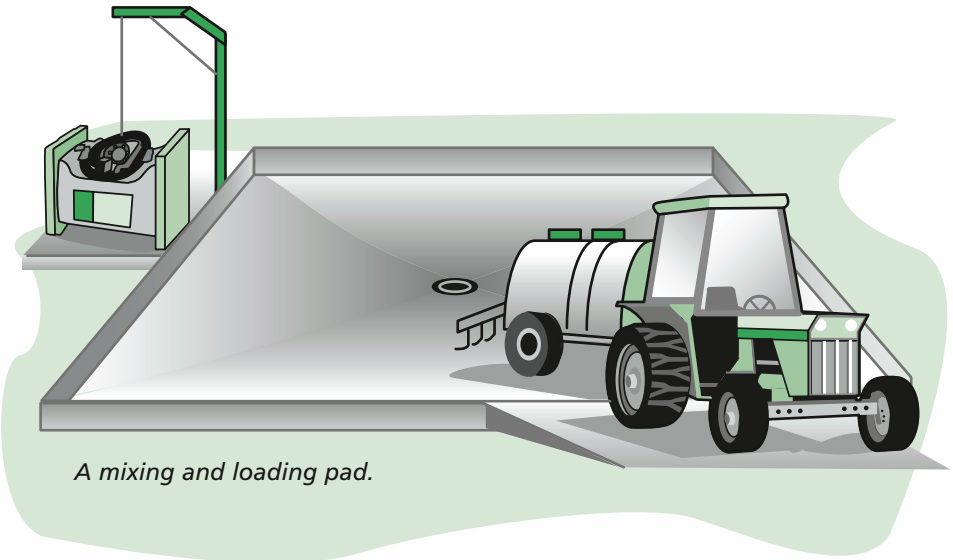
Larry Schulze, University of Nebraska

Enclosed cabs are considered a supplement to PPE, not a replacement for it.

Pesticide Containment Systems

If you often use the same location to mix and load pesticides or clean equipment, **a pesticide containment pad** may be necessary. These pads are designed to contain spills, leaks, overflows, and waste water for reuse by the applicator, or disposal by a commercial waste management contractor. If the spray tank contains pesticides, keep it on the pad. These pads make spills easier to clean up, and they may reduce pesticide waste by allowing the rinse water to be reused. They also help prevent environmental contamination.

Use a permanently installed containment pad for mixing, loading, and equipment cleaning; where large quantities of pesticides are handled or stored; and where 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,



A mixing and loading pad.

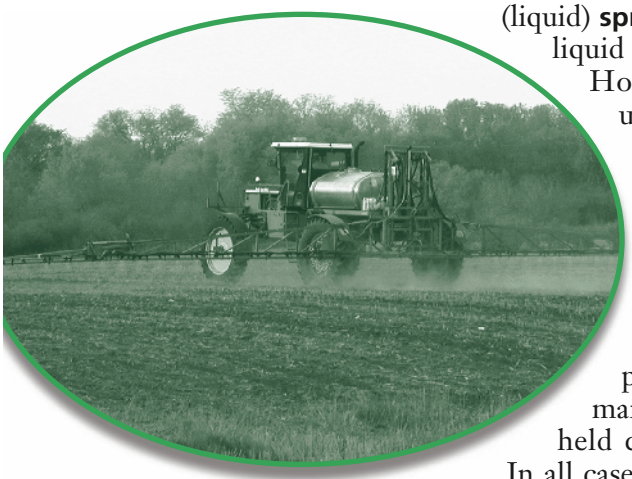
or no-wax sheeting. Construct a concave pad or one having curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to occur at the site. It also must be equipped with a system for removing and recovering spilled, leaked, or released material by either an automatic sump system or a manually operated pump. Smaller portable pads and lightweight trays made of heavy duty plastic may be used when mixing and loading at the application site.

APPLICATION EQUIPMENT

The application equipment or device must apply the pesticide to the intended target at the proper rate. Information on the label specifies the legal application rate and sometimes suggests the appropriate equipment for use with the product. The application equipment can range from an aerosol can to hand equipment to power equipment, including aircraft. The equipment may be carried, towed, or self-propelled.

Sprayers

The most common type of pesticide application equipment is the sprayer—nearly 90 percent of all pesticides are formulated for spraying. A **hydraulic** (liquid) **sprayer** uses water or other liquid carrier for the pesticide. However, in the case of ultra-low volume (ULV) spraying the pesticide is applied directly as formulated. Hydraulic sprayers range from large agricultural sprayers with multiple-nozzle **spray booms** and power sprayers to small manual backpack and hand-held compressed-air sprayers. In all cases, pressure from either a pump or compressed gas or air is used to atomize the spray mix at the nozzle.



Larry Schulze, University of Nebraska

A hydraulic sprayer with a spray boom.

Manual sprayers are designed for spot treatments and for areas unsuitable for larger units. They are relatively inexpensive, simple to operate, maneuverable, and easy to clean and store. Adjustable spray guns are commonly used with these units, but spray booms are available on some models.



Larry Schulze, University of Nebraska

A backpack sprayer is a type of hydraulic sprayer.

The **air-blast** (or mist) **sprayer** uses both water and air as carriers. The pesticide is diluted with water (except in ULV spraying). Spray droplets are formed by the nozzles and delivered to the target by an air stream. Air-blast

sprayers are typically used for disease and insect control on fruit trees, vineyards, vegetables, and Christmas trees.



M.J. Weaver, Virginia Tech Pesticide Programs

An air blast sprayer uses both water and air as carriers.

Sprayer Components

Because sprayers use water or other liquids to dilute and carry a pesticide, a **tank** is necessary to contain the spray mix. Use a tank large enough to eliminate frequent refills but not so large that the weight of the full tank becomes a problem. Choose a tank made of or coated with a material that does not corrode and can be easily cleaned. Corrosion and dirt clog screens and nozzles and increase wear on the equipment. Large tanks require an opening in the bottom to aid in the cleaning and draining. A large top opening is useful for filling, cleaning, and inspecting the tank. The opening must have a watertight cover to prevent spillage. A tank **agitator** is useful for most sprayable formulations but especially for wettable powders or dry flowables. Constant mixing of a pesticide and liquid carrier produces a uniform spray mixture (suspension or solution) resulting in an even application of the chemical.



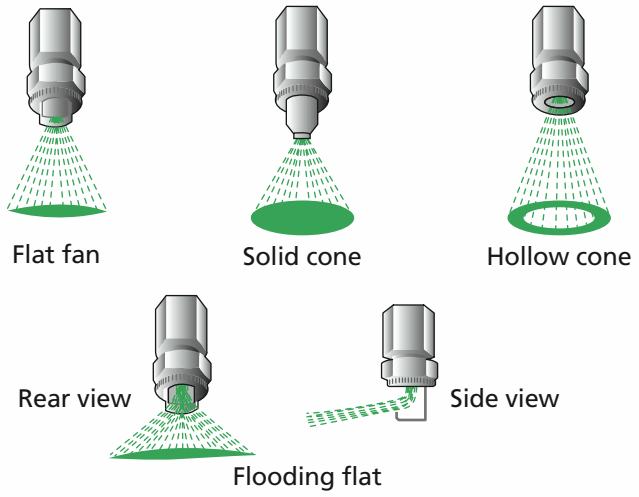
B. Hines, Michigan State University

A large capacity spray tank.

Sprayers require a **pump** to supply the needed pressure and volume to the nozzles and agitator. The pump parts must resist corrosion and be abrasion-resistant, especially when wettable powders or other abrasive formulations are used. Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Some pumps can be damaged if they are operated dry or with a restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and to prevent overheating.

Nozzles are a very important part of a sprayer. They control the amount of material applied, the formation of the droplets and their size, and the distribution and pattern of the droplets. A nozzle's spray pattern is made up of a wide variety of spray droplet sizes, from very fine to extra coarse. Nozzles are classified on the basis of the spray pattern and the droplet size they produce (see Figure 11.1). The size of the nozzle opening (**orifice**) affects the droplet size and flow rate. A nozzle that primarily produces coarse droplets is usually selected to minimize off-target drift. A nozzle that mainly produces fine droplets is required to obtain maximum surface coverage of the target. Base nozzle selection on the target pest, type of application, coverage desired, and potential for drift.

Figure 11.1 Nozzle Spray Patterns



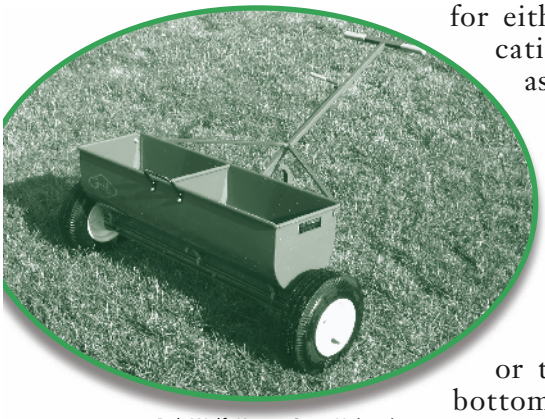
Nozzles are available in various materials including brass, aluminum,

plastic, stainless steel, hardened stainless steel, and ceramic. Select the nozzle material appropriate for the pesticide formulation. Never use brass or aluminum tips to apply abrasive materials such as wettable powders and dry flowables, because they wear too fast. Wear destroys the proper working of a nozzle, so replace worn nozzles. To reduce wear, use nozzle tips made of a hard, wear-resistant material such as hardened stainless steel or ceramic. Nozzles made of these materials are more expensive but last longer. Also, be sure you have the correct nozzle screen size for each nozzle.



Bob Wolf, Kansas State University

A rotary spreader.



Bob Wolf, Kansas State University

A drop spreader.

Granular Applicators

Granular applicators are available for either band or broadcast application. They may be operated as separate units but are often attached to other equipment such as planters or cultivating equipment to combine two or more operations. They usually operate by gravity feed and have an adjustable opening to regulate the flow.

Band applicators use hoses or tubes with deflectors on the bottom. Broadcast applicators use a system of tubes and deflectors or a spinner to spread the granules. The application rate is affected by the ground speed; granule size, shape, and density; field terrain; and even relative humidity and air temperature. When multiple band applicators are used, each individual unit must be calibrated with the specific material to be applied to ensure accurate application.

Rotary and **drop spreaders** are two common types of granular applicators. Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disk or fan. In a drop spreader, an adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed. Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.

Other Application Equipment

Additional types of application equipment include:

- Rubs, walk-through sprayers, and dipping vats for controlling pests on animals.
- Bait dispensers for control of rodents, insects, and predators.
- Foggers for indoor pest control and for some insect control outdoors.
- Chemigation systems for greenhouses and field crops.
- Dusters for small-scale disease and insect control.



Jack Kelly Clark, University of California Statewide IPM Program

Rubs are used for applying pesticides to livestock.



Jack Kelly Clark, University of California Statewide IPM Program

Dusters are used to apply dusts in confined areas.

EQUIPMENT CALIBRATION

Calibration is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area. The purpose of calibration is to ensure your equipment is applying the correct amount of material uniformly over a given area.

Equipment is manufactured to be adjustable. Charts or tables may be provided to assist the operator in making adjustments to the settings. These recommended settings, however, are only approximate and may not be appropriate for all situations. Therefore, your equipment must be calibrated periodically. This depends on the type of equipment and the frequency of use. The application rate of the sprayer is affected by travel speed, nozzle size, and sprayer pressure.

Equipment is calibrated by making a trial run on some premeasured area and measuring the output. For example, using a hand-held sprayer, spray a premeasured test area with water using the same pressure and techniques (i.e., travel speed and equipment) you would use when applying the pesticide. After spraying the test area, determine how much water was used. This volume can then be used to calculate the amount of water and pesticide needed to cover the intended application area.

The time invested in calibrating your equipment is time well spent. Accurate calibration to determine the application rate under your operating conditions is important for cost, efficiency, and safety.



M.J. Weaver, Virginia Tech Pesticide Programs

Calibrating a backpack sprayer.

Why Calibrate?

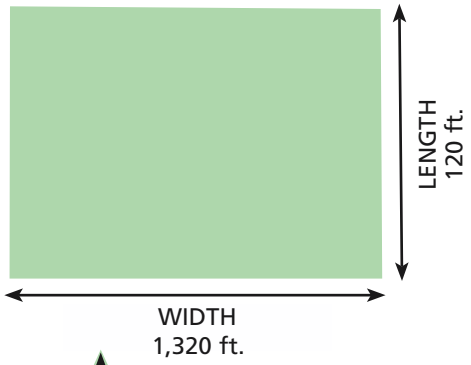
The purpose of calibration is to ensure that your equipment is applying the correct amount of pesticide material uniformly over a given area. Too little pesticide may fail to control the target pest. Too much pesticide is illegal and can result in damage to the treated plant, animal, or surface; can produce illegal residues on treated crops and animals; and can cause adverse effects to the environment and non-target organisms.

CALCULATING AREAS

For precise application, you need to know the size of the area to be treated. The following examples show how to determine the size of rectangular, triangular, and circular areas. See Appendix C—Conversions and Calculations.

Rectangular Areas

You want to apply a pesticide to an area that measures 1,320 feet by 120 feet. What is the area in square feet and in acres?



Area = length x width

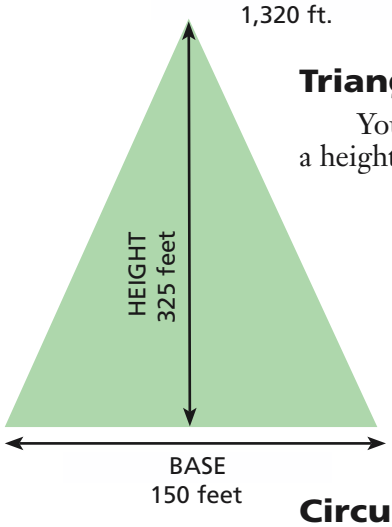
Area in square feet (sq. ft.)
1,320 ft. x 120 ft. = 158,400 sq. ft.

$$\text{Area in acres (A)} = \frac{158{,}400 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 3.6 \text{ A}$$

Note: 1 acre (A) = 43,560 sq. ft.

Triangular Areas

You are applying a pesticide to a triangular area that has a base of 325 feet and a height of 150 feet. What is the area?



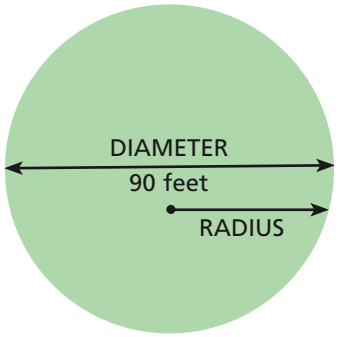
$$\textbf{Area} = \frac{\textbf{base x height}}{\textbf{2}}$$

$$\text{Area in square feet} = \frac{325 \text{ ft.} \times 150 \text{ ft.}}{2} = 24{,}375 \text{ sq. ft.}$$

$$\text{Area in acres} = \frac{24{,}375 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 0.6 \text{ A}$$

Circular Areas

If you have a circular area that has a 90-foot diameter, the radius (r) is 45 ft., what is the area?



Area = $3.14r^2$ ***Note:*** 3.14 (σ) is a constant. Radius is 1/2 diameter.

Area in square feet =

$3.14 \times 45^2 = 25{,}434 = 6{,}358.5$ sq. ft.

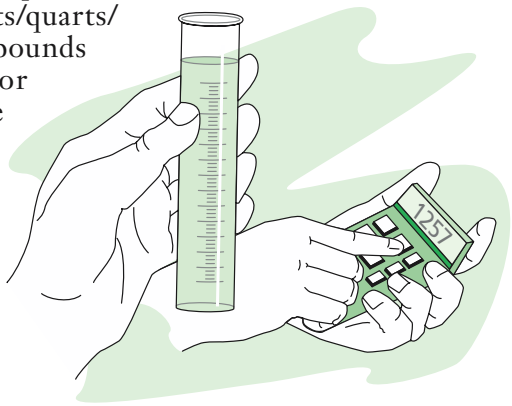
$$\text{Area in acres} = \frac{6{,}358.5 \text{ sq. ft.}}{43{,}560. \text{ sq. ft./A}} = 0.15 \text{ A}$$

CALCULATING THE APPLICATION RATE

Use the volume from your calibration test area to determine the amount of pesticide product and total spray mixture needed for your application area. First, convert your calibrated rate to one based on the area units found on the label. For example, when you calibrated the sprayer it delivered 2 gallons of water over a 250-square-foot test area. But you need to cover a 1,000-square-foot application area (i.e., four times the test area). You would then multiply 2 gallons of water by 4 to determine that you need to use 8 gallons of spray mixture to cover 1,000 square feet. Check the pesticide

label to determine the amount of pesticide to add to the spray mixture. For example, if the label recommends that 4 ounces of a liquid pesticide product be added to give a desired finished spray mixture of 1 gallon (there are 128 fluid ounces in 1 gallon), you add 4 ounces of product to 124 ounces of water. If you needed to apply a total of 8 gallons of spray mixture to cover 1,000 square feet, then you must use a total of 32 ounces (8 times 4 ounces) of pesticide product to 7¾ gallons of water. If the tank capacity of the sprayer is 4 gallons, then you need to fill up the tank twice, using 16 fluid ounces of product each time.

Labels vary how they recommend pesticide application rates. Some examples include ounces of product per 1,000 square feet, pints/quarts/gallons per 100 gallons, pounds of product per acre, or percent product in the tank. Be sure you understand how to calculate the correct amount of pesticide product and diluent needed before making the final mixture.



Calculate the application rate and measure the amount of pesticide needed.

Calculating the Application Rate

You determined from a calibration test that your boom sprayer delivered 10 gallons of water over a one-quarter (0.25) acre test area. You need to apply a pesticide product to a 10-acre field (43,560 square feet = 1 acre). The pesticide label recommends that 4 ounces of liquid product be added to give a desired finished spray mixture of 1 gallon (there are 128 fluid ounces in 1 gallon). How much spray volume and how much product are needed?

Step 1. How much spray mixture is needed for the 10-acre application area? Always use information from the calibration test. In this example, 10 gallons of water was used over a 0.25-acre calibration test area.

$$\frac{10 \text{ gallons}}{0.25 \text{ acre}} = \frac{Y \text{ gallons}}{10 \text{ acres}}$$

Cross multiplication:

$$Y = \frac{(10 \text{ gallons} \times 10 \text{ acres})}{0.25 \text{ acre}} = 400 \text{ gallons of spray mixture needed}$$

Step. 2. How much pesticide product is needed to make up 400 gallons of spray mixture? Use the label rate of 4 oz. product per 1 gal. spray.

400 gallons spray mixture x 4 ounces of liquid pesticide product per gallon = 1,600 ounces of product needed

Step 3. How many gallons of product are needed? Remember, 128 ounces = 1 gallon.

$$\frac{1{,}600 \text{ ounces of product}}{128 \text{ ounces/gallon}} = 12.5 \text{ gallons of product}$$

Final result: To treat 10 acres, you need a total final spray mix of 400 gallons that includes 12.5 gallons of the concentrated product.

TECHNIQUES FOR MINIMIZING DRIFT

Spray drift removes the chemical from the target, depositing the chemical where it is not intended. Application techniques and the equipment used greatly influence the amount of spray drift that occurs. Applicators must evaluate how their equipment is set up because off-target movement is affected by the type of nozzle, nozzle orifice size, sprayer pressure, and the height or distance of the nozzles from the target. It is important to review the pesticide label for specific information on drift reduction techniques or requirements. The applicator must also check weather conditions such as air stability, wind direction, and speed at the time and place of the application and follow all weather-related restrictions on the label.



Bob Wolf, Kansas State University

A wind meter is useful for determining when to spray.

Of the many nozzle types available for applying pesticides, several are specifically designed for reducing drift. Whenever practical, use large capacity (larger orifice) nozzles to minimize drift. The applicator uses the nozzle manufacturer's product guide to determine which nozzle and pressure combinations produce the desired range of spray droplet sizes. Select nozzles to give the largest droplet size that provides adequate coverage at the intended application rate and pressure.

In addition to the size of the nozzle orifice, newer features in nozzle design aid in drift reduction. Some new nozzle designs incorporate air into the spray to form an air-fluid mix. These air-induction nozzles, known as venturi nozzles, form a larger spray droplet, produce fewer fine particles, and provide energy to help transport the droplets to the target. These nozzles, however, require higher spray pressures (40 to 100 psi) to be effective. Even at these higher pressures, venturi nozzles still dramatically reduce the potential for drift.

Operating pressure also affects the droplet size and output volume of the sprayer. Doubling the pressure does not double the flow rate. To double the flow rate, you must increase the pressure four times. Pressure cannot be used to make major changes in application rate, but it can be used to correct minor changes because of nozzle wear. To obtain a uniform spray pattern and to minimize drift, keep the operating pressure within the recommended range for each nozzle tip. Exceeding the recommended pressure range often results in more drift potential. To maintain a proper spray pattern, adjust nozzles according to the manufacturer's recommendations on nozzle spacing and spray angle.



Pat Hipkins, Virginia Tech Pesticide Programs

A demonstration of a method to determine the uniformity of a nozzle spray pattern.

Spray height or distance from the target site is also an important factor in reducing drift. The closer the boom or spray nozzle is kept to the ground or target site, the less chance for drift; however, watch for pattern uniformity. For airblast sprayers, reduce drift by minimizing spraying over the canopy top, using the minimum air speed that can still give good penetration into the canopy, and considering the use of tower sprayers.

Another tool available for minimizing drift is the use of drift control additives. Tests indicate that the use of some drift control additives reduce

downwind drift deposits by 50 to 80 percent. Drift control additives are a specific type of chemical adjuvant. They must be mixed and applied according to label directions to be effective. Research, however, has shown that some products intended to reduce drift, in fact, result in more drift potential. Thoroughly evaluate drift control additives before adopting full use.

Using approved application techniques and adopting new technologies designed to reduce spray drift can improve the performance of spray mixes, benefit the environment, and be more cost-effective. Any one practice used alone may not sufficiently reduce drift. Therefore, incorporate as many drift-reduction techniques as practical into your spray program (Table 11.1).

Table 11.1. Recommended Techniques for Reducing Drift

Recommended Technique	Explanation
Follow label directions for reducing drift.	Read the label and reference the nozzle manufacturer's guide to determine which nozzle and pressure combinations are needed.
Select a nozzle to increase droplet size.	Large droplets are less prone to drift. Use the largest droplets that provide necessary coverage.
Increase nozzle size resulting in higher application volumes.	Larger capacity nozzles can reduce the amount of spray deposited off-target.
Consider using new technologies.	Drift-reduction nozzles (e.g., air-induction, venturi nozzles).
Lower boom height.	The higher the boom height is above the target, the greater the potential for drift. Lowering the boom height a few inches can reduce off-target drift.
Maintain appropriate travel speed.	High travel speeds may result in an unstable boom, high boom positions and increased drift potential.
Keep nozzle close to the target.	When using hand-held equipment, keeping the nozzle close reduces the potential for drift.
Avoid high application ground speeds or major speed changes across the field.	Speed changes may result in pressure adjustments causing droplet size variability. Sudden increases in speed may create high pressure that results in more drift potential.
Avoid applications during times of high wind speeds.	More of the spray volume moves off-target as wind increases. Wind currents can drastically affect spray droplet deposition.
Do not spray in the presence of a temperature inversion.	Temperature inversions prevent the dissipation of spray particles.
Consider using buffer zones/no-spray zones near sensitive areas.	Leave a buffer zone/no-spray zone if sensitive areas are downwind.
Use a drift-control additive when needed.	Drift-control additives increase the average droplet size produced by the nozzles. These additives, must not become your only drift reducing technique. They do not make up for poor spraying practices.

SUMMARY

To choose the appropriate pesticide application method, pesticide users must be aware of the nature of the target sites, pests, and available pesticides. Pesticide users must also be able to evaluate the cost and availability of both pesticide and non-pesticide control methods. This information can help in deciding which type of pesticide application procedure, if any, provides practical and efficient control.

Pesticide users must wear all safety equipment specified on the label during mixing, loading, application, and cleanup. The use of other safety systems also helps prevent pesticide exposures, spills, and environmental contamination. These include closed mixing and loading systems (mechanical systems and water-soluble packaging), enclosed cabs, and pesticide containment systems (containment pads).

Choosing the right application equipment is also an important factor in managing pests successfully. The equipment must be able to deliver the correct amount of pesticide to the intended target. A wide variety of pesticide application equipment is available, each suitable to a particular pest control situation. For example, on a small scale an aerosol can may be used to control household pests, while aircraft may be used to control mosquitoes or forest pests over a broad geographic area.

The most common type of application equipment used in pest management is the hydraulic sprayer. These range from small hand-held or backpack sprayers to large power sprayers. Applicators must understand the parts of the sprayer and how to adjust nozzles, spray volume, and pressure for reducing off-target drift. Spraying under the right weather conditions using proper application procedures can help reduce drift.

Calibrate sprayer and granular application equipment to ensure the correct amount of pesticide is being applied. Before making an application, be sure your equipment is properly calibrated and that you know how to use the label information to calculate the correct amount of pesticide.



Review Questions

CHAPTER 11: Pesticide Application Procedures

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

1. **Which type of pesticide application procedure involves the uniform application of a pesticide to an entire area or field?**
   - **A.** Broadcast application.
   - **B.** Band application.
   - **C.** Directed-spray application.
   - **D.** Basal application.

2. **Which type of pesticide application would you use to control cockroaches inside of buildings?**
   - **A.** Broadcast application.
   - **B.** Band application.
   - **C.** Crack and crevice application.
   - **D.** Basal application.

3. **An enclosed cab always provides enough protection from pesticide exposure to allow applicators to use less PPE than recommended on the label.**
   - **A.** True.
   - **B.** False.

4. **Which statement about containment pads is *true*?**
   - **A.** They should not be used if you mix and load frequently at the same site.
   - **B.** Pads make spill cleanup more difficult.
   - **C.** Pads should be made of permeable materials.
   - **D.** Pads should be used where large quantities of pesticides are handled or mixed.

5. **Which statement about sprayer nozzles is *true*?**
   - **A.** A nozzle that primarily produces fine droplets is usually selected to minimize off-target drift.
   - **B.** Coarse-sized droplets supply maximum coverage of the target.
   - **C.** Nozzle material should be selected based on the pesticide formulation.
   - **D.** Brass tips should be used when applying abrasive materials.

6. **Which statement about granular applicators is *true*?**
   - **A.** They do not require calibration.
   - **B.** Ground speed has no effect on the application rate.
   - **C.** In a rotary spreader, lighter granules are thrown farther than heavy ones.
   - **D.** Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.

7. **Which technique would help to minimize off-target drift?**
   - **A.** Spray during a temperature inversion.
   - **B.** Use the largest droplets practical to provide necessary coverage.
   - **C.** Increase the height of the nozzles above the target.
   - **D.** Increase pressure and travel speed.

8. **You are applying a pesticide to a triangular area that has a base of 60 feet and a height of 30 feet. What is the area?**
   - **A.** 300 square feet.
   - **B.** 600 square feet.
   - **C.** 900 square feet.
   - **D.** 1,200 square feet.

9. You are applying a pesticide to a circular area with a 20-foot diameter. What is the area?

A. 128 square feet.
B. 314 square feet.
C. 400 square feet.
D. 628 square feet.

10. You have calibrated your equipment to spray 50 gallons per acre. You need to spray 1 acre. The label calls for 3 pounds of formulation per 100 gallons of water. How much formulation should you add to the tank in order to make 50 gallons of finished spray?

A. 1.5 pounds.
B. 2 pounds.
C. 2.5 pounds.
D. 3 pounds.

CHAPTER 12

PROFESSIONAL CONDUCT

LEARNING OBJECTIVES



After studying this chapter, you should:

- Know how to recognize when a certified applicator must be present during an application from information provided on the label or by regulations.
- Understand the importance of keeping records of pesticide training for uncertified individuals.
- Assure that an uncertified individual that you supervise can understand and follow application procedures.
- Understand the importance of providing detailed guidance for pesticide applications that you supervise.
- Know your responsibilities in supervising uncertified individuals.
- Understand the importance of explaining appropriate federal and state laws and regulations to uncertified individuals that you supervise.
- Know how to communicate with customers and explain realistic expectations of pesticide applications.
- Know how to describe notification procedures for customers and neighbors prior to applications (e.g., chemical sensitivity registries, restricted-entry instructions, postapplication requirements).
- Know how to provide labels and material safety data sheets upon request.
- Know how to provide notification and signage required by laws and regulations for the duration of restrictions.
- Know how to address or refer public inquiries about pests and pesticide applications.

Webster's dictionary defines "professionalism" as the "conduct, aims, or qualities that characterize or mark a profession or a professional person." Many factors have an influence on the professional conduct of pesticide applicators. It is important that certified pesticide applicators understand the rules and regulations on supervising uncertified employees and know how to train employees in proper

pest control techniques. Implementing proper training and pesticide security measures assist the pesticide application business in establishing and maintaining a professional image. People are quite concerned about the safety and health effects associated with pesticides. Therefore, it is extremely important to be able to communicate with customers effectively, accurately, and in a professional manner about the nature of the pest problem, the chemical and non-chemical means to prevent and control pests, and the risks involved if a pesticide is used.

SUPERVISION

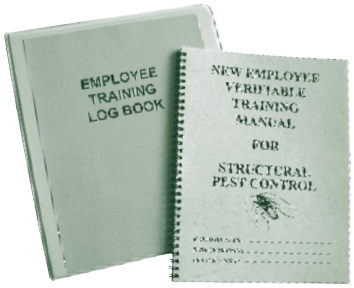
"Unless otherwise prescribed by its labeling, a pesticide shall be considered to be applied under the direct supervision of a certified applicator if it is applied by a competent person acting under the instructions and control of a certified applicator who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied" (FIFRA, Sec. 2 (e)(4)).



Tom Delaney, Professional Landcare Network

Supervision requires continual interaction between the supervisor and the employee.

This section in FIFRA establishes the minimum federal standard for direct supervision of uncertified individuals. Some states require a certified applicator to be physically present at the application site whenever an uncertified individual applies a restricted-use pesticide. Some states require the certified applicator to perform the application while other states require the certified applicator to be present during the application of *any* pesticide (i.e., both restricted-use and unclassified-use). The supervising certified applicator is responsible for the actions of the uncertified person throughout the entire application process—i.e., mixing, application, cleanup, and disposal. In some cases, product labels may restrict the use of certain pesticides to certified applicators only. In such instances, an uncertified applicator may assist the certified person, but the actual application must be performed by the person certified in the appropriate pest control category.



The phrase "under the direct supervision of" means the act or process whereby the handling and application of a pesticide is made by a "competent person" acting under the instructions and control of a certified applicator. The key words are "competent person." In this context, competency is defined as being properly qualified to perform functions associated with a pesticide application.

It is essential for supervisors to prepare and train each uncertified person to independently handle and apply pesticides in a responsible manner. Uncertified applicators need to be every bit as professional as their certified colleagues. It is important that uncertified persons understand basic information such as:

- Federal and state pesticide laws and regulations.
- Security and emergency procedures in the event of an incident.
- The importance of carefully following all label instructions.
- Knowledge about the pesticides and application equipment to be used and the pests to be controlled.
- The proper use of all personal protective equipment.
- The need to keep accurate and precise application records.
- The need to communicate regularly with the certified supervisor.

Proper supervision is not merely a single instructional event but rather a continuing educational process. Maintaining good training records helps to assure management that training

throughout the employee's career is timely and relevant. Supervision requires continual interaction between the supervisor and the uncertified person.

PESTICIDE SECURITY AND SUPERVISION

Pesticide security has the mission of protecting people, facilities, and the environment from harm. In pesticide certification and training, pesticide security is about allowing access to pesticides only by competent persons. Pesticide security is important for all pesticide distributors, retailers, and end users, including uncertified individuals. Supervisors, as well as those persons being supervised, must be knowledgeable about security procedures. Develop a formal written security plan that includes well-defined communication procedures between the supervisor and the applicator.

Given the availability of today's modern communication technologies—such as cell phones, pagers, and remote Internet access—maintaining frequent contact between the certified applicator and the uncertified staff need not be a problem. Such technologies permit immediate contact. No pesticide applicator, certified or uncertified, should be without such communication devices today.



Use all of today's communication devices to maintain frequent contact between supervisors and uncertified staff.

PUBLIC AND CUSTOMER COMMUNICATIONS

The importance of professionalism to a successful business cannot be overstated. A professional person or company must strive for excellence. Professionalism deals not only with how you and your equipment look but also with how you deal with other employees, customers, the public, and, in some cases, the media. This can all be summed up as "your professional image."

Professionalism includes continuing education, keeping up with current pesticide regulations, knowing enough to ask for outside help when you do not have all the answers, knowing the safety and environmental aspects of the job, and taking the initiative to communicate with your customers. What the public hears from the receptionist, technician, and pesticide applicator helps form their opinion of the company as much as do the final results.

Pesticide applicators must never give their customers or other members of the public the impression the pesticide products they use are "safe" or imply the products or services they offer are "safer" than those used by other companies. Creating a professional image begins with the vocabulary used by employees. It is important to use terminology about pests and pesticides the public can understand. Never use phrases such as "environmentally friendly," "safe," "safe for children and pets," "safer," and "harmless" when referring to pesticide products or to the services offered by a pesticide applicator. Also, avoid using the terms "organic," "natural," or "least toxic" because these terms lack a common definition and are likely to confuse your customers. Pesticide applicators must not refer to EPA- and state-registered products as "EPA-approved" or "state-approved." Such references can give the public the impression no risks are associated with the use of the pesticide products and these agencies endorse, approve, or recommend the use of particular products.

Acceptable terminology may include describing the product as "reduced risk" and/or "less toxic." Explain to the customer why the risk is reduced when compared with use of a higher toxicity product. Also explain whether the product requires more applications to be as effective. Provide customers information packets that explain the risks associated with the pesticide (this may include additional information from labels or MSDS).

It is important for pesticide applicators and pest management specialists



Always communicate to customers the risks associated with a pesticide and provide them with additional information.

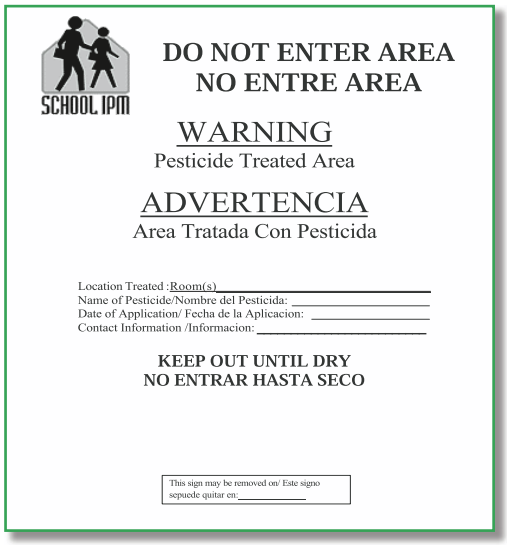
to spend time with each customer explaining *what* needs to be done and *why*. Show customers how environmental, cultural, and physical factors can contribute to ongoing pest problems. For example, moisture, humidity, planting site, sanitation, improper plant selection, and ineffective barriers all may play a role in pest outbreaks. Do not merely tell the customer what you are spraying for but rather show the customer the problems. Defining the *what* and *why* includes explaining product selection, how it is to be used, and anticipated results. Be factual and, above all, do not exaggerate the results your customer can expect from the treatment. Inform the customer about any postapplication label instructions, such as reentry restrictions, watering in a pesticide, or livestock grazing or feeding prohibitions, whether in the field, the garden, or a structure.

Some states have mandatory **preapplication notification** requirements for customers or neighbors. These include chemical hypersensitivity registries currently enforced in about a dozen states. Be sure to let your customers know if the neighbors have requested notification and if there are any concerns or objections involving the use of pesticides. At a minimum, prior notification to concerned individuals should include:

1. Date and address of the scheduled application.
2. Name and telephone number of the applicator.
3. The applicator's certification/license number, where applicable.

State laws and regulations may differ from these minimum notification requirements. Therefore, pesticide applicators must know what their state's specific notification requirements are before making an application.

Regulations in some states may require you to provide copies of labels and MSDS at the time of application. Such requirements usually involve applications around residential, school, and recreational property but rarely agricultural areas. States and other governmental entities may also require **posting** of the treated site immediately following a pesticide application, especially when the application is made to residential and golf course turf, landscape areas, ornamental plants, school property, or public access areas, or around the perimeter of structures. A number of states now have school integrated pest management (IPM) programs that require notification of school staff members and parents and posting of treated areas. Even in states where these requirements do not exist, companies often post notices at entry points to recently treated areas. This usually involves placing a small plastic flag or sign in a conspicuous place to alert people to avoid the treated area at least until the spray has dried



University of Florida

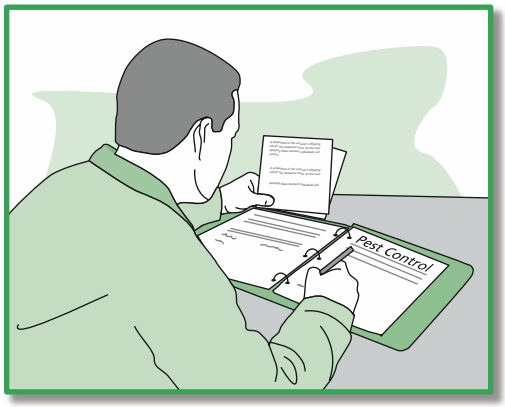
An example of a school pesticide application notification sign.

thoroughly. Check with your state, tribe, territory, or other pesticide regulatory agency to make sure you are in compliance with any posting requirements.

To maintain good customer and public communications, consider keeping more detailed records than required by federal and state laws. Records can prove invaluable as documentation in the event of a

complaint or a lawsuit against your business. Pesticide records provide all the necessary information about the pesticides and how they were actually applied, thus protecting the applicator from what may be false accusations. Additional information could include weather, nozzle sizes, spray pressures, ground speed, calibration, or any other special precautions that may have been used or taken. Records can also help determine which pesticide treatments work, which treatments do not work, and why.

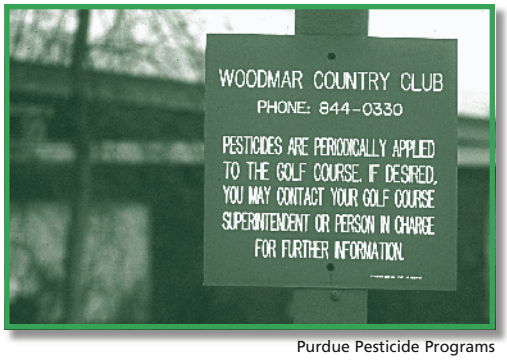
Record-keeping is also a major tool of IPM by documenting pest sightings and population levels, pest control techniques used, and overall environmental conditions. Good records enable an applicator to make more informed pest control decisions. If medical treatment for a pesticide injury is required for humans or animals, records can provide information necessary to the medical staff for diagnosis and treatment. Good records can also document the steps that were taken to protect farm workers and the environment from pesticides. Records may also be used to respond to the public's concern regarding pesticide use.



Consider keeping more detailed pesticide records than required by federal and state laws.

How to Answer Consumer Questions

Today, customers and other concerned individuals are likely to ask the pesticide applicator, the sales representative, or the service technician about the products that will be used to manage their pest problems. They may ask about possible effects on children, pets, property, the environment, and themselves. How you answer these questions can determine whether you have a satisfied customer. Preparing yourself and your staff to answer consumer concerns is the professional approach. A good way to familiarize every pesticide applicator and technician in the company with typical questions and answers is to discuss these during company training sessions. Role playing by the staff members can help reinforce correct and responsible responses. If requested by the customer or anyone else inquiring about pesticides, provide Web addresses and 800 phone numbers for pesticide emergencies and for pesticide information. For emergencies, contact the National Poison Control Center at 1-800-222-1222. For pesticide information, contact the National Pesticide Information Center (NPIC) at 1-800-858-7378 (http://npic.orst.edu). Also, when requested by your customer or other concerned individuals, be prepared to provide the trade and common names of the pesticides and copies of the product labels and MSDS.



Purdue Pesticide Programs

Posting a sign about pesticide applications helps promote good customer relations.

National Poison Control Center
1-800-222-1222

National Pesticide Information Center
(NPIC) 1-800-858-7378

Your Professional Image

It takes work to achieve and maintain a professional image. As a representative of your pest management company, seek to reinforce a positive company image. Remember, your work actions reflect on your company and on the entire pest management industry. Be sure to leave a positive impression.

SUMMARY

Certified applicators often supervise and instruct uncertified individuals. The minimum standard for supervision of pesticide applications is detailed under FIFRA. According to FIFRA, certified applicators do not necessarily have to be physically present during the application. Certified applicators, however, must be aware of any state laws or label requirements that have stricter standards.

To perform pesticide applications properly, uncertified individuals need adequate training and supervision to become competent at their task. Supervisors must be able to communicate effectively with employees as well as customers and the public. Both certified and uncertified employees must be able to address consumer questions clearly and accurately. It is a violation of the federal pesticide law to misrepresent the safety and efficacy of any pesticide. Applicators must also be aware of and follow up on any preapplication notifications or posting of treatment sites required by their state.

Properly training employees, enforcing security procedures, communicating effectively, and adhering to federal and state pesticide laws all contribute to a professional image. Looking and acting professional enhances consumer confidence in the pest management industry.



Review Questions

CHAPTER 12: PROFESSIONAL CONDUCT

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

1. **According to FIFRA, what is the minimum standard for direct supervision of a pesticide application by uncertified individuals?**
   - **A.** The application is done by a competent person with the certified applicator present at the time and place the pesticide is applied.
   - **B.** The application is done by a competent person acting under the instruction and control of a certified applicator who is available if and when needed.
   - **C.** The application is done by a competent person who has received a six-month training course by a certified applicator.
   - **D.** The application is done by a person who has passed a competency exam.

2. **Under which set of circumstances would the certified applicator be required to be physically present at the application site?**
   - **A.** Whenever a restricted-use pesticide is applied.
   - **B.** Whenever any type of pesticide is applied by an uncertified individual.
   - **C.** If state law or the label requires it.
   - **D.** When the pesticide is being applied inside or around a public building.

3. **Which would be an appropriate way to describe a relatively low-toxicity pesticide product to the customer?**
   - **A.** Environmentally friendly.
   - **B.** Non-toxic.
   - **C.** EPA-approved.
   - **D.** Use with caution.

4. **Which is *true* about preapplication posting requirements?**
   - **A.** All states require notification of school staff members 72 hours before an application is to be made to a school.
   - **B.** Some states maintain a registry of sensitive individuals who must be informed if a pesticide application is going to be made near them.
   - **C.** States do not vary in the minimum notification requirements to concerned individuals.
   - **D.** All states require residential areas to be posted before a pesticide application is made.

5. **Which statement about posting and notification requirements is *false*?**
   - **A.** Some states may require you to provide copies of labels and material safety data sheets at the time of application or upon request by the customer.
   - **B.** States and other governmental entities may require posting of treated sites immediately following a pesticide application.
   - **C.** Posting usually involves placing a small plastic flag or sign in a conspicuous place to alert people to avoid treated areas.
   - **D.** Most states require posting of and notification about pesticide applications made in agricultural areas.

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APPENDIX A

ANSWERS TO REVIEW QUESTIONS

CHAPTER 1 PEST MANAGEMENT

1. B. **2.** C. **3.** B. **4.** A. **5.** A.
6. C. **7.** A. **8.** A. **9.** B. **10.** B.

CHAPTER 2 FEDERAL PESTICIDE LAWS

1. A. **2.** B. **3.** C. **4.** A. **5.** A.
6. True. **7.** D. **8.** A.

CHAPTER 3 PESTICIDE LABELING

1. A. **2.** D. **3.** C. **4.** B **5.** A.
6. A. **7.** A. **8.** D. **9.** B **10.** D

CHAPTER 4 PESTICIDE FORMULATIONS

1. C. **2.** C. **3.** B. **4.** C. **5.** A.
6. D. **7.** C. **8.** B. **9.** A. **10.** D.

CHAPTER 5 PESTICIDE HAZARDS AND FIRST AID

1. A. **2.** A. **3.** B. **4.** D. **5.** A.
6. B. **7.** C. **8.** B. **9.** A. **10.** D.

CHAPTER 6 PERSONAL PROTECTIVE EQUIPMENT

1. B. **2.** A. **3.** D. **4.** A. **5.** B.
6. B. **7.** B. **8.** A. **9.** D. **10.** A.

CHAPTER 7 PESTICIDES IN THE ENVIRONMENT

1. A. **2.** B. **3.** C. **4.** D. **5.** B.
6. A. **7.** D. **8.** C. **9.** D.

CHAPTER 8 TRANSPORTATION, STORAGE, AND SECURITY

1. B. **2.** B. **3.** A. **4.** A. **5.** A.

6. B. **7.** C.

CHAPTER 9 EMERGENCY OR INCIDENT RESPONSE

1. D. **2.** A. **3.** D. **4.** C. **5.** B.

CHAPTER 10 PLANNING THE PESTICIDE APPLICATION

1. A. **2.** A. **3.** D. **4.** B. **5.** C.

6. D. **7.** D. **8.** C. **9.** A. **10.** D.

CHAPTER 11 PLANNING THE PESTICIDE APPLICATION

1. A. **2.** C.

3. False. It is recommended that enclosed cabs be considered a supplement to PPE, not a replacement for it, and that all PPE specified on the label be worn while working inside an enclosed cab.

4. D. **5.** C. **6.** D. **7.** B. **8.** C.

9. B. **10.** A.

CHAPTER 12 PROFESSIONAL CONDUCT

1. B. **2.** C. **3.** D. **4.** B. **5.** D.

APPENDIX B

GLOSSARY

ABIOTIC Related to non-living factors, such as air pollutants, wind, water, and temperature.

ABSORPTION The movement of a chemical into plants, animals (including humans), microorganisms, or soil.

ACARICIDE A pesticide used to control mites and ticks. A miticide is a type of acaricide.

ACIDIC Having a pH less than 7.

ACTION THRESHOLD A predetermined level of pest infestation or damage at which some type of pest management action must be taken.

ACTIVATED CHARCOAL A finely ground charcoal that adsorbs chemicals.

ACTIVATOR An adjuvant added to a pesticide to increase its toxicity.

ACTIVE INGREDIENT The chemical or chemicals in a product responsible for pesticidal activity.

ACUTE EFFECT An illness that occurs shortly after exposure to a pesticide.

ACUTE EXPOSURE An exposure to a single dose of pesticide.

ACUTE TOXICITY An injury produced from a single exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity. (See **CHRONIC TOXICITY.**)

ADJUVANT A substance added to a pesticide to improve its effectiveness or safety. Same as additive. Examples: penetrants, spreader-stickers, and wetting agents.

ADSORPTION The process whereby chemicals are held or bound to a surface by physical or chemical attraction. Clay and high-organic soils tend to adsorb pesticides.

ADULTERATED PESTICIDE A pesticide that does not conform to the specified standard or quality as documented on its label or labeling.

AEROSOL A chemical stored in a container under pressure. An extremely fine mist is produced when the material, dissolved in a liquid, is released into the air.

AGITATION The process of stirring or mixing in a sprayer.

AIR-BLAST SPRAYER A type of pesticide application equipment that uses a large volume of air moving at high speed to break up and disperse spray droplets from the nozzles.

ALGAE Relatively simple plants that are photosynthetic and contain chlorophyll.

ALGAECIDE (ALGICIDE) A pesticide used to kill or inhibit algae.

ALKALINE Having a pH greater than 7; also called basic.

ALLERGIC EFFECTS /ALLERGY A hypersensitivity to a specific substance, often called the allergen. An allergy may cause dermatitis, blisters, or hives; it could also cause illness, asthma, or life-threatening shock. Often the entire body is affected. Pesticide allergy symptoms are similar to other allergy symptoms—reddening and itching of the eyes, respiratory discomfort, and asthma-like symptoms.

ANNUAL A plant that completes its life cycle in one year.

ANTAGONISM The reduction of pesticide activity when two or more different pesticides are mixed together.

ANTIBIOTIC Chemical produced by a microorganism that is toxic to other microorganisms. Examples: streptomycin and penicillin.

ANTICOAGULANT A chemical that prevents normal blood clotting; the active ingredient in some rodenticides.

ANTIDOTE A practical treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

ANTI-SIPHONING DEVICE A hose attachment designed to prevent backflow of a pesticide mix from the spray tank into a water source.

ANTI-TRANSPIRANT A chemical applied to a plant to reduce the rate of transpiration or water loss.

APPLICATION RATE The amount of pesticide that is applied to a known area, such as an acre or 1,000 square feet or linear feet.

AQUIFER A geologic formation from which groundwater can be drawn. An aquifer can be a layer of sand, gravel, or other soil materials, or a section of bedrock with fractures through which water can flow.

ARACHNID A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks, and mites are arachnids.

ARTHROPOD An invertebrate animal characterized by a jointed body and limbs and usually a hard body covering that is molted at intervals. Insects, mites, and crayfish are arthropods.

ATROPINE (ATROPINE SULFATE) An antidote used to treat organophosphate and carbamate poisoning.

ATTRACTANT A substance or device to lure insects or other pests to a trap or poison bait.

AVICIDE A chemical used to kill or repel birds.

BACK-SIPHONING The movement of a liquid pesticide mixture from a spray tank through the filling hose into the water source.

BACTERIA (singular: **BACTERIUM**) Microscopic organisms, some of which are capable of producing diseases in plants and animals.

BACTERICIDE A chemical used to control bacteria.

BAIT A food or other substance used to attract a pest to a pesticide or a trap.

BAND APPLICATION An application of a pesticide or other material in or beside a crop row rather than over the entire field. (See **BROADCAST APPLICATION.**)

BASAL APPLICATION An application to plant stems or trunks at or just above the ground line.

BENEFICIAL INSECT An insect that is useful or helpful to humans. Examples are pollinators, parasites, and predators of pests.

BIENNIAL A plant that completes its life cycle in two years.

BIOACCUMULATION The ability of organisms to accumulate or store chemicals in their tissues.

BIOLOGICAL CONTROL The control of pests using predators, parasites, and disease-causing organisms. It may be naturally occurring or introduced.

BIOLOGICAL DEGRADATION The breakdown of chemicals due to the activity of living organisms, especially bacteria and fungi in the soil.

BIOMAGNIFICATION The process whereby some organisms accumulate chemical residues in higher concentrations than those found in the organisms they consume.

BIOPESTICIDE A pesticide derived from naturally occurring materials.

BOOM A pesticide application device attached to a truck, tractor, aircraft, or other vehicle, or held by hand, to which multiple spray nozzles are attached.

BOTANICAL PESTICIDE A pesticide produced from naturally occurring chemicals in plants. Examples: nicotine, pyrethrum, and rotenone.

BRAND NAME The registered or trade name, number, or designation given to a specific pesticide product or device by the manufacturer or formulator.

BROADCAST APPLICATION The uniform application of a pesticide or other material over an entire field or area.

BROADLEAF PLANTS Plants with broad, rounded, or flattened leaves with netted veins. Examples: dandelions and roses. Different from the narrow, bladelike leaves with parallel veins of grasses, sedges, rushes, and onions.

BROAD-SPECTRUM PESTICIDE A pesticide that is effective against a wide range of pests.

BUFFERS Adjuvants used to retard chemical degradation of some pesticides by lowering the pH of alkaline water and maintaining the pH within a narrow range even with the addition of acidic or alkaline materials.

CALIBRATE/CALIBRATION To properly adjust equipment; to determine the correct amount of material to be applied to the target area.

CARBAMATES A group of pesticides commonly used for control of insects, mites, fungi, and weeds. N-methyl carbamate insecticides, miticides, and nematicides are cholinesterase inhibitors.

CARCINOGEN A substance or agent able to produce malignant tumors (cancer).

CARRIER An inert liquid, solid, or gas added to an active ingredient to make a pesticide formulation. A carrier is also the material, usually water or oil, used to dilute the formulated product for application.

CAUSAL ORGANISM The organism (pathogen) that produces a given disease.

CAUTION The signal word associated with pesticide products classified as slightly toxic; these pesticides have an oral LD_{50} greater than 500mg/kg and a dermal LD_{50} greater than 2,000mg/kg.

CERTIFIED APPLICATOR A person qualified to apply or supervise the application of restricted-use pesticides.

CHEMICAL NAME The technical name of the active ingredient(s) found in the formulated product. This complex name is derived from the chemical structure of the active ingredient.

CHEMIGATION The application of pesticides or fertilizers to a target site in irrigation water. Also known as injector systems when used in greenhouses.

CHEMTREC The Chemical Transportation Emergency Center. It supports a toll-free number that provides 24-hour information for chemical emergencies such as a spill, leak, fire, or accident—1-800-424-9300.

CHLORINATED HYDROCARBON A pesticide containing chlorine, carbon, and hydrogen. Many are persistent in the environment. Examples: chlordane, DDT, methoxychlor. Also called **ORGANOCHLORINES.**

CHLOROSIS The yellowing of a plant's normally green tissue.

CHOLINESTERASE A chemical catalyst (enzyme) found in humans and many other animals that regulates the activity of nerve impulses by deactivating the chemical neurotransmitter acetylcholine.

CHRONIC TOXICITY The ability of small amounts of pesticide from repeated, prolonged exposure to cause injury. (See **ACUTE TOXICITY.**)

COMMERCIAL APPLICATOR A certified applicator who uses or supervises the use of pesticides for purposes other than those covered under a private applicator certification.

COMMON NAME A name given to a pesticide active ingredient by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names, but each active ingredient has only one recognized common name. Example: the common name for Sevin insecticide is carbaryl.

COMPATIBILITY AGENT An adjuvant used to enhance the mixing of two or more pesticide products and/or fertilizers.

COMPATIBLE When two or more chemicals can be mixed together without reducing the effectiveness or characteristics of any individual chemical in the mixture, they are said to be compatible.

CONCENTRATION The amount of active ingredient in a given volume or weight of formulated product.

CONTACT EFFECTS Injury at the point of contact, including skin discoloration and irritation (dermatitis) such as itching, redness, rashes, blisters, and burns. Also, swelling, stinging, and burning of the eyes, nose, mouth, or throat are contact effects.

CONTACT PESTICIDE Any pesticide that controls pest organisms upon contact. These may be insecticides, miticides, fungicides, or herbicides.

CONTAINMENT PAD An impermeable pad used for mixing and loading pesticides and cleaning equipment that is designed to catch spills, leaks, overflows, and wash water for reuse or disposal.

CONTAMINATION The presence of an unwanted substance in or on a plant, animal, soil, water, air, or structure. (See **RESIDUE.**)

CORROSIVE POISON A poison containing a strong acid or base that will severely burn the skin, mouth, stomach, or respiratory tract.

CRACK AND CREVICE APPLICATION The application of small amounts of pesticide into cracks and crevices in buildings such as along baseboards and in cabinets.

CROSS-CONTAMINATION When one pesticide accidentally mixes with another pesticide, usually in an improperly cleaned sprayer or in storage because of the airborne movement of a volatile pesticide.

CROSS-RESISTANCE When a pest population that is already resistant to one pesticide becomes resistant to a related chemical with a similar mode of action.

CURATIVE PESTICIDE A pesticide that can inhibit or kill a disease-causing organism after it is established in the plant or animal.

DANGER—POISON The signal word associated with pesticide products classified as highly toxic. This signal word is also associated with pesticide products that are corrosive or highly irritating to skin and eyes.

DAYS TO HARVEST The minimum number of days permitted by law between the last pesticide application and the harvest date. Same as **PREHARVEST INTERVAL.**

DAYS TO SLAUGHTER The minimum number of days permitted by law between the last pesticide application and the date the animal is slaughtered.

DECONTAMINATE To remove or degrade a chemical residue from the skin or a surface.

DEFOAMING AGENT An adjuvant used to reduce the foaming of a spray mixture due to agitation.

DEFOLIANT A chemical that initiates the premature drop of leaves, often as an aid in harvesting a crop.

DEGRADATION The process by which a chemical compound is broken down to simpler compounds by the action of microorganisms, water, air, sunlight, or other agents. Degradation products are usually, but not always, less toxic than the original compound.

DELAYED TOXICITY Illnesses or injuries that do not appear immediately after exposure to pesticides. The effects generally occur between 24 hours and several days after exposure.

DEPOSIT The presence of a pesticide on a treated surface after application.

DERMAL Pertaining to the skin.

DERMAL TOXICITY The ability of a pesticide to cause injury to a human or animal when absorbed through the skin.

DERMATITIS The inflammation, itching, irritation, or occurrence of a rash after exposure to a chemical.

DESICCANT A chemical that promotes drying or loss of moisture from leaves or other plant parts. Also, a chemical that removes water from arthropods or destroys the waxy covering that protects these organisms from water loss.

DETOXIFY To render a pesticide active ingredient or other poisonous chemical harmless.

DIAGNOSIS The positive identification of a problem and its cause.

DILUENT Any inert liquid, solid, or gaseous material that is combined with a pesticide active ingredient during the manufacturing process. Also, the water, petroleum product, or other liquid in which the formulated product is mixed before application. Also referred to as the **CARRIER.**

DIRECTED APPLICATION A precise application to a specific area or site, such as a basal application to woody plants or a crack and crevice treatment in a building.

DISINFECTANT A chemical or other agent that kills or inactivates disease-producing microorganisms in animals, seeds, or other plant parts. Also, commonly refers to chemicals used to clean or surface-sterilize inanimate objects.

DISPERSING AGENT An adjuvant that facilitates the mixing and suspension of a pesticide formulation in water.

DORMANT SPRAY A pesticide application made in late winter or early spring before the resumption of active growth by plants.

DOSE, DOSAGE The quantity of pesticide applied to a given site or target.

DRIFT The airborne movement of a pesticide spray, dust, particle, or vapor beyond the intended contact area.

DRIFT CONTROL ADDITIVE An adjuvant added to a spray mixture to reduce drift.

DROP SPREADER A common type of granular application equipment that has an adjustable sliding gate that opens holes in the bottom of the hopper, allowing the granules to flow out by gravity feed.

DRY FLOWABLE A dry, granular pesticide formulation that forms a suspension when added to water. Same as **WATER DISPERSIBLE GRANULE.**

DUST A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.

ECONOMIC INJURY LEVEL The pest population density that causes losses equal to the cost of control measures.

ECONOMIC THRESHOLD The pest population density (number of pests per unit of area) at which control measures are needed to prevent the pest from causing economic injury.

EMULSIFIABLE CONCENTRATE A pesticide formulation produced by mixing an active ingredient and an emulsifying agent in a suitable petroleum solvent. When it is added to water, a milky emulsion is usually formed.

EMULSIFYING AGENT (EMULSIFIER) A chemical that aids in the suspension of one liquid in another that normally would not mix together.

EMULSION A mixture of two liquids that are not soluble in each another. One is suspended as very small droplets in the other with the aid of an emulsifying agent. Example: emulsifiable concentrate in water.

ENCAPSULATED PESTICIDE A pesticide formulation with the active ingredient enclosed in capsules of polyvinyl or other synthetic materials; principally used for slow release and to prolong their effectiveness. May also refer to a method of disposal of pesticides and pesticide containers by sealing them in a sturdy, waterproof container to prevent leakage of contents.

ENCLOSED CAB Tractor cabs, cockpits, and truck/vehicle cabs that surround the occupant(s) and may help to prevent exposure to pesticides as long as all doors, hatches or windows are kept closed during the pesticide application.

ENDANGERED SPECIES Individual plants or animals whose population has been reduced to near extinction.

ENVIRONMENT All the features that surround and affect an organism or group of organisms.

ENVIRONMENTAL PROTECTION AGENCY (EPA) The federal agency responsible for implementing pesticide rules and regulations and registering pesticides.

EPA ESTABLISHMENT NUMBER A number assigned to each pesticide production facility by the EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product.

EPA REGISTRATION NUMBER A number assigned to a pesticide product by the EPA when the product is registered by the manufacturer or the designated agent. The number must appear on all labels for a particular product.

ERADICANT A chemical or other agent (steam, heat) used to eliminate an established pest from a plant, animal, or specific site (soil, water, buildings).

ERADICATION A pest management strategy that attempts to eliminate all members of a pest population from a defined area.

EXPOSURE Unwanted contact with pesticides or pesticide residues by people, other organisms, or the environment.

FIFRA The Federal Insecticide, Fungicide, and Rodenticide Act, a federal law dealing with pesticide regulations and use.

FLOWABLE A pesticide formulation in which a very finely ground solid particle, composed of both active and inert ingredients, is suspended in a liquid carrier. These formulations are mixed with water before spraying.

FOAMING AGENT An adjuvant designed to reduce pesticide drift by producing a thick foam.

FOG TREATMENT The application of a pesticide as a fine mist or fog.

FOLIAR Refers to pesticide applications to the leaves of plants.

FOOD CHAIN Sequence of species within an ecological community, each member of which serves as a food source for the species next higher in the chain.

FORMULATION The pesticide product as purchased, containing a mixture of one or more active ingredients, carriers (inert ingredients), and other additives diluted for safety and ease of application.

FUMIGANT A pesticide that forms gases or vapors toxic to plants, animals, and microorganisms.

FUNGI (singular: **FUNGUS**) Non-chlorophyll-bearing plants that live as saprophytes or parasites. Some infect and cause diseases in plants, animals, and humans or destroy wood and fiber products. Others are beneficial—for instance, decomposers and human food sources. Examples: rusts, mildews, molds, smuts.

FUNGICIDE A chemical used to control fungi.

FUNGISTATIC AGENT A chemical that inhibits the germination of fungal spores or the growth of mycelium but does not kill the fungus.

GENERAL-USE PESTICIDE A pesticide that can be purchased and used by the general public. (See **RESTRICTED-USE PESTICIDE.**)

GERMINATION The sprouting of a seed or the production of a germ tube (mycelium) from a fungus spore.

GPA Gallons per acre.

GPM Gallons per minute.

GRANULE A dry pesticide formulation. The active ingredient is either mixed with or coated onto an inert carrier to form a small, ready-to-use, low-concentrate particle that does not normally present a drift hazard. Pellets differ from granules only in their precise uniformity, larger size, and shape.

GROUNDWATER Water located in aquifers beneath the soil surface from which well water is obtained or surface springs are formed.

GROWTH REGULATOR A chemical that alters the growth processes of a plant or animal.

HABITAT The place where plants or animals live, feed, and reproduce.

HARVEST AID CHEMICAL A chemical material applied to a plant before harvest to reduce the amount of plant foliage. (See **DEFOLIANT.**)

HAZARD The likelihood that injury or death will occur from a given level and duration of exposure to a toxic chemical.

HEAT STRESS A potentially life-threatening overheating of the body.

HERBACEOUS PLANTS Plants that do not develop woody tissues.

HERBICIDE A pesticide used to control weeds.

HOST A plant or animal on or in which a pest lives and feeds.

HOST RESISTANCE The ability of a host plant or animal to resist attack by pests or to be able to tolerate the damage caused by pests.

HYDRAULIC SPRAYER A type of pesticide application equipment that uses water under pressure to deliver the pesticide to the target site.

HYDROLYSIS Breakdown of a chemical in the presence of water.

ILLEGAL RESIDUE A quantity of pesticide remaining on or in the crop/animal at harvest/slaughter that is either above the set tolerance or is not allowed to be used on the crop/animal.

IMPREGNATES Pet collars, livestock ear tags, adhesive tapes, plastic pest strips, and other products with pesticides incorporated into them. These pesticides slowly emit pesticide vapors over time and provide control of nearby pests.

INCOMPATIBLE Two or more materials that cannot be mixed or used together.

INERT INGREDIENTS Inactive materials in a pesticide formulation that do not possess pesticidal activity, although some inert ingredients may be toxic or hazardous to humans.

INGREDIENT STATEMENT The portion of the label on a pesticide container that gives the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.

INHALATION TOXICITY The property of a pesticide to be poisonous to humans or animals when breathed in through the nose and mouth into the lungs.

INOCULUM That portion of the pathogen that can cause disease in a host.

INORGANIC PESTICIDES Pesticides of mineral origin—they do not contain carbon.

INSECT GROWTH REGULATOR (IGR) A type of insecticide that controls certain insects by disrupting their normal growth process from immature to adult.

INSECTICIDE A pesticide used to control or prevent damage caused by insects and related arthropods.

INSECTS Arthropods characterized by a body composed of three segments and three pairs of legs.

INSOLUBLE Refers to a chemical that does not dissolve in a liquid. For example, a wettable powder does not dissolve in water but rather forms a suspension.

INTEGRATED PEST MANAGEMENT (IPM) The use of all suitable pest control methods to keep pest populations below the economic injury level. Methods include cultural practices; use of biological, physical, and genetic control agents; and the selective use of pesticides.

INVERT EMULSION An emulsion in which water droplets are suspended in an oil rather than the oil droplets being suspended in water.

INVERTEBRATE A class of animals that lack backbones. Insects, spiders, nematodes, and snails and slugs are examples of invertebrates.

KEY PEST A pest that may cause major damage on a regular basis unless it is controlled. (See **SECONDARY PEST.**)

LABEL All printed material attached to or part of a pesticide container. The label is a legal document.

LABELING The pesticide product label and all supplemental pesticide information that complements the information on the label but may not necessarily be attached to or part of the container.

LARVAE (singular: **LARVA**) Immature forms of insects that undergo complete metamorphosis—developmental stages are egg, larva, pupa, and adult.

LARVICIDE A pesticide used to kill insect larvae. Commonly used to control mosquito and black fly larvae.

LC_{50} The concentration of a pesticide, usually in air or water, that can kill 50 percent of a test population of animals. LC_{50} is usually expressed in parts per million (ppm). The lower the LC_{50} value, the more acutely toxic the chemical.

LD_{50} The dose or amount of a pesticide that can kill 50 percent of the test animals when eaten or absorbed through the skin. LD_{50} is expressed in milligrams of chemical per kilogram of body weight of the test animal (mg/kg). The lower the LD_{50} value, the more acutely toxic the chemical.

LEACHING The movement through soil of a pesticide or other chemical that is dissolved in water.

LETHAL CONCENTRATION See **LC_{50}**.

LETHAL DOSE See **LD_{50}**.

LIFE CYCLE The series of stages that an organism passes through during its life. Many pest species, both plants and animals, pass through several life stages during which their susceptibility or tolerance to pesticides varies greatly.

MATERIAL SAFETY DATA SHEET (MSDS) A safety data sheet available from the manufacturer that provides information on chemical properties, toxicity, first aid, hazards, personal protective equipment, and emergency procedures to be followed in the event of a spill, leak, fire, or transportation crisis.

METABOLITE In pesticides, a compound derived from changes in the active ingredient through chemical, biological, or physical reactions. The metabolite may be simpler or more complex and may or may not be more poisonous than the original chemical.

METAMORPHOSIS A change in the shape, size, and/or form of animals as they develop from eggs through adults.

MICROBIAL DEGRADATION Breakdown of a chemical by microorganisms.

MICROBIAL PESTICIDE Bacteria, viruses, fungi, and other microorganisms used to control pests. Also called **BIORATIONALS**.

MICROENCAPSULATED PESTICIDE A formulation in which the pesticide active ingredient is encased in plastic capsules that release the pesticide slowly after application when the capsules start to break down.

MICROORGANISM An organism that is so small it cannot be seen without the aid of a microscope.

MINI-BULK CONTAINER A container that ranges in volume from 40 to 600 gallons and is adapted to closed systems. A mini-bulk container can be returned to the dealer for refilling.

MISCIBLE LIQUIDS Two or more liquids that can be mixed and will remain mixed under most conditions. Water and ethyl alcohol are miscible; water and oil are not.

MITE A small arthropod similar to an insect but with eight legs, two body parts, and no antennae.

MITICIDE A pesticide used to control mites. Same as **ACARICIDE.**

MODE OF ACTION The way in which a pesticide exerts a toxic effect on the target plant, animal, or microorganism.

MOLLUSCICIDE A chemical used to control snails and slugs.

MOLTING In invertebrates such as insects, spiders, and mites, the process of shedding the outer body covering or exoskeleton. Molting takes place to allow the animal to grow larger.

MUTAGEN A substance or agent able to cause genetic changes in living cells.

MYCELIUM The mass of filaments that forms the body of a fungus.

MYCOPLASMA A microorganism possessing many virus- and bacteria-like properties. Some cause plant diseases.

NARROW-SPECTRUM PESTICIDE A pesticide that is effective against only one or a few species of pests; the term is usually associated with insecticides and fungicides.

NATURAL ENEMIES The predators, parasites, and pathogens that attack and often kill other organisms.

NECROSIS The death of plant or animal tissues that results in the formation of discolored, sunken, and dead (necrotic) areas.

NEMATICIDE A pesticide used to control nematodes.

NEMATODES Microscopic, colorless, worm-like animals that live as saprophytes or parasites. Many cause diseases of plants or animals.

NEUROTOXIN A substance or agent able to cause disorders of the nervous system.

NO OBSERVABLE EFFECT LEVEL (NOEL) The maximum dose or exposure level of a pesticide that produces no observable toxic effect on test animals.

NON-PERSISTENT PESTICIDE A pesticide that does not remain active in the environment more than one growing season.

NON-POINT-SOURCE POLLUTION Pollution that comes from a widespread area. The movement of pesticides into streams or groundwater following a broadcast application to an agricultural field, large turf area, or right-of-way is an example of non-point-source pollution.

NON-SELECTIVE PESTICIDE A pesticide that is toxic to a wide range of plants or animals without regard to species. For example, a non-selective herbicide can kill or damage all plants it contacts.

NON-TARGET ORGANISMS Plants or animals within or adjacent to a pesticide-treated area that are not the intended targets of a pesticide application.

NOXIOUS WEED A plant defined by law as being particularly troublesome, undesirable, and difficult to control.

NYMPH The developmental state of insects with gradual metamorphosis that hatches from the egg. Nymphs become adults.

OCCASIONAL PEST A pest that does not recur regularly but causes damage intermittently as a result of changing environmental conditions or fluctuations in populations of natural enemies.

ONCOGEN A substance or agent able to induce tumors (not necessarily cancerous) in living tissues. (See **CARCINOGEN.**)

ORAL TOXICITY The occurrence of injury when a pesticide is taken by mouth.

ORGANOPHOSPHATES A large group of pesticides that contain the element phosphorus. Most are non-persistent insecticides, miticides, and nematicides. Many are highly toxic. Examples: malathion, parathion, diazinon, chlorpyrifos.

OVICIDE A material that destroys eggs.

OXIDIZER A highly reactive chemical that is potentially explosive and a fire hazard under certain conditions.

PARASITE A plant, animal, or microorganism living in, on, or with another living organism for the purpose of obtaining all or part of its food.

PARTICLE DRIFT The airborne movement of particles such as pesticide dusts, and pesticide-contaminated soil from the application site.

PATHOGEN A disease-causing organism.

PELLET A pesticide formulation consisting of dry active and inert ingredients pressed into a uniformly sized and shaped ready-to-use material; larger than granules.

PENETRANT An adjuvant added to a spray mixture to enhance the absorption of a pesticide.

PERCOLATION The downward movement of water through soil.

PERENNIAL A plant that lives for more than two years.

PERMEABILITY Refers to the ease with which water and dissolved pesticides can flow through porous materials such as soil, gravel, or sand.

PERSISTENT PESTICIDE A pesticide chemical (or its metabolites) that remains active in the environment more than one growing season. Some compounds can accumulate in animal and plant tissues or remain in the soil for years.

PERSONAL PROTECTIVE EQUIPMENT (PPE) Devices and clothing that protect pesticide applicators, handlers, and workers from exposure to pesticides.

PEST An undesirable organism (insect, bacterium, fungus, nematode, weed, virus, rodent) that is injurious to humans, desirable plants and animals, manufactured products, or natural products.

PESTICIDE Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

PESTICIDE CONCENTRATE A pesticide formulation before any dilution occurs.

PESTICIDE HANDLER A person who works directly with pesticides, such as during mixing, loading, transporting, cleaning, storing, disposing, and applying, or who repairs pesticide application equipment.

PEST RESISTANCE The ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it.

pH A measure of acidity/alkalinity; acid below pH7, basic or alkaline above pH7.

PHEROMONE A substance emitted by an animal to influence the behavior of other animals of the same species. Some are synthetically produced for use in insect traps.

PHOTODEGRADATION Breakdown of chemicals by the action of sunlight.

PHYTOTOXICITY Chemical injury to plants.

PISCICIDE A chemical used to control pest fish.

PLACARDS Public notices. U.S. Department of Transportation placards are diamond-shaped warning signs placed on all vehicles that transport certain types and quantities of hazardous materials.

PLANT GROWTH REGULATOR (PGR) A pesticide used to regulate or alter the normal growth of plants or the development of their plant parts.

POINT OF RUNOFF When a spray starts to run or drip from the leaves and stems of plants, or the hair or feathers of animals.

POINT-SOURCE POLLUTION The contamination of water and soil from a specific, identifiable place or location, such as a spill site or a permanent mixing, loading, and cleaning site.

POISON CONTROL CENTER An agency, generally a hospital, that has current information on proper first-aid techniques and antidotes for poisoning emergencies.

POSTEMERGENCE A pesticide that is applied after the weed or crop plants have appeared through the soil. Usually used to specify the timing of herbicide applications.

PPB Parts per billion. A way of expressing amounts of chemicals in or on food, plants, animals, water, soil, or air. One part per billion equals 1 pound in 500,000 tons.

PPM Parts per million. One part per million equals 1 pound in 500 tons.

PRECIPITATE A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.

PREDACIDE A pesticide used to control predaceous animals, usually mammals.

PREDATOR An animal that attacks, kills, and feeds on other animals. Examples of predaceous animals are bears, wolves, coyotes, hawks, owls, snakes, fish, spiders, and many insects and mites.

PREEMERGENCE A pesticide that is applied before the weed or crop plants have appeared through the soil. Usually used to specify the timing of herbicide applications.

PREHARVEST INTERVAL Same as **DAYS TO HARVEST.**

PREMIX A pesticide product formulated by the manufacturer with more than one active ingredient.

PREPLANT PESTICIDE A pesticide applied before planting a crop.

PRESSURE-RINSE The process of decontaminating an empty pesticide container with water by using a special high-pressure nozzle to rinse the container.

PRIVATE APPLICATOR A person using or supervising the use of restricted-use pesticides to produce an agricultural commodity on his/her own land, leased land, or rented land, or on the lands of his/her employer.

PROPELLANT The inert ingredient in self-pressurized products that forces the active ingredient from the container. (See **AEROSOL.**)

PROTECTANT A pesticide applied to a plant or animal before infection or attack by the pest to prevent infection or injury by the pest.

PROTECTIVE EQUIPMENT Equipment intended to protect a person from exposure during the handling and application of pesticides. Includes long-sleeved shirts and long trousers, coveralls, suitable hats, gloves, shoes, respirators, and other safety items as needed.

PUPA The developmental stage of some insects between larva and adult.

PYRETHROID A synthetic insecticide that mimics pyrethrin, a naturally occurring pesticide derived from certain species of chrysanthemum flowers.

QUARANTINE A regulatory method to control the introduction and dissemination of plant and animal pests into new areas. Involves inspections, treatments, and destruction of contaminated plants/animals or their parts.

RATE OF APPLICATION The amount of pesticide applied to a plant, animal, unit area, or surface; usually expressed as per acre or per 1,000 square feet, linear feet, or cubic feet.

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

REGISTERED PESTICIDES Pesticide products that have been registered by the Environmental Protection Agency for the uses listed on the label.

REPELLENT A compound that keeps insects, rodents, birds, or other pests away from plants, domestic animals, buildings, or other treated areas.

RESIDUAL PESTICIDE A pesticide that continues to remain effective on a treated surface or area for an extended period following application.

RESIDUE The pesticide active ingredient or its breakdown product(s) that remain in or on the target site or in the environment after treatment. Pesticide residues may be on treated crops, feed products, or livestock that are moved from the treatment site.

RESISTANT A population of organisms that are uninjured or unaffected by a certain dosage of pesticide chemical used to successfully control other populations of the same organism. Also, plants and animals that are unaffected by a pest species. (See **TOLERANT.**)

RESTRICTED-ENTRY INTERVAL (REI) The amount of time that must elapse between treatment of the crop and the time when a person can reenter and handle the crop without wearing protective clothing and equipment or receiving early-entry training. Also referred to as **REENTRY INTERVAL.**

RESTRICTED-USE PESTICIDE A pesticide that can be purchased only by certified pesticide applicators and used only by certified applicators or persons under their direct supervision. Not available for use by the general public because of high toxicities and/or environmental hazards.

RINSATE A liquid obtained from rinsing pesticide containers and application equipment.

RODENTICIDE A chemical used to control rodents.

ROTARY SPREADER A common type of granular application equipment that distributes the granules to the front and sides of the spreader, usually by means of a spinning disk or fan.

RTU (ready-to-use) Low-concentrate formulations that are ready to use and require no further dilution before application.

RUNOFF The movement of water and associated materials on the soil surface.

SAFENER An adjuvant used to reduce the phytotoxic effects of a pesticide.

SAPROPHYTE An organism that obtains its food from dead or decaying organic matter.

SATURATED ZONE The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water.

SECONDARY PEST A pest that becomes a serious problem when a key pest or natural enemy is controlled or eliminated.

SEED PROTECTANT A pesticide applied to seeds before planting to protect them from insects, fungi, and other soil pests.

SELECTIVE PESTICIDE A pesticide that is toxic to some pests but has little or no effect on other similar species. Example: some fungicides are so selective that they control only powdery mildews and no other fungi.

SERVICE CONTAINER A container designed to hold concentrate or diluted pesticide mixtures; not the original pesticide container.

SHELF LIFE The maximum period of time that a pesticide concentrate can remain in storage before losing some of its effectiveness.

SIGNAL WORDS Words that are required to appear on every pesticide label to denote the relative acute toxicity of the product. The signal words are DANGER—POISON used with a skull and crossbones symbol for potentially lethal products, DANGER for severe skin and eye damage, WARNING for moderately toxic, or CAUTION for slightly toxic compounds.

SILVICIDE A herbicide used to destroy brush and trees.

SITE The crop, animal, structure, commodity, or area where a pesticide is applied to control pests.

SLURRY A thick suspension of a pesticide made from a wettable powder and water.

SOIL APPLICATION A pesticide applied directly on or in the soil rather than on a growing plant.

SOIL DRENCH To soak or wet the ground surface with a pesticide. Large volumes of the pesticide mixture are usually needed to saturate the soil to any depth.

SOIL INCORPORATION The movement of a pesticide into soil by either mechanical means or irrigation.

SOIL INJECTION The placement of a pesticide below the surface of the soil. This is a common application method for fumigants and termiticides.

SOIL RESIDUAL PESTICIDE A chemical or agent that prevents the growth of all organisms present in the soil; a non-selective pesticide. Soil persistence may be temporary or permanent, depending on the chemical.

SOLUBILITY The ability of a chemical such as a pesticide to dissolve in a solvent, usually water.

SOLUBLE POWDER A finely ground dry pesticide formulation that will dissolve in water or some other liquid carrier.

SOLUTION Mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are completely dissolved. Example: sugar in water.

SOLVENT A liquid such as water, oil, or alcohol that will dissolve another substance (solid, liquid, or gas) to form a solution.

SPACE SPRAY A pesticide applied as a fine spray or mist to a confined area.

SPORE The reproductive unit of a fungus. A spore is analogous to a plant seed.

SPOT TREATMENT An application to a small, localized area where pests are found.

SPRAY DEPOSIT The amount of pesticide chemical that remains on a sprayed surface after the droplets have dried.

SPREADER An adjuvant used to enhance the spread of a pesticide over a treated surface, thus improving the coverage.

STABILITY Refers to the ability of a chemical such as a pesticide to resist breaking down into metabolites. A highly stable pesticide can be stored for long periods without loss of activity.

STATE LEAD AGENCY (SLA) The agency within a state or territory designated by the EPA as having the authority for carrying out the provisions of FIFRA.

STERILANT A pesticide that prevents pests from reproducing.

STICKER An adjuvant used to improve the adherence of spray droplets to a plant, animal, or other treated surface.

STOMACH POISON A pesticide that must be eaten by an animal to be effective—it will not kill on contact.

STRUCTURAL PESTS Pests that attack and destroy buildings and other structures, clothing, stored food, and manufactured/processed goods. Examples: termites, cockroaches, clothes moths, rats, dry-rot fungi.

SUMMER ANNUAL Plants that germinate in the spring or summer and complete their life cycle within one year.

SUPPLEMENTAL LABELING EPA-approved written, printed, or graphic material supplied by the pesticide manufacturer that provides additional product information not present on the current container label. The additional information may include new application sites and rates, safety guidelines, Worker Protection Standard and PPE requirements, and endangered species advisories.

SURFACTANT An inert ingredient that improves the spreading, dispersing, and/or wetting properties of a pesticide mixture.

SUSCEPTIBLE A plant, animal, or site that is affected by a pest. Also refers to pest populations that can be controlled by pesticides.

SUSPENSION A pesticide mixture consisting of fine particles dispersed or floating in a liquid, usually water or oil. Example: wettable powders or flowables in water.

SWATH The width of the area covered by one sweep of an airplane, ground sprayer, spreader, or duster.

SYMPTOM Any detectable change in an organism resulting from the activities of a pathogen or other pest. Also, an indication of pesticide poisoning in humans and other animals.

SYNERGISM The effect of two or more pesticides applied together that is greater than the sum of the individual pesticides applied separately. Example: Pesticide X kills 40 percent of an insect population; Pesticide Y kills 20 percent. When applied together, X and Y kill 95 percent.

SYSTEMIC EFFECTS Poisoning effects that occur at sites other than the entry point into the body.

SYSTEMIC PESTICIDE A chemical that is absorbed and translocated within a plant or animal.

TANK MIX A mixture of products in a spray tank.

TARGET The plants, animals, structures, areas, or pests at which the control method is directed.

TECHNICAL MATERIAL The pesticide active ingredient in pure form as it is manufactured by a chemical company. It is usually combined with inert ingredients or additives in formulations such as wettable powders, dusts, emulsifiable concentrates, or granules.

TEMPERATURE INVERSION A weather-related event that occurs when cool air is trapped near the surface under a layer of warm air. Under these conditions very little vertical mixing of air occurs, and small spray droplets or vapors may remain suspended in the cool air layer for long periods and move with any air flow. Damage from spray drift often occurs under such conditions.

TERATOGEN A substance or agent able to produce abnormalities or defects in living human or animal embryos and fetuses. These defects are not usually inheritable.

TERMITICIDE An insecticide used to control termites.

THICKENER A drift control adjuvant such as cellulose or gel used to promote the formation of a greater proportion of large droplets in a spray mixture.

TOLERANCE The maximum amount of a pesticide residue that may legally remain on or in food or feed commodities at harvest or slaughter; established by the EPA for each crop and every pesticide used on a specific crop.

TOLERANT A characteristic of organisms (including pests) that are able to withstand a certain degree of stress such as weather, pesticides, or attack by a pest.

TOXIC Poisonous to living organisms.

TOXICANT A poisonous substance such as the active ingredient in a pesticide formulation.

TOXICITY The degree or extent to which a chemical or substance is poisonous.

TOXICOLOGY The study of the effects of toxic substances on living organisms.

TOXIN A naturally occurring poison produced by plants, animals, or microorganisms. Examples: the poison produced by the black widow spider, the venom produced by snakes, the botulism toxin.

TRADE NAME A brand name that is registered as a trademark by the manufacturer.

TRANSLOCATION The movement of materials within a plant or animal from the site of entry. A systemic pesticide is translocated.

TRANSPORTATION SECURITY PLAN A plan required of all operations that transport pesticides in containers that are larger than 119 gallons or in quantities greater than 1,000 pounds. The U.S. Department of Transportation requires that the plan include protection against unauthorized access, a security check for employees that pick up and transport placarded hazardous materials, and a security plan for the intended travel route. Vehicles that transport pesticides in these quantities must be placarded (see **PLACARDS**).

TRIPLE-RINSE The process of decontaminating an empty pesticide container by partially filling the container with water, replacing the lid, shaking the container, and then pouring the rinsate in the spray tank. This process is repeated three times.

ULTRA-LOW VOLUME (ULV) Sprays that are applied at 0.5 gallon or less per acre, often as the undiluted formulation.

UNCLASSIFIED PESTICIDES Pesticides that are commonly referred to as general-use pesticides. They can be bought and used by the general public without special permits or restrictions.

USDA United States Department of Agriculture.

VAPOR DRIFT The movement of chemical vapors from the application site. Like pesticide spray drift, vapor drift can injure non-target plants or animals.

VAPOR PRESSURE The property that causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical—the easier it will evaporate.

VECTOR An animal (e.g., insect, nematode, mite) or plant (e.g., dodder) that can carry and transmit a pathogen from one host to another.

VERTEBRATE An animal characterized by a segmented backbone or spinal column.

VIRUS Ultramicroscopic parasites. Viruses can multiply only in living tissues and cause many animal and plant diseases.

VOLATILITY The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

WARNING A signal word used on pesticide products that are considered moderately toxic; these pesticides have an oral LD_{50} between 50mg/kg and 500mg/kg or a dermal LD_{50} between 200 and 2,000mg/kg.

WATER-DISPERSIBLE GRANULE A dry, granular formulation that breaks apart and disperses to form a suspension when added to water. (See **DRY FLOWABLE**.)

WATER-SOLUBLE CONCENTRATE A liquid pesticide formulation that dissolves in water to form a true solution.

WATER-SOLUBLE PACKET Wettable powder or soluble powder formulations packaged in a special type of plastic bag that dissolves and releases its contents when placed in water.

WATER TABLE The boundary between the overlying unsaturated rock or soil and the saturated zone.

WEED A plant growing where it is not wanted or where it is in direct conflict with the well-being of humans and their activities.

WETTABLE POWDER A dry pesticide formulation in powder form that forms a suspension when added to water.

WETTING AGENT An adjuvant used to reduce the surface tension between a liquid and the contact surface for more thorough coverage.

WINTER ANNUAL Plants that germinate in the fall and complete their life cycle within one year.

WORKER PROTECTION STANDARD (WPS) A federal regulation that intends to reduce the risk of pesticide poisoning and injuries among agricultural workers and handlers. The WPS requires agricultural employers to provide protections to workers and handlers, including but not limited to: safety training, posting of application sites, and decontamination supplies.

APPENDIX C

CONVERSIONS & CALCULATIONS

Effective application of pesticides depends on many factors. One of the more important is to correctly calculate the amount of material needed. Unless you have the correct amount of pesticide in your tank mix, even a correctly calibrated sprayer can apply the wrong rate.

Manufacturers provide application rate instructions on every pesticide label. Due to the variety of ways in which these recommendations are stated (such as lbs. of active ingredient (a.i.) per acre, lbs. of formulation per 100 gal. of spray, or ozs, of a.i. per 1,000 sq. ft.) it is often necessary to adapt the recommendations to different areas and volumes, or even other units. Sometimes the amount of active ingredient must be converted to the amount of actual product. This process can be very confusing.

Conversion Factors

To use this conversion table, multiply the number in the left-hand column by the conversion factor in the center column. This converts your original number to the units in the right-hand column.

Examples:

1.0 gallon equals how many ounces?
1.0 gallon x 128 = 128 fluid ounces

2.5 gallons equals how many ounces?
2.5 gallons x 128 = 320 fluid ounces

Multiply	By	To get	Multiply	By	To get
Acres	43,560	Square feet	Gallons	128	Ounces (liquid)
Acres	4,840	Square yards	Gallons	8	Pints (liquid)
Acres	0.405	Hectares	Gallons	4	Quarts (liquid)
Bushels	64	Pints	Gallons, H_2O	8.345	Pounds of water
Bushels	32	Quarts	Grams	0.001	Kilograms
Cubic feet	1,728	Cubic inches	Grams	1,000	Milligrams
Cubic feet	0.037	Cubic yards	Grams	0.035	Ounces
Cubic feet	7.481	Gallons	Grams per liter	1,000	Parts per million
Cubic feet	59.84	Pints (liquid)	Hectares	2.47	Acres
Cubic feet	29.92	Quarts (liquid)	Inches	2.54	Centimeters
Cups	8	Ounces (liquid)	Kilograms	1,000	Grams
Cups	16	Tablespoons	Kilograms	2.205	Pounds
Feet	30.48	Centimeters	Kilometers	3,281	Feet
Feet	12	Inches	Kilometers	0.621	Miles
Feet	0.305	Meters	Liters	0.264	Gallons
Feet	1/3 or 0.333	Yards	Liters	2.113	Pints (liquid)
Gallons	3.785	Liters	Liters	1.057	Quarts (liquid)

Multiply	By	To get	Multiply	By	To get
Meters	100	Centimeters	Pints (liquid)	0.5	Quarts (liquid)
Meters	3.281	Feet	Pounds	453.592	Grams
Meters	39.37	Inches	Pounds	16	Ounces
Meters	0.001	Kilometers	Pounds	0.0005	Tons
Meters	1,000	Millimeters	Quarts	2	Pints
Meters	1.094	Yards	Quarts	0.25	Gallons
Miles	5,280	Feet	Quarts	0.946	Liters
Miles	1,760	Yards	Quarts (liquid)	32	Ounces (liquid)
Miles per hour	88	Feet per minute	Quarts (liquid)	2	Pints (liquid)
Miles per hour	1.467	Feet per second	Rods	16.5	Feet
Miles per minute	88	Feet per second	Square miles	640	Acres
Miles per minute	60	Miles per hour	Square yards	9	Square feet
Ounces (dry)	28.35	Grams	Square yards	1,296	Square inches
Ounces (dry)	0.063	Pounds	Tablespoons	3	Teaspoons
Ounces (liquid)	0.063	Pints (liquid)	Temperature		
Ounces (liquid)	0.031	Quarts (liquid)	(°C) + 17.98	1.8	Temperature °F.
Parts per million	0.001	Grams per liter	Temperature		
Pecks	16	Pints (dry)	(°F) – 32	0.555	Temperature °C.
Pecks	8	Quarts (dry)	Tons	907.185	Kilograms
Pints	0.125	Gallons	Tons	2,000	Pounds
Pints	0.473	Liters	Yards	3	Feet
Pints	2	Cups	Yards	36	Inches
Pints (liquid)	16	Ounces (liquid)	Yards	0.914	Meters

PESTICIDE CALCULATIONS

Formulations such as wettable and soluble powders, emulsifiable concentrates, and flowables are sold as concentrates and must be diluted in the spray tank with an appropriate carrier. Water is the most common carrier, but kerosene, oil, and other liquids are sometimes used. Below are examples of how to properly calculate how much pesticide should be added to a spray tank.

Mixing Soluble and Wettable Powders

Pounds per 100 gallons Directions for wettable or soluble powders may be given in pounds of pesticide formulation per 100 gallons of carrier. You must know the capacity in gallons of your spray tank (or the number of gallons you will be adding to your spray tank if the job requires only a partial tank load). Then use the following formula:

$$\frac{\textbf{Gallons in tank} \times \textbf{Pounds per 100 gallons recommended}}{\textbf{100 gallons}} = \textbf{Pounds needed in tank}$$

Example:

Your spray tank holds 500 gallons. The label calls for 2 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank?

$$\frac{\text{500 gallons} \times \text{Pounds per 100 gallons (2)}}{\text{100 gallons}} = \text{Pounds needed in tank (10)}$$

500 X 2 ÷ 100 = 10

You should add 10 pounds to the tank.

Example:

You need to spray only one acre and your equipment is calibrated to spray 60 gallons per acre. The label calls for 2 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank to make 60 gallons of finished spray?

$$\frac{\text{Gallons in tank (60)} \times \text{Pounds per 100 Gallons (2)}}{\text{100 gallons}} = \text{Pounds needed in tank (1.2, or 19 oz)}$$

60 X 2 ÷ 100 = 1.2

Number of pounds to add is 1.2, or 19 oz.

Pounds per acre The label may list the recommended dosage as pounds per acre. If the job requires a full tank, you must know how many gallons your equipment applies per acre and spray tank capacity. Use these formulas:

$$\frac{\text{Gallons in tank}}{\text{Gallons applied per acre}} = \text{Acres sprayed per tankful}$$

Acres sprayed per tank X Pounds formulation per acre = Pounds formulation needed in tank

Example:
Your sprayer applies 15 gallons per acre and your tank holds 400 gallons. The label rate is 3 pounds of formulation per acre.

$$\frac{\text{Gallons in tank (400)}}{\text{Gallons per acre (15)}} = \text{Acres sprayed per tankful (26.7)}$$

400 ÷ 15 = 26.7

Acres sprayed per tankful (26.7) X Pounds formulation per acre (3) = Pounds formulation needed in tank (80.1)

26.7 X 3 = 80.1

Add 80 pounds of pesticide formulation to the tank.

If the job requires less than a full tank, you must know how many acres you wish to treat and how many gallons your sprayer is pumping 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 wish to spray 3.5 acres and your equipment is applying 15 gallons per acre. The label rate is 3 pounds per acre.

Gallons per acre (15) X Acres to be treated (3.5) = Gallons needed in tank (52.5)

15 X 3.5 = 52.5

Acres to be treated (3.5) X Pounds formulation per acre (3) = Pounds formulation needed in tank (10.5)

3.5 X 3 = 10.5

If the recommended dosage 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:

$$\frac{\text{Pounds of a.i. per acre X 100}}{\text{Percent of a.i. in formulation}} = \text{Pounds formulation per acre}$$

Then follow the formulas listed above under "pounds per acre" to find the pounds of formulation to add to your tank.

Example:
You wish to apply 2 pounds of active ingredient per acre. Your formulation is 80 percent WP.

$$\frac{\text{Pounds of a.i. per acre (2) X 100}}{\text{Percent a.i. in formulation (80)}}$$

= Pounds formulation per acre (2.5)

2 X100 ÷ 80 = 2.5

Mixing Liquid Formulations

Rates for liquid formulations (EC, F, etc.) are often listed as pints, quarts, or gallons per 100 gallons or per acre. Make these calculations as you did above for pounds per 100 gallons or pounds per acre, but in the formulas substitute the appropriate liquid measure for "pounds."

Example:
The label rate is 2 pints of pesticide formulation per 100 gallons of water. Your spray tank holds 300 gallons.

$$\frac{\text{Gallons per tank (300) X Pints per 100 gallons (2)}}{\text{100 gallons}}$$

= Pints formulation needed in tank (6)

300 X 2 ÷ 100 = 6

Example:
Your sprayer applies 22 gallons per acre and your tank holds 400 gallons. The label rate is 1.5 quarts per acre.

$$\frac{\text{Gallons in tank (400) X Quarts per acre (1.5)}}{\text{Gallons per acre (22)}}$$

= Quarts needed in tank (27.3)

400 X 1.5 ÷ 22 = 27.3

If the recommendation for a liquid formulation is listed as pounds of active ingredient per acre, you must first convert that figure to gallons of formulation to apply per acre. The label of a liquid formulation always tells how many pounds of active ingredient are in one gallon of the concentrated formulation (4 EC has 4 pounds of active ingredient per gallon; 6 EC contains 6 pounds per gallon, etc.)

$$\frac{\text{Pounds of a.i. needed per acre}}{\text{Pounds of a.i. per gallon of formulation}} = \text{Gallons of formulation per acre}$$

Example:
The recommendation is for 1 pound of active ingredient per acre. You purchased an 8 EC, which contains 8 pounds of active ingredient per gallon. Your tank holds 500 gallons and is calibrated to apply 25 gallons per acre.

$$\frac{\text{Pounds a.i. to apply per acre (1)}}{\text{Pounds a.i. per gallon (8)}} = \text{Gallons per acre (1/8, or 1 pint)}$$

1 ÷ 8 = 0.125 (1/8)

$$\frac{\text{Gallons in tank (500)}}{\text{Gallons per acre (25)}} = \text{Acres per tankful (20)}$$

500 ÷ 25 = 20

Acres per tankful (20) X Gallons per acre (1/8 or .125) = Gallons to add to tank (2.5)

20 X .125 = 2.5

Square Feet vs. Acre Mixing

The label rate is sometimes given in pounds, pints, quarts, or gallons per 1,000 square feet. If you have calibrated your equipment in terms of 1,000 square feet, you must adjust the formulas above from an acre to 1,000 square feet. The following formulas may be used with either liquid or dry formulations:

$$\frac{\text{Gallons per tank}}{\text{Gallons applied per 1,000 square feet by equipment}} = \text{Number of 1,000 square feet sections per tankful}$$

Number of 1,000 square feet sections sprayed per tankful X pints, quarts, gallons, or pounds of formulation needed per 1,000 square feet = Amount of formulation to add to tank.

However, if you have calculated the area you are to treat in acres, you must convert the 1,000-square-foot rate to a rate per acre as follows:

$$\frac{\text{43,560 (sq. ft. per acre)}}{\text{1,000 square feet}} = 43.5$$

Pints, quarts, gallons, or pounds per 1,000 square feet X 43.5 = Pints, quarts, gallons, or pounds of formulation to apply per acre

To convert from the rate per acre to a rate per 1,000 square feet (or 100 square feet):

$$\frac{\text{Pints, quarts, gallons, or pounds of formulation recommended per acre}}{\text{43.5 (435 for 100 sq. ft.)}} = \text{Pints, quarts, gallons, or pounds of formulation per 1,000 square feet (or 100 sq. ft.)}$$

From Penn State *Pesticide Education Manual*, third edition

The section on conversion tables was adapted from the *Pocket Pesticide Calibration Guide*, compiled by Frank Boys and Frank Murphey, University of Delaware.

The section on pesticide calculations was adapted from *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators*, North Carolina State University.

APPENDIX D

Additional Federal Pesticide Laws & Federal Record-keeping Requirements

In addition to the laws and regulations discussed in Chapter 2, there are other federal statutes that affect the use, storage, transport, disposal, and marketing of pesticides. Some of these laws and regulations fall under the jurisdiction of the U.S. Environmental Protection Agency; others are the responsibility of other federal agencies. Further WPS and record-keeping requirements are also discussed here to supplement the discussion in Chapter 2.

WORKER PROTECTION STANDARD (WPS)

The U.S. Environmental Protection Agency's Worker Protection Standard, as amended in 1995, is a regula-tion aimed at reducing the risk of pesticide poisonings, injuries, and exposure to workers and pesticide handlers in agriculture. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these requirements include owners/operators of agricultural establishments and owners/operators of commercial businesses that are hired to apply pesticides on agricultural establishments or to perform crop-advising tasks on such establishments. The WPS helps protect workers and pesticide handlers who are agricultural employees on farms and in forests, nurseries, and greenhouses from occupational exposure to agricultural pesticides.

Pesticide handlers

Pesticide handlers under WPS are those individuals who mix, load, or apply agricultural pesticides; clean or repair pesticide application equipment; or assist with the application of pesticides.

Agricultural workers

Agricultural workers under WPS are those individuals (e.g., weeders, irrigators, pruners, and harvesters) who perform tasks related to the cultivation and harvesting of plants on farms or in greenhouses, nurseries, or forests. Workers include anyone employed for any type of compensation (including self-employed) to do tasks—such as carrying nursery stock, repotting plants, or watering—related to the production of agricultural plants on an agricultural establishment.

Agricultural workers do NOT include such employees as office staff, truck drivers, mechanics, and any other workers not engaged in worker/handler activities.

The WPS requires agricultural employers to provide:

Personal protective equipment—Personal protective equipment must be provided and maintained for handlers and early-entry workers.

Notification of workers—Workers must be notified about treated areas so they may avoid inadvertent exposures.

Decontamination supplies—Handlers and workers must have an ample supply of water, soap, and towels for routine washing and emergency decontamination.

Emergency assistance—Transportation to a medical care facility must be made available if a worker or handler may have been poisoned or injured. Information must be provided about the pesticide to which the person may have been exposed.

Pesticide safety training and safety posters—Training is required for all workers and handlers, and a pesticide safety poster must be displayed.

Access to labeling and site-specific information—Handlers and workers must be informed of pesticide label requirements. Central posting of recent pesticide applications is required.

The WPS also establishes a restricted-entry interval (REI), which is the time immediately after a pesticide application during which an individual cannot enter the treated area. Each pesticide that is registered for use on sites falling under the provisions of the WPS has an established REI that appears on the label. The REI is based on the toxicity classification of the pesticide.

The EPA has allowed for an exception to the WPS that permits workers, under specified conditions, to enter pesticide-treated areas during a restricted-entry interval (REI) to perform tasks that involve limited contact with pesticide-treated surfaces. This exception allows workers the flexibility during an REI to perform limited-contact tasks that could not have been foreseen and which, if delayed, would cause significant economic loss. At the same time, the exception includes significant provisions to limit pesticide exposure and risk to employees performing limited-contact tasks. Check the WPS regulation for the provisions of the exception to allow limited-contact early-entry activities.

Pesticide labels contain specific information—under the section "Agricultural Use Requirements"—on compliance with the WPS. In addition to general information about compliance with the WPS, this section of the label contains specific information about the required personal protective equipment that must be worn, type of notification that must be given to workers, and the restricted-entry interval (REI) for that particular product. Further information on the WPS requirements can be obtained from www.epa.gov/pesticides.

FIELD SANITATION STANDARD

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, hand-washing facilities, and clean drinking water. The standard also requires the employers to inform each employee about the following good hygiene practices:

- Use the water and facilities provided for drinking, hand-washing, and elimination.
- Drink water frequently, especially on hot days.
- Urinate as often as necessary. Wash hands both before and after using the toilet.
- Wash hands before eating and smoking.

HAZARDOUS MATERIALS TRANSPORTATION UNIFORM SAFETY ACT (HMTUSA)

The Hazardous Materials Transportation Uniform Safety Act (HMTUSA, 1990) relates to transporting pesticides. Shipment of pesticides and other dangerous substances across state lines is regulated by the U.S. Department of Transportation (DOT). The DOT issues the rules for transporting these materials. If you ever transport pesticides between states, you should know that:

- The pesticides must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a DOT-approved sign.
- The pesticides may not be hauled in the same vehicle with food or feed products or with packaging material intended for use with such products.
- You must contact DOT immediately after each accident when someone is killed, when someone is injured badly enough to go to a hospital, or when damage is more than $50,000.
- You must tell DOT about all spills during shipment.

Contact the state, tribal, or territorial DOT office for detailed information on which pesticides are listed as hazardous substances and what rules apply to them during transport.

HAZARD COMMUNICATION STANDARD (HCS)

Under the U.S. Department of Labor, the Occupational Safety and Health Administration (OSHA) is responsible for enforcing the provisions of the Hazard Communication Standard (HCS), better known as the Federal Worker Right-to-Know law. This law is designed to protect employees who handle, use, or may be exposed to hazardous chemicals (including pesticides) in the workplace as part of their normal job duties. With the exception of farms, the HCS covers all employers with one or more employees; farms employing the equivalent of 10 or more full-time employees are covered.

The requirements of the HCS fall into the following categories:

Chemical inventory—Employers must compile a list of all hazardous chemicals in their workplace.

Material safety data sheets—MSDS for each hazardous chemical in the workplace must be kept on file where employees can review them without having to ask permission.

Warning labels—Each container of hazardous chemical must be labeled, tagged, or marked with the identity of its contents, appropriate hazard warnings for employee protection, and the name of the chemical manufacturer.

Training—Employers must conduct an information and training program for employees exposed to hazardous chemicals. This training must in-clude a review of the HCS, where MSDS are filed and how to inter-pret the information on an MSDS, the health effects of the hazardous chemicals in the workplace, where personal protective equipment is kept and when it is used, employee work practices to minimize exposure to chemicals, and chemical spill response procedures.

Written Hazard Communication Program—The written program must include the policies and procedures used at the facility to ensure that the requirements of the HCS are met.

States, tribes, and territories often have their own worker right-to-know provisions, which may be more stringent than the federal HCS. Contact your state, tribal, or territorial authority about applicable requirements.

FEDERAL OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA)

The Occupational Safety and Health Act contains requirements for all employers to keep records of all work-related deaths, injuries, and illnesses. This law is administered by the U.S. Department of Labor. Employers must make periodic reports about any employee who seeks medical treatments, loses consciousness, is restricted from work or motion, or transfers to another job. Employers do not have to report situations in which only first-aid treatment is required. In addition, this act requires investigation of employee complaints related to exposure to hazardous materials, including pesticides.

SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA TITLE III)

On October 17, 1986, the Superfund Amendments and Reauthorization Act (SARA), was signed into law. This act is administered by the US EPA and revises and extends the authorities established under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Commonly known as Superfund, CERCLA provides authority for federal cleanup of uncontrolled hazardous waste sites and response to spills or accidental releases of hazardous substances. Title III of SARA, also known as the Emergency Planning and Community Right-to-Know Act of 1986, is intended to encourage and support emergency planning efforts at the state and local levels and to provide the public with information on potential chemical hazards present in their communities.

Title III is subdivided into three parts. Subtitle A establishes the framework for local emergency planning. Subtitle B provides the mechanism for community awareness of hazardous chemicals present in the community—i.e., it requires submission of material safety data sheets, emergency and hazardous chemical inventory forms, and toxic chemical release forms to state and local governments. Only those businesses regulated under the Occupational Safety and Health Administration (OSHA) are subject to the requirements of Subtitle B, whereas any person or business storing or using specific quantities of certain chemicals must comply with the requirements of Subtitle A. (Note that agricultural operations, such as farms, are not exempt from the requirements of Subtitle A.) Subtitle C contains general provisions on trade secret protection, enforcement, and public availability of information.

Emergency Planning

The Environmental Protection Agency (EPA) has compiled a list of chemicals that could cause serious, irreversible health effects through accidental releases. These are designated "extremely hazardous substances." Any facility (defined as "all buildings, equipment, structures, and other stationary items located on a single site or on contiguous or adjacent sites and owned or operated by the same person") where an extremely hazardous substance is present in an amount in excess of the threshold planning quantity (TPQ) is required to notify your state's emergency response agency.

Emergency Release Notification

Associated with each designated extremely hazardous substance is a reportable quantity (RQ). This section of the regulation requires reporting of an accidental release (such as a spill) of any extremely hazardous substance if the release involves an amount equal to or greater than the RQ, and the release is not confined to the facility. Accidental spills and releases, such as those while

in transit are generally first reported to local emergency responders (i.e., state police, 911) before being reported to other state and local authorities.

Penalties

Any person who fails to comply with the requirements under this provision is subject to civil penalties of up to $25,000 for each violation and up to $25,000 for each day during which the violation continues, in accordance with sections 325 (b)(1) and 25(b)(2) of the act. A person who knowingly and willfully fails to provide notice may, upon conviction, be fined up to $25,000 or imprisoned for up to two years, or both. In the case of a subsequent conviction, he or she may be fined up to $50,000 or imprisoned for up to 5 years, or both.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The U.S. Environmental Protection Agency regulates wastes under the Resource Conservation and Recovery Act (RCRA) also enacted in 1976. The EPA issues a list of materials that are considered hazardous. The RCRA also applies to certain flammable, corrosive, reactive, or toxic wastes, even if they are not on the list. Therefore, some pesticides could be "regulated hazardous wastes" under the RCRA.

"Wastes" include unrinsed containers, excess pesticides and pesticide dilutions, and rinse water and wash water that contain a listed chemical and cannot be used. Triple-rinsed pesticide containers are not considered hazardous waste under the RCRA, and as a result, they can be disposed of in sanitary landfills.

The RCRA regulates pesticide users who accumulate wastes of acutely toxic pesticides totaling 2.2 pounds or more per month or wastes of any RCRA-regulated pesticides totaling 2,200 pounds per month. Any such user must register as a generator of hazardous waste, obtain an ID number from the EPA, and follow certain disposal requirements.

States, tribes, and territories often have their own hazardous waste laws, which may be more stringent than the RCRA. Contact your state, tribal, or territorial authority about applicable requirements.

FEDERAL AVIATION ADMINISTRATION

Application of pesticides from aircraft is regulated by the Federal Aviation Administration (FAA) and may be regulated by your state. The FAA judges both the flying ability of pilots and the safety of their aircraft. FAA rules say, as FIFRA does, that an aerial applicator may not apply any pesticide except as the labeling directs.

FEDERAL TRADE COMMISSION ACT

The Federal Trade Commission Act (FTC), under Section 5 of the Act, prohibits unfair, misleading, or deceptive (unsubstantiated) advertising practices (similar to "claims differ" or misbranding violations under FIFRA but without product sales and distribution). In the past, the FTC has been concerned primarily with safety-related claims for pesticides that may lead consumers to believe that the pesticide is less hazardous than the toxic data indicate or as indicated by the warning or precautionary statements (e.g., claims of absolute human or environment safety such as "safe," "non-hazardous," or "no danger"). The FTC handles claims that use dangling or incomplete safety comparisons that do not inform consumers or provide the basis of the comparison or the characteristics being compared (e.g., "safer," "less toxic," or "less hazardous"). The FTC is also concerned with claims that contradict or

are inconsistent with the label's safety instructions (e.g., "easy to use," when, in fact, the label contains lengthy and detailed use procedures, or "no special protective clothing needed," when the label warns the user to avoid contact with eyes or skin).

This act also gives the FTC authority over the language used by pest control businesses (e.g., structural and lawn and landscape) in their advertising and marketing programs regarding pest control services and the pesticides that may be used as part of the service.

RECORD-KEEPING REQUIREMENTS FOR COMMERCIAL APPLICATORS

Under FIFRA, Section 11 and 26(c), EPA requires commercial applicators to maintain records. Current federal regulations specify that commercial applicators must record information on the kinds, amounts, uses, dates, and places of applications of restricted-use pesticides. The pesticide regulatory authority for your area (i.e., EPA, other federal agencies, states, tribes, territories, or other regulatory agencies) may require that commercial applicators keep the following pieces of information on applications:

- The name and address of the person for whom the pesticide was applied.
- The location of the pesticide application.
- The pest being controlled.
- The crop, commodity, or site where the pesticide was applied.
- The date and time of each application.
- The trade name and EPA registration number of the pesticide applied.
- The amount of the pesticide applied and the percentages of active ingredient per unit of the pesticide used.
- The type and amount of pesticide disposed of, method of disposal, date of disposal, and location of disposal site.

Federal regulations require that records be retained for two years, and be made available to pesticide regulatory officials upon request. Related sections of FIFRA give the EPA the authority to inspect both the books and records and the establishments of commercial pesticide applicators.

States, tribes, territories, and other agencies often have their own record-keeping requirements for commercial applicators, which may be more stringent than federal standards. Contact your state, tribe, territory, or agency about applicable requirements.

FEDERAL PESTICIDE RECORD-KEEPING PROGRAM FOR PRIVATE APPLICATORS

The United States Department of Agriculture, Agricultural Marketing Service (USDA AMS) administers the federal Pesticide Record-Keeping Program, which requires all certified private applicators to keep records of their use of federally restricted-use pesticides for a period of two years.

The federal Pesticide Record-Keeping Program was authorized by the Food, Agriculture, Conservation, and Trade Act of 1990, commonly referred to as the 1990 Farm Bill. Under this law, all certified private pesticide applicators who have no requirement through state regulations to maintain restricted-use pesticide records must comply with the federal pesticide record-keeping regulations. Certified private pesticide applicators who are required to maintain records of restricted-use pesticide applications under state regulations

will continue to keep their records as required by their state.

The pesticide record-keeping regulations require the certified private pesticide applicator to record the following within 14 days of the application:

- The brand or product name (trademark name) of the pesticide being used.
- The EPA registration number. The registration number is not the same as the EPA establishment number, which is also located on the label.
- The date of the pesticide application, including month, day, and year.
- The location of the restricted-use pesticide application (not the address of the farm or business). Options are by county, range, township, or section; identification system established by the USDA, such as plat IDs used by the Farm Service Agency (FSA) or the Natural Resources Conservation Service (NRCS); legal property description, as listed on the deed of trust or county/city records; or an applicator-generated identification system that accurately identifies the location of the application.
- Crop, commodity, stored product, or site being treated.
- Size of the area treated. Record this information in the unit of measure (such as acres, linear feet, bushels, cubic feet, number of animals, etc.) that is normally expressed on the label in reference to the application being made.
- The name of the private applicator performing and/or supervising the application.
- The certification number of the private applicator. If the name of the private applicator and the certification number are kept together, this information has to be listed only once. (Note: the name and certification number may be noted at the front of a record book if the same applicator is making the applications.)

If you apply restricted-use pesticides on the same day in a total area of less than 1/10 acre (e.g., spots treatments of noxious weeds), you are required to record the following:

- Date of application—month, day, and year.
- Brand or product number.
- EPA registration number.
- Total amount of pesticide applied.
- Location of the pesticide application, designated as "spot application," and a short description.

The spot treatment provision e*xcludes greenhouse and nursery applicators*, who must keep all records required by the private applicator record-keeping law.

Attending licensed healthcare professionals or those acting under their direction, USDA representatives, and state regulatory representatives with credentials have legal access to the records. No standard federal form is required, so that pesticide record-keeping can be integrated into the applicator's current record-keeping system.

If you do not comply with the record-keeping requirements, you may be fined up to $550 for a first offense and not less than $1,100 for any later offense (unless it is determined that you have made a good-faith effort to comply).

RECORD-KEEPING REQUIREMENTS UNDER THE WORKER PROTECTION STANDARD

The Worker Protection Standard (WPS) requires agricultural employers to make pesticide application information available in a central location. The following information must be posted: the location and description

of the treated area; the product name and EPA registration number; the active ingredient and restricted-entry interval of the pesticide; and the time and date of application. Thus, pesticide applicators should provide such information to the agricultural employer of the establishment.

Though not required by federal law, applicators should consider maintaining application records for all pesticide applications, both general- and restricted-use. In addition, you should consider maintaining information on the weather conditions (i.e., temperature, wind speed, and wind direction) at the site of application, along with measures that may have been used to minimize spray drift. In addition to pesticide application records, applicators should consider keeping documentation on employee training in the use of pesticides. Though not required by federal law through the provisions of either FIFRA or the WPS, this documentation can help substantiate that employees received initial training on the proper use of pesticides when they were hired. In the case of WPS, it will help document that the mandatory training requirements were satisfied. Information such as each employee's name, Social Security number, or work identification number, and the date the training was completed should be maintained as part of the training records. Having the employee sign and date the training record should also be considered to verify that he/she received the training. Another type of employee training record that should be considered is documentation on the training materials and sources of the materials that were used. This same documentation should be considered for the employee's initial pesticide training and any additional or updated pesticide training the employee may receive. As with pesticide application records, states, tribes, territories, and other agencies often have their own record-keeping requirements on employee training. Contact your state, tribe, territory, or agency about applicable requirements.

APPENDIX E

PRACTICE EXAM

1. **Breeding or selecting plants and animals with characteristics for resistance to pests is an example of which type of pest management method?**

   A. Biological control.
   B. Mechanical control.
   C. Genetic control.
   D. Physical/environmental modification.

2. **Using a plow to destroy weeds is an example of which type of mechanical control method?**

   A. Exclusion.
   B. Trapping.
   C. Cultivation.
   D. Irrigation.

3. **Which statement is *true* about chemical control as a pest management method?**

   A. Pesticides play a key role in pest management programs and sometimes are the only control method available.
   B. Pesticides include any material that is applied to plants and the soil but not to water or harvested crops.
   C. A highly selective pesticide controls a wide variety of pests.
   D. Systemic pesticides are not absorbed by treated plants or animals.

4. **Which statement is *true* about pest management goals?**

   A. Pesticides are never used to prevent pests.
   B. Preventive and suppressive pest control goals are rarely combined.
   C. Cultivation and mowing of weeds are ways to prevent and suppress pest populations.
   D. Over large areas, eradication is a practical approach to pest control.

5. **Which term describes the pest population density that causes losses equal to the cost of control measures?**

   A. Economic threshold.
   B. Economic injury level.
   C. Action threshold.
   D. Pest threshold.

6. **Which would decrease the likelihood of pesticide resistance?**

   A. Increasing label dosages.
   B. Using pesticides from the same class of chemicals.
   C. Applying the pesticide over a wide area.
   D. Using pesticides with multiple sites of toxicity in an organism.

7. **Which federal law requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides?**

   A. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).
   B. Federal Food, Drug, and Cosmetic Act (FFDCA).
   C. Food Quality Protection Act (FQPA).
   D. Worker Protection Standard (WPS).

8. **What are the two main classifications of pesticides under FIFRA?**

   A. Organic and inorganic.
   B. General-use and unclassified use.
   C. Regulated and unregulated.
   D. Unclassified use and restricted-use.

9. **What is a tolerance as set by the EPA?**

   A. The maximum amount of pesticide residue that may legally remain on or in a commodity at the time of harvest or slaughter.
   B. The maximum amount of pesticide residue that workers may be exposed to during the course of an average workday.
   C. The minimum amount of pesticide residue that may remain on a crop during the growing season.
   D. The minimum amount of pesticide residue that may be consumed by a 150-pound person on a yearly basis.

10. **Which of the following sections under FIFRA could be used to allow the use of an unregistered pesticide to control an "emergency" pest problem?**

    A. Section 3.
    B. Section 18.
    C. Section 24 (c).
    D. Section 25 (b).

11. **The name "VIP No Pest 75WP" on a pesticide label indicates:**

    A. The chemical name and 75 percent inert ingredients formulated as a wettable powder.
    B. The brand name and 25 percent active ingredients, formulated as a wettable powder.
    C. The brand name and 75 percent active ingredients, formulated as a wettable powder.
    D. The chemical name and 25 percent active ingredients, formulated as a wettable powder.

12. **Which signal word appears on a label with a skull and crossbones symbol?**

    A. DANGER—POISON.
    B. DANGER.
    C. WARNING.
    D. CAUTION.

13. **Which statement is *true* about protective clothing and equipment statements?**

    A. Pesticide labels are very consistent in the type of information they contain on protective clothing and equipment.
    B. When a respirator is required, the model is always specified on the label.
    C. It is not necessary to follow all advice on protective clothing or equipment that appears on the label.
    D. If a pesticide label does not specifically mention a type of protective clothing or equipment that does not rule out the need for the additional protection or equipment.

14. **"This product is highly toxic to bees" is an example of which type of precautionary statement?**

    A. Acute toxicity hazard.
    B. Environmental hazard.
    C. Physical or chemical hazard.
    D. Agricultural use requirement.

15. Which is *true* about REIs (restricted-entry intervals)?

A. The pesticide manufacturer sets REIs
B. The REI statement is most often listed under "Non-agricultural use requirements."
C. REIs are not covered under the EPA's Worker Protection Standard (WPS).
D. If there are multiple REIs on a label, the REIs are usually found at the beginning of each use section for each crop.

16. How much active ingredient is there in a 20-pound bag of Atrazine 90DF?

A. 4 pounds.
B. 9 pounds.
C. 18 pounds.
D. 20 pounds.

17. What type of pesticide formulation consists of a liquid dispersed as droplets in another liquid and may require agitation?

A. Microencapsulated.
B. Solution.
C. Suspension.
D. Emulsion.

18. Which liquid pesticide formulation contains solid particles that do not dissolve in either water or oil and may contribute to abrasive wear of nozzles and pumps?

A. Ultra-low volume (ULV).
B. Invert emulsions.
C. Aerosols (A).
D. Flowables (F)/liquids (L).

19. Which dry/solid formulation requires constant agitation and may be abrasive to pumps and nozzles and cause them to wear out quickly?

A. Dusts (D).
B. Granules (G).
C. Wettable powders (WP).
D. Soluble powders (SP).

20. Which type of dry/solid pesticide formulation is always applied dry and can easily drift to non-target sites?

A. Dusts.
B. Granules.
C. Pellets.
D. Baits.

21. What type of formulation covers either a liquid or dry pesticide particle with plastic?

A. Pellets.
B. Microencapsulates.
C. Water-soluble packets.
D. Water-dispersible granules.

22. Which statement is *true* about adjuvants?

A. They possess pesticidal activity.
B. They must be registered by the U.S. Environmental Protection Agency.
C. Adjuvants often increase spray application problems.
D. Adjuvants are either premixed in the pesticide formulation or added to the spray tank mixture.

23. Which type of adjuvant increases the adhesion of solid particles to target surfaces?

A. Compatibility agents.
B. Stickers.
C. Drift retardants.
D. Defoaming agents.

24. Which equation reflects the relationship between pesticide safety concerns?

A. Hazard = toxicity x exposure.
B. Toxicity = hazard x exposure.
C. Exposure = hazard x toxicity.
D. Hazard = exposure x risk.

25. Which statement is *true* about the LD_{50} and LC_{50}?

- **A.** The LD_{50} and LC_{50} measure multiple toxic effects.
- **B.** The LD_{50} and LC_{50} translate directly to humans.
- **C.** The LD_{50} and LC_{50} measure the potential buildup of effects due to multiple exposures.
- **D.** The LD_{50} and LC_{50} measure acute toxicity.

26. Which signal word is associated with Hazard Class II (i.e., small to medium dose could cause death, illness, or skin, eye, or respiratory damage) and must have the Spanish word "Aviso" on the label?

- **A.** DANGER—POISON.
- **B.** DANGER.
- **C.** WARNING.
- **D.** CAUTION.

27. What should be done if cholinesterase levels fall significantly below baseline?

- **A.** Have the pesticide handler increase the use of personal protective equipment until the cholinesterase level builds back up again to normal levels.
- **B.** Remove the pesticide handler from pesticide exposure for at least one year.
- **C.** Remove the pesticide handler from pesticide exposure until such time as the cholinesterase level builds back up again to normal levels.
- **D.** Seek medical attention immediately for the pesticide handler and have them avoid mixing and loading pesticides for 48 hours after the last exposure.

28. What would be the first objective if dermal exposure to a pesticide has occurred?

- **A.** Get the victim to fresh air immediately.
- **B.** Administer artificial respiration.
- **C.** Rinse the pesticide off to prevent absorption.
- **D.** Apply a first-aid ointment to the affected area.

29. Which statement is *true* about inducing vomiting for a victim of oral pesticide exposure?

- **A.** Always induce vomiting after a victim has swallowed a pesticide.
- **B.** Induce vomiting with the victim lying flat on his back.
- **C.** Ipecac syrup is routinely recommended to induce vomiting.
- **D.** Before inducing vomiting, first give the victim at least 2 glasses of water to dilute the product.

30. What type of PPE should you wear during an application if large amounts of a pesticide could be deposited on your clothing over an extended period of time?

- **A.** A coverall made of a cotton-synthetic blend.
- **B.** A chemical-resistant suit made of rubber or plastic.
- **C.** A chemical-resistant rubber apron.
- **D.** Long-sleeved shirt and long pants made of a woven cotton fabric.

31. Which is the appropriate way to wear gloves and footwear for a job in which you will be working with your arms raised some of the time and lowered some of the time?

- **A.** Wear gloves with your sleeves over them and put your pant legs outside your boots.
- **B.** Wear gloves outside of your sleeves and wear your plant legs inside your boots.
- **C.** Wear gloves with a cuff closed tightly outside the sleeve and wear your pant legs inside your boots.
- **D.** Wear gloves with a cuff closed tightly outside the sleeve and wear your pant legs outside your boots.

32. Which statement is *true* about respiratory protection?

- **A.** Air-purifying respirators supply additional oxygen.
- **B.** All respirators are approved by the EPA.
- **C.** Filters are classified on the basis of oil degradation resistance and filter efficiency.
- **D.** Non-powered particulate respirators use a fan to help draw air through a cartridge.

33. Which statement is *true* about replacing reusable PPE?

- **A.** Reusable items need to be replaced only at the end of the work season.
- **B.** Gloves generally last longer than footwear, aprons, headgear, and protective suits.
- **C.** Glove replacement is a high priority.
- **D.** If PPE is starting to thin out, it can be reused as long as there are no holes.

34. What should you do with clothing made of cotton or polyester that has been heavily contaminated with pesticides labeled with the signal word DANGER–POISON, DANGER, or WARNING?

- **A.** Discard such items in a hazardous waste collection site.
- **B.** Discard items with regular trash.
- **C.** Launder the items separately from other clothing using two entire wash cycles.
- **D.** Launder the items separately using one wash cycle, and line dry.

35. Which practice would help prevent groundwater or surface water contamination?

- **A.** Eliminate grass strips that are between treated fields and streams.
- **B.** Store and mix herbicides around abandoned wells.
- **C.** Select pesticides that tightly adsorb to soil and are not persistent.
- **D.** Apply pesticides broadly over large areas.

36. Which statement is *true* about factors affecting spray drift?

- **A.** Ground applications usually produce more spray drift than aerial applications.
- **B.** High rates of evaporation and high temperatures reduce drift.
- **C.** For reducing drift potential, spraying at midday is usually best.
- **D.** Spraying during temperature inversions can result in significant long-distance drift.

37. Which statement is *true* about pesticide effects on non-target organisms?

- **A.** Drift is one of the primary causes of damage to crops and other plants in adjacent areas.
- **B.** Granular or pelleted pesticide formulations are the safest for preventing injury to birds and other animals.
- **C.** Most livestock poisoning by pesticides occurs when they breathe in vapors from nearby treated fields.
- **D.** Very few herbicides can cause phytotoxic injury.

38. Which items should be stored at the pesticide storage site?

- **A.** Food and feed.
- **B.** PPE for mixing and loading and medical supplies.
- **C.** Spill cleanup kit and emergency PPE.
- **D.** Medication and veterinary supplies.

39. Which statement is *true* about storage of pesticide containers?

- **A.** You may store pesticides in bottles or jars as long as they are appropriately labeled.
- **B.** Keep bags of wettable and soluble powders open, so they are exposed to the air.
- **C.** Store liquid formulations and small containers of dry formulations on wood shelving.
- **D.** Place bulk or mini-bulk tanks on a reinforced concrete pad or other impermeable surface.

40. What should be done with cancelled pesticide products that can no longer be legally used?

- **A.** Use them up by applying them at a rate greater than specified by the label.
- **B.** Store them in the same area as other pesticides but mark them as outdated.
- **C.** Recycle them by mixing them with other pesticide products.
- **D.** Treat as hazardous waste and dispose of accordingly.

41. Which statement is *true* about potential problems from pesticide fires?

- **A.** Pesticides containing oils or petroleum products are the least flammable.
- **B.** Vapors or smoke from pesticide fires may be harmful to animals but not to plants.
- **C.** Pesticides may be flammable but never explosive.
- **D.** Runoff from a pesticide fire site may contain highly toxic chemicals.

42. Which is *not* a recommended safety precaution for a pesticide storage facility?

- **A.** Locate storage facilities as far as possible from places where people and animals live.
- **B.** Post signs that indicate combustible materials are stored at the facility.
- **C.** Store glass or pressurized containers in sunlight.
- **D.** Keep foam-type fire extinguishers in all storage areas.

43. Which statement is *true* about chemical incompatibility?

- **A.** It is not necessary to consider chemical compatibility effects when mixing a pesticide with hard water, chlorinated water, or fertilizers.
- **B.** Increasing the chemical activity of two or more products mixed together is always harmful.
- **C.** Chemical incompatibility occurs when the chemical activity of the mixed products is reduced.
- **D.** Labels do not provide information on avoiding chemical incompatibility.

44. Which is *not* a means of preventing contamination of water sources?

- **A.** When filling the tank, keep the hose down in the pesticide mixture.
- **B.** Use a check valve, anti-siphoning device, or backflow preventer when pumping water directly from the source into a mix tank.
- **C.** Mix and load pesticides on a containment pad.
- **D.** Locate mixing equipment so that leaks or spills flow away from a drain or water source.

45. Which statement is true about cleaning pesticide equipment?

- **A.** Always wash equipment in the same location unless you use a containment pad or tray.
- **B.** There is very little risk of pesticide exposure during equipment cleanup.
- **C.** It is a good idea to wait until the end of the work week before cleaning up equipment.
- **D.** Sloppy cleanup practices are one of the main causes of equipment failure or malfunction.

46. Which type of pesticide application procedure would you use to apply a herbicide between the rows of crops?

- **A.** Broadcast application.
- **B.** Band application.
- **C.** Crack and crevice application.
- **D.** Foliar application.

47. You are applying pesticide to a rectangular area that is 50 feet long by 20 feet wide. What is the area in square feet?

- **A.** 70 square feet.
- **B.** 100 square feet.
- **C.** 500 square feet.
- **D.** 1,000 square feet.

48. You determined from a calibration test that your boom sprayer delivers 8 gallons of water over a 0.25-acre (1/4-acre) test area. You need to apply pesticide to a 10-acre field. How much spray mixture is needed for the 10-acre application area?

- **A.** 80 gallons.
- **B.** 120 gallons.
- **C.** 320 gallons.
- **D.** 400 gallons.

49. From your calibration test, you determine that your backpack sprayer delivers 0.25 gallon of water to cover a 250-square-foot test area. The label recommends applying pesticide at a rate of 6 ounces of product per gallon. How many ounces of product are needed to cover a 1,000-square-foot application area?

- **A.** 6 ounces.
- **B.** 12 ounces.
- **C.** 18 ounces.
- **D.** 24 ounces.

50. Which would likely be an *inappropriate* way to explain a pest control procedure to the customer?

- **A.** Telling the customer what you are spraying for and also showing him the problem.
- **B.** Assuring the customer that he/she will receive 100 percent control after one application.
- **C.** Informing the customer of post-application label instructions.
- **D.** Explaining to the customer factors that have contributed to the pest problem.

ANSWERS

1. C.	2. C.	3. A.	4. C.	5. B.	6. D.	7. D.
8. D.	9. A.	10. B.	11. C.	12. A.	13. D.	14. B.
15. D.	16. C.	17. D.	18. D.	19. C.	20. A.	21. B.
22. D.	23. B.	24. A.	25. D.	26. C.	27. C.	28. C.
29. D.	30. B.	31. D.	32. C.	33. C.	34. A.	35. C.
36. D.	37. A.	38. C.	39. D.	40. D.	41. D.	42. C.
43. C.	44. A.	45. D.	46. B.	47. D.	48. C.	49. A.
50. B.						

APPENDIX F

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APPENDIX G

PESTICIDE-RELATED RESOURCES

RELEVANT WEB SITES

U.S. Environmental Protection Agency

http://www.epa.gov/

U.S. Environmental Protection Agency, Pesticide Program

http://www.epa.gov/pesticides

EPA Regional Pesticide Program Offices

http://www.epa.gov/pesticides/local/index.htm

Region 1 (serves Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont):
http://www.epa.gov/NE/eco/pest/index.html

Region 2 (serves New Jersey, New York, Puerto Rico and the U.S. Virgin Islands):
http://www.epa.gov/pesticides/local/region2/index.htm

Region 3 (serves Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia):
http://www.epa.gov/reg3wcmd/pesticides.htm

Region 4 (serves Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee):
http://www.epa.gov/pesticides/local/region4/index.htm

Region 5 (serves Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin):
http://www.epa.gov/reg5rcra/ptb/pest/

Region 6 (serves Arkansas, Louisiana, New Mexico, Oklahoma, and Texas):
http://www.epa.gov/earth1r6/6pd/pd-p/pest.htm

Region 7 (serves Kansas, Missouri, Nebraska, and Iowa):
http://www.epa.gov/Region7/pesticides/index.htm

Region 8 (serves Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming):
http://www.epa.gov/region8/toxics_pesticides/pests/pesthome.html

Region 9 (serves Arizona, California, Hawaii, Nevada, and the territories of Guam and American Samoa):
http://www.epa.gov/pesticides/local/region9/index.htm

Region 10 (serves Alaska, Idaho, Oregon, and Washington):
http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/Pesticides

The Office of Hazardous Materials Safety, U.S. Department of Transportation

http://hazmat.dot.gov

Pesticide Safety Programs

http://pep.wsu.edu/psp

Natural Resources Conservation Service

http://www.nrcs.usda.gov

United States Department of Agriculture

http://www.usda.gov

USDA Pesticide Recordkeeping Program (PRP)

http://www.ams.usda.gov/science/prb/sdpr.htm

Ag Container Recycling Council

http://www.acrecycle.org

National Pesticide Information Center

http://npic.orst.edu

State and Regional Poison Control Centers

http://npic.orst.edu/poison.htm

Chemtrec—the 24-hour HAZMAT Communications Center

http://www.chemtrec.org

Earth 911 (Environmental information, including local community information)

http://www.earth911.org

Northeastern Region Pesticide Safety Education Center

http://www.nepsec.psu.edu

Southern Regional Pesticide Safety Education Center

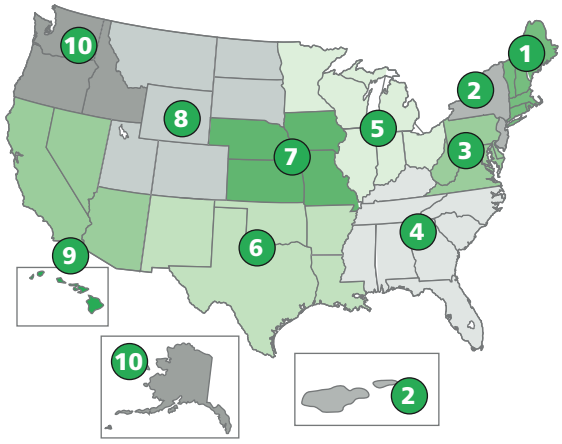
http://ipm.ncsu.edu/srpsec/promo

Regional IPM Centers

http://www.ipmcenters.org

EPA REGIONAL PESTICIDE PROGRAM OFFICES

EPA Regional Pesticide Offices



Region 1

1 Congress Street
Suite 1100
Boston, MA 02114-2023
Tel. (617) 918-1111

Region 2

290 Broadway
New York, NY 10007-1866
Tel. (212) 637-3000

Region 3

1650 Arch Street
Philadelphia, PA 19103-2029
Tel. (215) 814-5000

Region 4

61 Forsyth Street, SW
Atlanta, Georgia 30303-8960
Tel. (404) 562-9900

Region 5

77 West Jackson Boulevard
Chicago, Il 60604-3507
Tel. (312) 353-2000

Region 6

1445 Ross Avenue
Dallas, Texas 75202-2733
Tel. (214) 665-6444

Region 7

901 N. 5th Street
Kansas City, Kansas 66101
Tel. (913) 551-7003

Region 8

999 18th St., Suite 300
Denver, CO 80202-2466
Tel. (303) 312-6312

Region 9

75 Hawthorne St.
San Francisco, CA 94105
Tel. (415) 947-8021

Region 10

1200 Sixth Avenue
Seattle, WA 98101
Tel. (206) 553-1200

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