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This is a part of publication az1149: "Arizona Agricultural Pesticide Applicator Training Manual," 2000, College of Agriculture, The University of Arizona, Tucson, Arizona, 85721.

CHAPTER 1:

PESTS & PESTICIDE CONTROL

This is a part of publication az1149: "Arizona Agricultural Pesticide Applicator Training Manual," 2000, College of Agriculture and Life Sciences, The University of Arizona, Tucson, Arizona, 85721. Full publication located at located at http://ag.arizona.edu/pubs/insects/az1149/

I. Introduction to Pest Control Techniques

Chapter Objectives

By the time you finish this chapter, you will

- be able to recognize pests by identifying physical characteristics;
- understand how different pests reproduce and develop;
- identify the types of control strategies that are part of integrated pest management (IPM);
- be familiar with how diseases affect plants;
- have a general knowledge of vertebrate pest control;
- understand the importance of weed control.

Terms To Know

Action threshold — Point at which some action is required to decrease a pest level.

Certified applicator — Individual who can legally apply restricted-use pesticides.

Eradication — A complete destruction or removal of an entire pest population.

Host — Plant or animal on or in which a pest lives.

Integrated Pest Management — Combination of appropriate pest control tactics into a single plan (strategy) to reduce pests and their damage to acceptable limits, according to economic and environmental requirements.

Metamorphosis — Change in structure of an animal during normal growth stages.

Pathogen — Organism that causes disease in other organisms.

Pest — An organism out of place; any plant or animal that interferes with health, comfort, or productivity.

Prevention — Preventing a pest from becoming a problem by using varied control and management techniques.

Resistance — Pest organism that has developed behavioral or genetic tolerance for a pesticide.

Scouting — Regularly searching for, identifying, and assessing numbers of pests and the damage they cause.

Suppression — Reducing pest numbers or damage to an acceptable level.

Arizona agriculture continues to be an important segment of our state's economy. Agrochemicals are a critical part of growers' and producers' crop production. However, there is heightened awareness regarding agrochemicals and contamination of our environment. Therefore, a thorough understanding of pest management as it relates to prevention, suppression, and eradication is critical. It is important that the applicator know the various aspects of pest management. These include natural controls, resistant varieties, biological and cultural controls, and how they come together in an Integrated Pest Management (IPM) program. These concepts apply whether dealing with an arthropod pest, a disease agent, a weed, or a vertebrate pest. It is important that applicators protect themselves and the environment and help produce a safe and viable food supply.

II. Pest Management Principles

As a certified applicator, you should become familiar with pests you are likely to encounter in your work. You should concentrate specifically on pest characteristics, damage characteristics, and pest biology.

In addition to the general information provided in this chapter, you can obtain identification aids (such as drawings or photographs) and specific publications from your local Cooperative Extension office or the Arizona Department of Agriculture, among others.

A *pest* is any troublesome animal, insect, plant, or disease that interferes with health, comfort, or productivity. In controlling pests, the most important principle is to choose a method aimed at keeping pest damage to an acceptable minimum. You will need to evaluate available options in terms of cost, nontarget health, environmental effects, and degree of damage reduction you can reasonably expect. A pest control program is usually intended to achieve one of three main objectives:

1. **Prevention**: keeping the pest from becoming a problem
2. **Suppression:** reducing pest numbers or damage to an acceptable level
3. **Eradication**: destroying an entire pest population (usually in a regulatory program)

The keys to a good pest control program are knowledge of the pest, anticipation of problems, and options to solve those problems. The primary steps in solving any pest problem are as follows:

1. Know your plant, animal, or disease pest. Proper identification of the pest can save time, money, chemicals, and effort. You can identify a pest by using pest control guidelines, consulting identification books, or having the pest examined and identified by a specialist. It's always a good idea to collect several specimens of the pest and its damage. Different species often look alike, and damage is an important identification tool. In addition, many insects, mites, nematodes, and plant diseases are too small to identify in the field. To accurately identify them requires the use of special tools or analysis of the damage (Fig 1.1). Other keys to help with the identification may be time of year, location, and environmental conditions. If you are dealing with weeds, a history of weed infestation in individual fields will help you plan a preventative program.

Figure 1.1 Microscopic identification

2. Make sure you understand the benefits and risks of each available control method or combination of methods.
3. Choose the method or methods most effective at controlling the pest population, while causing the least harm to yourself, others, and the environment.
4. Apply control strategies at the appropriate time; since each pest has its own growth pattern, treatment measures are much more effective if applied when a pest is vulnerable to a specific method.

Pesticide applications are most effective when they are used as part of an IPM program that uses a combination of methods. In planning and carrying out pest control strategies, consider the following:

- Integrated Pest Management
- Natural forces (e.g., heat, humidity)
- Pest-resistant plant varieties
- Biological controls
- Cultural controls
- Mechanical controls
- Sanitation
- Chemical controls

Integrated Pest Management (IPM)

The strategy of *integrated pest management* (IPM) involves combining the following factors to reduce a pest population in the most cost-effective, convenient, and environmentally safe way. Factors such as pest history, crop growth and development, visual observations, pest monitoring, development of action thresholds (Fig 1.2), weather, and cultural practices are considered before control decisions are made. IPM uses all available practical options to keep pests below economically harmful levels, minimize pesticide resistance, and prevent possible damage to the environment. Goals include conserving natural enemies and avoiding secondary pest problems through compatible biological, cultural, mechanical, and chemical methods.

Figure 1.2 Sampling with a sweep net

Integrated Pest Management techniques are often tailored to a specific site, crop, and situation. The rising costs of pesticides, the banning of certain chemicals, the greater environmental requirements of the Food Quality Protection Act, and the increasing pest resistance to chemicals have made IPM more important in controlling pests. Research in Arizona has shown that an effective scouting program, using action thresholds to time chemical applications, results in fewer applications while producing yields and quality equal or superior to those provided by traditional timing of chemical treatments. An exception is found in several vegetables, where natural enemies sometime act as contaminates and have to be eliminated.

Natural forces

Certain *natural controls* can cause pest populations to rise and fall independently of human actions. These controls, which include climate, water, food supplies, and natural enemies may help or hinder pest control (Fig 1.3). In many cases, natural controls do not control the pest quickly enough to prevent injury or damage, and other pest control methods must be used. You should be aware of the influences of natural controls and take advantage of them whenever possible.

Pest-Resistant Varieties

The use of resistant plant varieties will help keep pest populations below harmful levels by making the environment less favorable for them. Pest resistance varieties work in two ways: (1) certain chemicals within the plant prevent the pest from completing its life cycle, or (2) the variety is more vigorous or tolerant of the pest than other varieties and less likely to be seriously damaged by pest attacks. Modern biotechnology is producing crop varieties that are

genetically engineered to withstand pesticides or to resist certain types of pests. For example, new technology transfers the bacteria Bt (Bacillus thuringiensis) into cotton plants so they can defend themselves against Lepidoptera larvae. The cotton has a Bt gene inserted into it's genetic material. This gene produces a natural protein that kills insects after the protein is ingested. Experience shows that a reservoir of non-Bt cotton is needed to maintain the susceptibility of the pest population.

Biological Controls

Biological control involves the use of enemies of the pest, such as parasites, predators, and diseases, or of hormones that influence the pest's life cycle by preventing normal growth or reproduction. Most types of biological control occur naturally, but certain hormones may be synthetically produced. Biological control methods can vary in their degree of control. Successful biological control programs have been found in high value crops (e.g. orchards, vineyards) as well as low value crops (e.g. pasture, hay). Depending on the circumstances, such programs may be more suitable to areas where some degree of damage is not economically harmful,

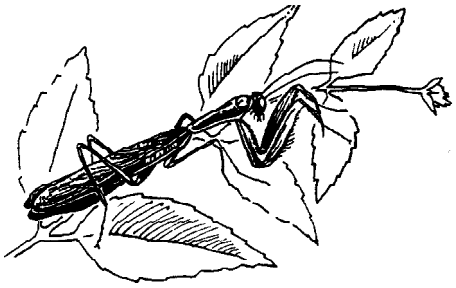


Figure 1.3 Biological control, the praying mantis

such as recreational areas or forest areas. If a pesticide is to be used and you have an option to use one that is less harmful to biological control agents, it should be the chemical of choice.

Cultural Controls

Cultural control consists of practices used to alter the overall environment, the condition of the host, or the behavior of the pest in order to prevent or repress an infestation. By varying planting dates, rotating crops, harvesting early, and changing tillage practices, one can manipulate pest problems to suppress or even eradicate pests. For example, mandatory cotton plow-down dates in Arizona illustrate the use of a cultural control practice that reduces the number of over-wintering sites for pink bollworms, thus reducing pesticide applications.

Mechanical Controls

Mechanical or physical controls reduce populations by directly eliminating pests or radically altering their environment. For example, hand picking, trapping, and freezing are familiar methods of mechanical insect control. Cultivation and hoeing are examples of mechanical weed control.

Sanitation

Sanitation practices help suppress certain pests by removing sources of food, water, and shelter. Other forms of sanitation that prevent the spread of pests are decontamination of equipment, livestock, and other possible carriers before bringing them into a pest-free area. Decontaminating equipment controls weeds by preventing weed seeds from moving into adjacent fields.

Chemical Controls

Pesticides are *chemical controls* used to destroy pests, control their activity, or prevent them from causing damage. A *pesticid*e can be defined as any material that is applied to plants, the soil, water,

harvested crops, structures, clothing, and furniture, or animals. A pesticide kills, attracts, repels, or regulates a pest. Herbicides, insecticides, rodenticides, nematicides, and miticides are common types of pesticides. Other substances classified as pesticides include repellents or attractants, insect or plant growth regulators, and defoliants. Generally, pesticides are the fastest, most economical way to control pests and may, in many instances, be the only control technique available. However, pesticides should always be part of an Integrated Pest Management Program. You will need to choose the best chemical for the job and determine when chemical applications are necessary.

III. Arthropod Pests

Arthropods include insects, arachnids (e.g., spiders, scorpions, mites, and ticks), and other invertebrates. Arthropods pests are responsible for many problems in Arizona agriculture, while others are important to or an integral part of our agriculture (e.g. bees and other pollinators). In order for a grower or field consultant to conduct a sound pest management program, a thorough knowledge of the specific arthropod pest's identity, growth pattern, development, and life cycle is necessary. Life cycle information is essential so that control measures can be timed to occur during the most vulnerable stage of development.

Insects

Insects thrive in more environments than any other group of animals. They feed on leaves; tunnel or bore into stems, stalks, or branches; feed on seeds and nuts; or suck sap from leaves, flowers, and fruit. Insects can also transmit plant and animal disease organisms.

Not all insects are pests, however; certain insects help people by pollinating plants, recycling organic matter, or feeding on pests.

Physical Characteristics

In the adult stage, with few exceptions, all insects have two physical characteristics in common: (1) three pairs of jointed legs and (2) three body regions–head, thorax, and abdomen. The thorax bears wings (if present) and three pairs of legs (Fig 1.4). The abdomen is usually composed of eleven segments; along each side of the segments are openings, called *spiracles* through which the insect breathes.

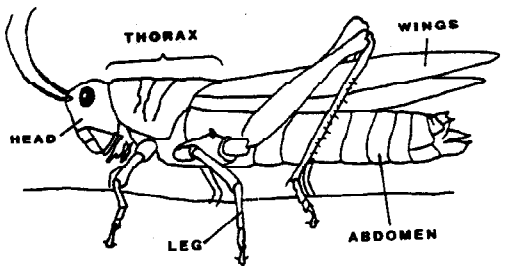


Figure 1.4 Basic anatomy of an insect.

In identifying a particular insect, the most important characteristics to examine are the wings and the mouth parts. Some insects have no wings, while others have two or four wings. The differences in size, shape, and texture of the wings, and the pattern of the veins, can be used to identify insect species.

The mouth is very important not only for identification, but for selecting the proper pesticide to achieve control. The two major types of mouth parts are chewing and sucking.

Chewing mouth parts are generally composed of a pair of cutting or crushing mandibles and a pair of maxillae. In insects such as grasshoppers, the mandibles and maxillae work sideways to cut off and chew or grind solid food.

Sucking mouths are modified to get liquids from other living organisms; mosquitoes, true bugs, and aphids have piercing and sucking mouth parts.

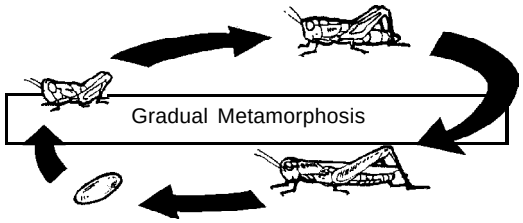


Figure 1.5 Gradual metamorphosis.

Life Cycle

Many insects undergo changes in form, called *metamorphosis*, between the time they hatch and the time they reach adulthood. Metamorphosis, or change, is generally categorized as gradual (simple) or complete. In *gradual metamorphosis* (Fig 1.5), the egg hatches into a nymph. However, because insects have exoskeltons, they have to shed the hard outercovering to grow or molt. Each stage between a molt is called an ***instar***. The earlier instars, in general, are easier to control. As adults, these insects have no prolonged resting period and appear similar to early instars, but without wings. Examples of insects that undergo gradual metamorphosis include grasshoppers, crickets, termites, aphids, and leafhoppers.

Insects that undergo *complete metamorphosis* (Fig 1.6) have several major changes. A typical development involves egg, larva, pupa, and adult stages. In general, eggs are laid on the host that will be fed on by the larvae. As the larvae grow, they molt and feed, with later instars consuming more food as they develop. Upon reaching the last instar, larvae look for a place to form a pupa, or resting stage. Inside the pupa, a transformation takes place and the adult emerges. The adult looks nothing like the immature larva and usually has the ability to fly. Among the many types of insects undergoing complete metamorphosis are beetles, moths, and butterflies.

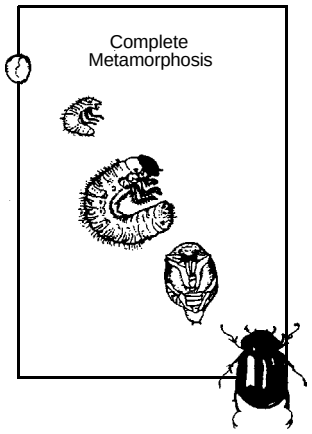


Figure 1.6 Complete metamorphosis.

Arachnids

Several major Arizona pests, although often mistakenly called insects, are actually arachnids. Arachnids, which include spiders, scorpions, adult mites, and ticks, have eight legs, two body regions and no antennae (Fig 1.7). In general, only the mites and ticks are agricultural pests, with mites primarily plant pests while ticks feed on the blood of vertebrates. Most mites are very small and difficult to see without the aid of a hand lens or microscope. They usually develop from egg to adult in a few days to a week, and overwinter as either eggs or adults. Plant-feeding mites often produce serious economic or visual damage, including leaf discoloration, galls, and defoliation. Ticks, on the other hand, usually can be seen with the natural eye. They live much longer, some requiring 1-2 years to reach maturity, and are found on warm-blooded hosts. Some ticks inject toxins during feeding that may cause paralysis of the host, while other ticks transmit disease-causing microorgansims. Arachnid metamorphosis is incomplete, but this may include up to twenty instars before the arachnid reaches adulthood.

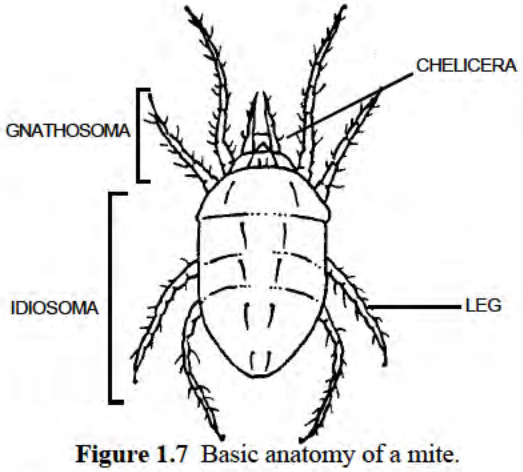


Figure 1.7 Basic anatomy of a mite.

Controlling Pests

The key to a successful pest control program is knowing the stage in which the pest is most vulnerable. Insects are usually difficult to control in either the egg or pupal stage because they are inactive, nonfeeding, immobile, and often in inaccessible areas (underground or in cocoons, cases, or cracks).

Control strategies should be aimed at early instars, because as insects mature, they become most destructive and more difficult to control. Insect resistance also can be a factor in control strategy, particularly with insects that have multiple generations in a season.

The most desirable control is normally achieved during the early larval or nymphal stages. During these early stages, the insects are small and vulnerable and not capable of laying eggs. Control during these stages requires careful monitoring of populations and thorough knowledge of the pest's life cycle, habits, and feeding patterns.

Insect Control Strategies

Crop value is also a very important consideration in making pest control decisions. Chemical control of pests is usually justifiable when the resulting increase in marketable production more than offsets the cost of control.

When pest damage becomes economically harmful and other forms of control have proven inadequate, chemical pesticides may be the only way to save a crop. Pesticides also are important in controlling more than one major pest with a single treatment. *Preventive control* measures can be useful if you know that certain pests develop annually to a damage point in a given area at a given time. Many preventive approaches with chemicals involve soil applications, sometimes months before the pest arrives. Certain early treatments, once the presence of the pest has been confirmed, can then be used to prevent the pest from reaching its maximum rate of growth and reproduction; the preventive application should also occur before crop foliage has grown to the point where it protects the pest from direct contact with spray or dusts.

At times, pesticides are essential to achieve adequate protection of crops and forest resources and to preserve human health and well-being. Pesticides are especially useful as short-term pest management tools.

For these reasons, pesticides will continue to be an important part of IPM programs. However, it is important to remember that, whenever possible, pesticides should be used only to augment other control measures and should always be used in a manner that minimizies damage to the environment.

IV. Disease Agents

A *plant disease* is any harmful condition that makes a plant differ from normal plants in ap-

pearance or function. The cause of plant diseases may be broadly divided into two basic groups: *abiotic* and *biotic*. Abiotic (nonparasitic) diseases are caused by unfavorable growing conditions, such as too little or too much water or fertilizer, improper light, temperature extremes, or injury from machines or chemicals. Biotic (parasitic) diseases are caused by plant pathogens, such as fungi, bacteria, nematodes, viruses, and mycoplasmas, that can multiply and spread from plant to plant.

Disease Development — The Disease Triangle

The occurrence of a biotic disease requires that the *disease triangle* (Fig 1.8) be complete. The components of the disease triangle are a causal agent (pathogen that is capable of causing disease), a susceptible host, and favorable environmental conditions for the disease to develop. A disease will not develop unless all of these are present for a specific time.

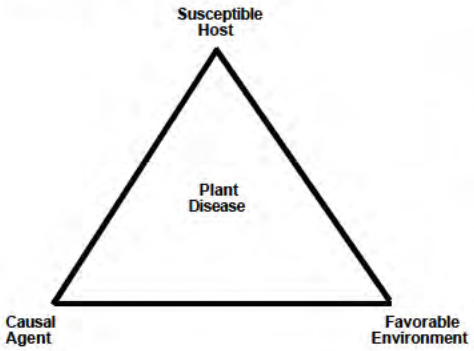


Figure 1.8 Disease Triangle.

The three main ways a plant responds to a pathogen are:

- overdevelopment of tissue such as galls, swelling, and leaf curls;
- underdevelopment of tissue such as stunting, lack of chlorophyll, and incomplete development of organs; and
- death of tissue such as blight, leaf spot, wilting, and cankers.

Development and Diagnosis of Plant Disease

A *parasitic disease* depends on the parasite's life cycle, which is greatly affected by the environment. Temperature and moisture are especially important. The disease process starts when the parasite arrives at a vulnerable point on the plant (inoculation). If environmental conditions are favorable, the parasite will begin to develop on the host. This developmental stage, before injury appears, is called **incubation**. If the parasite penetrates the plant, the stage called **infection** starts. The plant is considered diseased when it shows damage from the parasite.

Any attempt to control plant diseases without sufficient knowledge of the disease and the conditions favoring the development of the disease organisms usually results in failure. For maximum effectiveness, the first step is to diagnose the disease correctly.

Diseased plants can be recognized by comparison to healthy ones. Knowledge of normal plant growth is necessary to recognize disease. To identify the cause of plant disease, observe the symptoms. Different diseases may cause similar symptoms in plants; leaf spots, wilts, or galls on roots may be caused by different agents, including many that are not pathogens. Often the only way to pinpoint the cause is to find the signs of a particular disease agent, such as fungal spores or bacterial ooze. Many pathogenic agents, including fungi, bacteria, and nematodes, can only be positively identified by an expert using sophisticated laboratory procedures.

Pathogenic Plant Diseases

Bacteria

Pathogenic *bacteria* are generally small, single-celled organisms, that can not be seen without a microscope. Most plant-infecting bacteria are rod-shaped and require warmth and moisture to muliply and spread. Bacteria invade tissues through natural openings (stomata) and through wounds. Diseases can be seen as galls, leaf spots, soft rots, and scabs.

Fungi

Most *fungi* live off dead organic matter and are known as **saprophytes**. These primitive plants or fungi are generally beneficial because they break-down plant materials and build up soil fertility. Most pest fungi have vegetative bodies called **myceliam**, which are made up of tiny filamentous strands called **hyphae**. The mycelium grows though the tissues of the infected host, resulting in reproduction by the fungi by means of spores. Spores are spread by wind, rain, irrigation water, insects, and cultural practices. Fungi invade tissues similarly to bacteria, via natural openings and wounds. Disease symptoms include soft rots on fruits, smuts, rusts, leafspots, wilting, and malfunction of plant parts, such as leaf curling. Powdery mildew, sooty mold, and root and stem rots are types of fungi.

Viruses

Viruses are extremely small organisms that grow and develop in living cells. Viruses alter the host cells' chemical activity (metabolism), using their own genetic information to produce more virus. As the virus multiplies, the resulting symptoms include stunting of plant growth, color variations, and russetting on the fruit, with leaf veins showing color variations. Viruses can be spread by mites and several plant-feeding insects, such as aphids, leafhoppers, and whiteflies, as well as cultivation practices.

Controlling Plant Diseases

At present, plant disease control measures are mainly preventive. Once a plant is infected and symptoms appear, few control methods (including pesticides) are effective.

Nonchemical Controls

In some crops, certain plant diseases can be controlled or reduced by eliminating other nearby plants or plant parts that serve as hosts for the disease organisms (cultural control and sanitation). Diseases often can be controlled by systematically removing infected plants and pruning infected plant parts before the disease spreads to uninfected plants (mechanical or physical controls). Planting resistant varieties of crops can also help control disease organisms.

Infected crop residues often provide an ideal environment for carry-over of many pathogens. In some cases the pathogen increases greatly in residues. Three basic techniques are used in crop residue management:

1. Deep plowing buries pathogen-infected residues and surface soil, replacing them with soil that is relatively free from pathogens.
2. Fallowing reduces pathogen carry-over because the pathogen's food source decays.
3. Burning kills pathogens and removes supporting residues. This practice, however, may not be legal in some areas.
4. Crop rotation is the successive plantings of different crops on the same land. Crop rotation reduces residue-borne fungal and bacterial diseases.

Chemical Controls

Chemicals used to control plant pathogens include fungicides, bactericides, and nematicides. The general term **fungicide** is often used to describe chemicals that combat both fungi and bacteria. Fungicides can be classified as protectants, eradicants, or systemics.

Protectants must be applied before or during infection by the pathogen. To be effective, they must either be persistent or applied repeatedly.

Eradicants, which are less common, are applied after infection has occurred. They act on contact by killing the organism or preventing its further growth and reproduction.

Systemics are used to kill disease agents on living plants. Systemic chemicals are transported in the sap stream from the application site to other plant parts. This type of chemical may act as both a protectant and eradicant.

Successful chemical control of plant diseases requires proper timing; on many crops, this may be before infection occurs. Label directions often call for routine protectant applications every seven to ten days during a period of high risk of infection. Almost all plant disease chemicals are applied as cover sprays to reach and protect potential sites of infection.

V. Weeds

A weed is simply *a plant out of place* or a plant that is undesirable due to certain characteristics. Weeds can also interfere with harvest. Weeds are a constant problem statewide for growing agricultural crops. They can reduce the vigor and growth of crop stands by competing for water, nutrients, and sunlight. Most major weeds adapt well to local climate, soil, and other external conditions and can compete successfully with cultivated crops. Most weeds produce large quantities of seeds, which may lay dormant in the soil for extended periods, sometimes over 20 years, before germinating. In general, only 3% of the identified plant species found in the world are considered weeds. In Arizona, many weeds are nonnative and have been introduced inadvertently or intentionally from foreign countries, leaving behind their natural enemies.

Life Cycle

Before you can control a weed, you must know how it grows. An important fact is the length of the life cycle, which can be annual, biennial, or perennial (Fig 1.9).

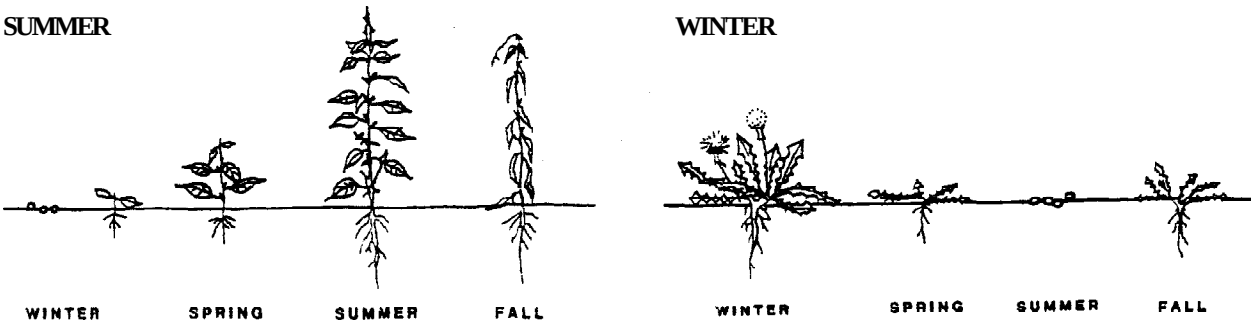


Figure 1.9 Examples of life histories of summer and winter annuals.

Annuals

Plants with a one-year life cycle are *annuals*. They grow from seed, mature, and produce seed for the next generation in one year or less. Many annuals are grasslike (crabgrass and foxtail) or broadleaved (pigweed and cocklebur).

Summer annuals grow from seeds that sprout in the spring, mature, produce seed, and die before the winter; *winter annuals* grow from seeds that sprout in the fall, mature, produce seed, and die before the summer. Examples include annual bluegrass (winter) and burclover (summer).

Biennials

Biennials are plants that live for two growing seasons. These sprout and undergo vegetative growth during the first season, then flower, produce seeds, and die the following season. The rosette of leaves formed during the first year usually lie close to the ground, and thus are well adapted to lawns, pastures, and orchards. Examples are bullthistle and wild carrot.

Perennials

Perennials are plants that live more than two years and may live indefinitely. Perennial plants may mature and reproduce in the first year and repeat the vegetation, seed production, and maturity stages in several following years. Most perennials grow from seed; many also produce tubers, bulbs, rhizomes, or stolons. Examples of perennials are nutsedge and plantain (Fig 1.10).

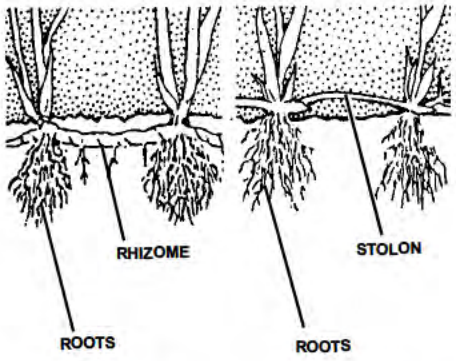


Figure 1.10 Examples of perennial plants with different root structures.

Creeping perennials produce seeds but also produce rhizomes and stolons. Examples include Bermuda grass, Johnsongrass, and field bindweed. Simple perennials normally reproduce by seeds, but root pieces may produce new plants following mechanical injury during cultivation. Examples include dandelions and some trees and shrubs.

Weed Control Methods

Methods that can be used for weed control include (1) preventive measures, (2) crop rotation, (3) controlled burning, (4) mechanical control, (5) biological controls, and (6) chemical controls.

Preventive control measures, such as cleaning contaminated equipment before changing fields, should be adopted where practical and should be the first step in an effective weed control program. Crop rotation is probably the cheapest and easiest method of weed control because certain weeds are more common in some crops than in others and some crops are more competitive with certain weeds than others. Controlled burning of unwanted vegetation can be a valuable tool in the conversion of brush lands to productive grazing lands. Mechanical controls such as cultivating, hoeing, and pulling weeds are the most pollution-free method of weed control. Biological controls include the use of insects and diseases that control weeds but do not harm desirable crops. Chemical controls or herbicides are used for killing or inhibiting plant growth. Herbicides can be selective or non-selective. *Selective* herbicides kill only certain types of weeds, such as grasses or broadleaf plants. *Non-selective* herbicides kill many types of weeds.

Classification of Herbicide

The classification of herbicide action is based on whether the herbicide is: 1) applied to the foliage after the plant has sprouted *(postemergence herbicide)*; 2) to the soil before the plant is visible *(preemergence herbicide)*; 3) the path by which the herbicide enters the plant (*contact* or *translocation*); and 4) whether the herbicide is *selective* or *nonselective* **(**Fig 1.11). What follows is a discussion of the combination of herbicides classification one might encounter on the job.

Foliage – Contact – Nonselective
This type of herbicide is applied to the weed's foliage directly underneath a crop; it kills any foliage on contact with little or no translocation to other parts of the plant. A wick application comes under this heading.

Foliage – Contact – Selective
This type of herbicide kills the weed by causing a burning effect on the foliage. Because these herbicides affect only plants with certain types of waxy films on the leaves, some crops and weeds are not injured.

Foliage – Translocated – Nonselective
These herbicides are applied to the foliage and are absorbed and translocated throughout the plant. Use is generally restricted to before planting and after harvest.

Foliage – Translocated – Selective
These herbicides work in the same way as the translocated nonselective herbicides, but because they react only with certain plants, weeds can be treated while the crop is present with little or no injury.

Soil – Short Residual – Nonselective
Only a few herbicides belong in this group; methyl bromide is an example. The soil is fumigated to kill all weeds and weed seeds. The fumigation cover should be kept on the soil for at least twenty-four hours. After an additional forty-eight hour period, planting can begin without injury.

Soil – Short Residual – Selective
Any herbicide that is applied to the soil prior to planting a crop or immediately after planting and has a residue of less than one year belongs in this group. These herbicides are often referred to as preplant incorporated or pre-emergence herbicides. The chemical is applied to the soil and primarily absorbed through the roots.

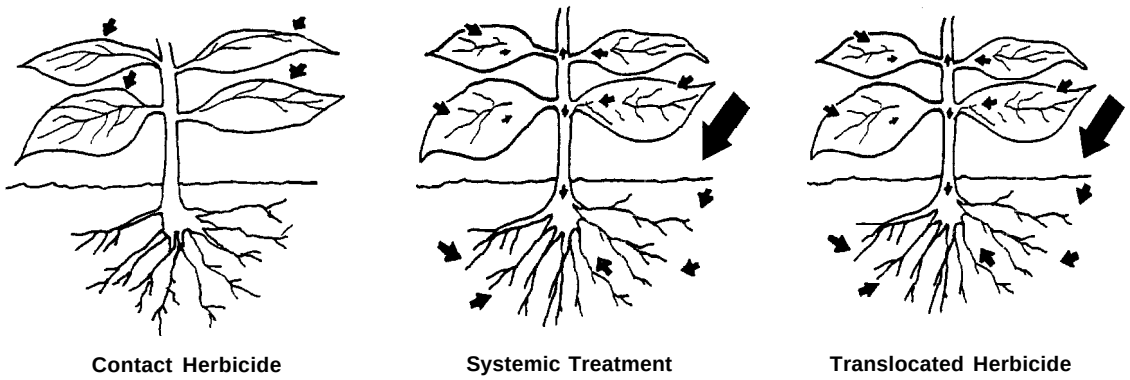


Figure 1.11 Herbicide modes of action, or before planting the seed (**preplant** herbicide).

Soil – Long Residual – Nonselective
These herbicides are used to control all vegetation for long periods of time. They are desirable for use near or under parking lots, and around buildings and storage areas.

Soil – Long Residual – Selective
These herbicides are used to control weeds growing around deep-rooted crops such as fruit trees, nut trees, and grapes. They are applied to the foliage of the weed and are eventually absorbed through the root system. Due to their low solubility, they seldom move downward to the root systems of deeper rooted crops. They have a residual of nearly a year.

VI. Vertebrate Pests

Vertebrates are animals with internal, skeleton and jointed backbones. They include *fish, reptiles, birds, and mammals.* A vertebrate may be a pest in some situations but highly desirable in others. In Arizona, *birds and rodents* (e.g., mice and rats) become pests when they destroy or eat crop seeds and fruit, peck holes in the leaves of some leafy vegetable crops, endanger humans and other animals, and nest near dwellings. Predators such as *coyotes* and *bears* may also be pests, depending on their location and whether they are affecting livestock. *Deer* and *javelina* may be considered pests in several areas of the state.

General Control Tactics

The main objective of any pest control program is damage reduction in a practical and environmentally acceptable manner. Control methods should be based on a knowledge of the biology and habits of the animal causing damage. In this way, efforts will be more effective and maximize safety. There are several steps to consider.

- Promptly and accurately identify the animal causing the damage. Use the type of damage, droppings, tracks, burrow, nests, or food caches to aid in identification.
- If possible, alter the habitat to make the area less desirable to the pest (e.g., exclusion).
- Use a control method appropriate to the location, time of year, and other environmental considerations.
- Monitor the site for reinfestation in order to determine if additional control is necessary.

The most commonly used methods for controlling wildlife pests include determining the presence of the pest, habitat modification, behavior alteration, population reduction, baiting precautions, or a combination of these methods.

A. Determining the Presence of the Pest

Identification of potential pests and interceding to prevent damage is easier, safer, less expensive, and less time-consuming than waiting until damage has already occurred. Regular inspection of buildings, fields, range, and surrounding areas will help prevent an increase in wildlife pests.

B. Habitat Modification

Modifying an animal's habitat by removing the nest or fencing off an area, often provides lasting and cost-effective relief from damage caused by wildlife pests. Habitat modification is effective because it limits a pest's access to food, water, and shelter.

C. Behavior Alteration

Using methods that change the behavior of an animal may lead to a reduction in the pest and its damage. Several repellants are available, both chemical and physical. These include foul-tasting coatings, sound devices, lights, and electrically-charged wire.

D. Population Reduction

Toxic baits or traps may be necessary to reduce pest numbers. Survivors will continue to reproduce, however, so it is essential to couple efforts with methods to improve sanitation, exclusion, and other habitat alterations.

E. Baiting Precautions

Prebaiting of damaged areas with non-toxic baits is advisable. As a safeguard to human and domestic animals, alternative method treatments, such as fumigants or anticoagulant baits in bait boxes, should be considered in preference to broadcasting baits. During treatment, make sure quantities of toxic bait will not present a hazard to non-target species. Posted warning signs may be necessary in the baited area.

Rodent carcasses can be disposed of by burying. Make sure burial is deep enough so that it cannot be unearthed by scavengers. Handling carcasses with a shovel or pitch fork is recommended to minimize possible contact with ectoparasites, such as fleas.

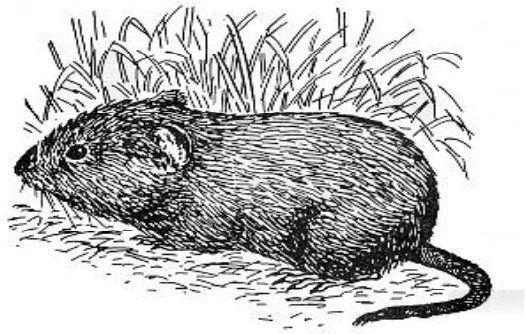
Specific Mammal Pests

Pocket gophers feed on many agricultural crops, eating a wide variety of roots, tubers, grasses, seeds, bulbs, and, sometimes, even the bark of trees. The mounds of fresh soil that are the result of burrow excavation indicate their presence. Their feeding and burrowing habits cause damage to a variety of plants. They may damage water lines, and their tunnels can divert and carry off irrigation water, which could lead to soil erosion. Successful control depends on early detection and control measures appropriate to the situation. Trapping can be a safe and effective method to control pocket gophers; several brands of gopher traps are available. Strychnine-treated bait, however, is the most common type used for pocket gopher control. This gopher bait is poisonous and should be handled with extreme caution. Read and follow label directions carefully.

Pocket gopher

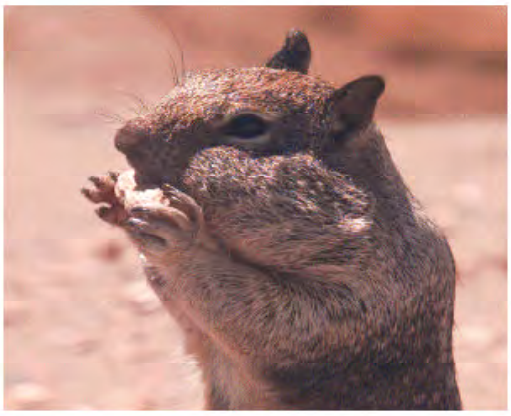
Meadow mice **(**field mice, voles) will damage alfalfa tops and roots, permanent pastures, hay, cole crops, carrots, potatoes, and the bark of citrus trees. Meadow mice are active all year regardless of the weather. They usually live in colonies and forage at any time of the day or night. However, they are usually most active during the day. In cultivated areas, meadow mice populations can be found in favorable habitats such as canal banks, roadsides, or adjacent uncultivated land. Invasion of crops occurs when populations build up or when wild habitat becomes unfavorable, such as when range grasses dry up in summer. Control

measures include registered grain baits and proper vegetation management, which help prevent meadow mice populations from increasing.



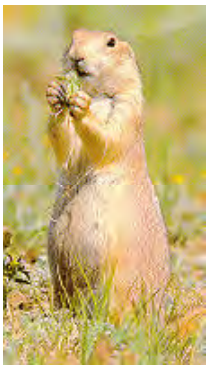
Meadow mouse

Squirrels can damage grains, fruit and nut orchards, and certain vegetable and field crops, including cotton. Their burrows can destroy irrigation ditches and levees. They can also significantly reduce the amount of green foliage available for grazing cattle, espeially during the winter months. Trapping is appropriate for controlling ground squirrels in small areas. Fumigation of burrows and the use of toxic bait (rodenticides) are alternatives for control in larger areas. Never fumigate under buildings. Be certain to follow label instructions closely, especially regarding safety and the use of poisonous baits.



Squirrel

Prairie dogs can be found in meadows, green fields, or natural rangeland or pastures. They are active during the day, foraging and burrowing, with "towns" sometimes crowding together more than 25 or more burrows per acre. They feed on the roots of grass and can destroy whole acres of rangeland. Control of prairie dogs consists of trapping, shooting, and toxic baits. Trapping and shooting are used for limited infestations, but most agricultural situations require fumigants or toxic baits.



Deer are active mornings and evenings, and move singly or in small groups, following definite trails. They may feed on field crops such as corn, shrubs, tree twigs, buds, and vegetables. Males polish their antlers against tree and shrub limbs. They will also invade gardens and orchards, destroying fruits and vegetables.

Deer

See the current Arizona Pest Control Advisor study guide for more details regarding vertebrate pest control.

Chapter One
Pests and Pest Control — Question and Answer Review

1. Q. What is the definition of a pest?

A. An organism out of place; anything that injures, spreads disease, or competes with humans, domestic animals, or feed crops. A pest interferes with health, comfort, or productivity.

2. Q. What is the first thing you should do when you detect the presence of a pest you may need to control?

A. Identify the pest to be sure you know exactly what the problem is.

3. Q. Why is proper identification of pests important?

A. In order to successfully control a pest, it is critical that you are able to identify the common pests that you work with, as well as their hosts. Otherwise, you may use the wrong method of control, choose the wrong pesticides, or treat too early, too late, or too often, thereby doing more harm than good. Proper identification assures you treat the problem and avoid treating only the symptoms.

4. Q. Explain what is meant by *prevention, suppression,* and *eradication* of pests.

A. *Prevention* is keeping a pest from becoming a problem; *suppression* is reducing pest numbers or damage to an acceptable level; *eradication* is destroying an entire pest population.

5. Q. Describe pest *monitoring* and explain how it can be important to pest control strategy.

A. *Monitoring* is checking or scouting for pests in an area to determine what pests are present, how many of each kind of pest are in the area, and how much damage they are causing. Monitoring is important to many pest control strategies because it helps determine if the threshold has been reached and whether control measures have been effective.

6. Q. Name the three main body parts of an insect.

A. Head, thorax, and abdomen.

7. Q. Beetles undergo gradual metamorphosis — true or false?

A. False.

8. Q. Name three organisms associated with plant disease.

A. Bacteria, fungi, nematodes, or viruses.

9. Q. What are the three types of plant life cycles?

A. Annual, biennial, and perennial.

10. Q. Explain the difference between preplant, preemergence, and postemergence herbicides.

A. Preplant: Herbicide applie to the soil before planting
Preemergence: Herbicide applied to the soil before a plant has sprouted.
Postemergence: Herbicide applied to the soil after a plant has sprouted.

11. Q. Define the terms nonselective, translocation, and long-residual.

A. Nonselective: a herbicide which will kill any foliage on contact with little or no translocation.
Translocation: herbicides applied to the foliage, absorbed, and moved through the plant.
Long-residual: a residual of nearly a year or longer; these herbicides seldom move downward to the root zone.

12. Q. What does vertebrate mean?

A. Animals with a jointed backbone. Bears, coyotes, deer, ground squirrel, javelina, meadow mice, pocket gophers, etc.

13. Q. What is IPM? Explain the concept.

A. IPM, or Integrated Pest Management, is a strategy designed to reduce pest populations to tolerable levels. It consists of the balanced use of cultural, biological, mechanical, physical, and chemical controls that are environmentally compatible and economically feasible.

CHAPTER 2:

PESTICIDE LABEL & MSDS

This is a part of publication az1149: "Arizona Agricultural Pesticide Applicator Training Manual," 2000, College of Agriculture and Life Sciences, The University of Arizona, Tucson, Arizona, 85721. Full publication located at located at http://ag.arizona.edu/pubs/insects/az1149/

I. Introduction

Chapter Objectives

By the time you finish this chapter, you should be able to

- interpret the terms label and labeling;
- identify the meaning of "Restricted-Use" classification and explain where to look for it on pesticide labeling;
- distinguish among common name, chemical name, and brand name and know which to use to most accurately identify a pesticide product;
- interpret the signal words and symbols on pesticide labeling;
- know the types of hazard precautionary statements on pesticide labeling;
- interpret the statement "It is a violation of Federal law to use this product in a manner inconsistent with its labeling";
- explain the pesticide user's responsibility to follow use directions and requirements not on the label but contained in separate documents.

Terms To Know

Acute effect — Illness or injury that appears immediately or very soon after exposure to pesticide or combination of pesticides.

Allergic effect — Harmful effect, such as skin rash or asthma, that some people develop in reaction to pesticides.

Carrier — Primary material used to allow pesticide to be dispersed effectively; for example, talc in dust formulation, water mixed with wettable powder before spray application, or air that disperses pesticide in air blast application.

Commercial applicator — Certified applicator who applies pesticides for hire.

Delayed effect — Illness or injury that appears shortly, but usually more than 24 hours, after exposure to pesticide or combination of pesticides.

Distributor product — Product produced and registered by manufacturer or formulator and sold under different name by distributor.

Label — The pesticide label and all associated materials, including supplemental labels, special local needs registration information, and manufacturer's information.

Labeling — All related information about pesticide product mentioned by the label or accompanying product, such as brochures and leaflets.

Oncogenicity — Ability to cause tumors.

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

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

Precautionary statement — Pesticide labeling statement that alerts you to possible hazards from use of pesticide product and sometimes indicates specific actions to take to avoid these hazards.

Private applicator — Certified applicator who can apply restricted-use pesticides to property owned or rented by applicator or employer and/ or those for trade of service.

Restricted-use pesticide — Pesticide that has been restricted by the EPA or ADA because it could cause harm to humans or environment even when applied by certified applicators.

Target pest — Pest toward which control measures are being directed.

The pesticide label is extremely important to the applicator. The information and instructions on the label come from years of research and testing. The labeling gives you instructions on how to use the product safely and correctly. When followed, the label outlines steps to protect you, the public, and the environment. Therefore, read the label completely and carefully for each pesticide you use. **Do not rely on your memory**. Keep in mind that the Food Quality Protection Act (see Chapter 8) will likely change many labels; it is your responsibility to be aware of these label changes.

It is illegal to use a pesticide in any way inconsistent with the label. A pesticide may be used only on the sites listed in the directions for use. You must not use higher dosages, higher concentrations, or more frequent applications than recommended on the label. You must follow all directions for use, including directions concerning safety, mixing, dilution, storage, and disposal. You must wear the specified personal protective equipment listed. The use directions and instructions are not advice; they are **mandatory requirements**.

II. The Label Is The Law!

Federal law permits you to use pesticides in ways not specifically mentioned on the label, as long as it is consistent with what is labeled. You may, for example,

- apply a pesticide at any dosage, concentration, or frequency *less* than that listed on the label
- apply a pesticide on a target pest *not* listed on the label if the application is to a site that *is* listed
- use any *appropriate* equipment or method of application *not* prohibited by the label
- mix a pesticide or pesticides with a fertilizer if the mix is *not* prohibited by the label
- mix two or more pesticides, if *all* of the dosages are *at* or *below* the full recommended rate for each of the products

EPA Approval Required of All Labels

The Environmental Protection Agency (EPA) reviews pesticide labeling to make sure that it contains all the information needed for safe and effective use of the product and that the information is backed up by data submitted (or cited) by the manufacturer. EPA may require the manufacturer to change the labeling if it does not contain enough information or if the information is wrong. EPA also may require that the labeling include other information about laws or regulations that have been adopted to protect humans or the environment.

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

As a certified applicator, you are responsible for applying **only registered pesticides**. You may encounter four major registration situations:

1. Federal registration
2. Special local needs registration
3. Emergency exemptions from registration
4. Experimental use permits

Federal EPA registrations are the most common. Most pesticide uses are registered this way. Look for the official EPA registration number (which must appear on the label) to be sure you are buying an approved product. Remember that not all federally registered products are registered in each state. A pesticide registered in another state *may not* be registered in Arizona.

Special local needs registrations (known as *SLN's* or 24c registrations) allow states to further control how the pesticide is used in their jurisdiction, including registering additional uses or adding limitations for a federally registered pesticide. These registrations often involve adding application sites, pests, or alternate control techniques to those listed on the federally registered labeling, for local pest situations.

Supplemental labeling must be provided for each SLN registration. Applicators must have a copy of the SLN labeling in their possession in order to apply the pesticide for that purpose. The registration number of SLN labeling will include the initials "SLN" and the standard two-letter abbreviation code for the state that issued the registration (e.g., AZ000001). These registrations are legal only in the state or local area specified in the labeling. Any application in another state or region is subject to civil and criminal penalties. Extension personnel, pesticide dealers, and other professionals will help keep you informed of SLN registrations that pertain to local area needs.

Emergency exemptions from registration are used when an emergency pest situation arises for which no pesticide is registered. If both federal and SLN registrations would take too long to enact, an emergency registration can be used. Known as *Section 18 exemptions*, these registrations are handled by the highest governing official involved, usually a state governor or federal agency head. This provision allows a pesticide product to be sold and used for a non-registered purpose for a specified period of time. A permit is needed for each location prior to use. Strict controls and recordkeeping are required for all these emergency uses. You must understand all of the special requirements and responsibilities involved whenever you use pesticides with emergency exemptions.

Classification of Pesticide Uses

EPA categorizes every use of every pesticide as either *unclassified* or *restricted-use*. Many times all the uses of a particular formulation are classified as restricted or all are unclassified. Sometimes, however, certain uses of a formulation are restricted and other uses of the same product are not. In these cases, the directions for use for the two classifications must be clearly separate from one another. Entirely different packaging and labeling are used.

III.Parts of the Generic Label

The parts of the generic label are keyed numerically and these parts are discussed on the following pages.

Restricted-Use Pesticides - 1

Pesticides, or some of their uses, are classified as restricted if they could cause harm to pesticide handlers or other persons, or to the environment unless they are applied by certified applicators who have the knowledge to use these pesticides safely and effectively. The word "use" in this phrase is a general term and refers to such activities as:

(1) Chemco Ag Products
RESTRICTED USE OF 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. See Precautionary Statements for reasons for this product being classified Restricted Use.

(2) GreenLess

(3) **90DF** Herbicide

(4) EPA Reg. No. 9999-111

Use of GreenLess 90DF in Alfalfa, Cotton, Wheat, and Pumpkins

(5) EPA Establishment No. 5840-AZ-1

(6)

ACTIVE INGREDIENTS	BY WEIGHT
NoPest (2E,4,7,8,-methyl-goneo)	90%
INERT INGREDIENTS	10%
TOTAL	100%

(7) KEEP OUT OF REACH OF CHILDREN

(8) **WARNING!**
AVISO!

(9) Chemco Inc.
7 Common Ave.
No Town, State 77777

(10) **STATEMENT OF PRACTICAL TREATMENT**

IF SWALLOWED, call a physician or poison control center. Drink 1 or 2 glasses of water and induce vomiting by touching the back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person.

IF IN EYES, flush with plenty of water. Get medical attention if irritation persists.

IF ON SKIN, wash with plenty of soap and water.

IF INHALED, remove victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

(11) **ENVIRONMENTAL HAZARDS**

Do not apply directly to water or wetlands.

Keep out of lakes, streams or ponds. Do not contaminate water by cleaning equipment or disposal of wastes. **GreenLess** is a pesticide which can move (seep or travel) through soil and can contaminate groundwater which may be used as drinking water. In case of significant spill, call CHEMTREC (800)424-9300.

(12) **Re-entry period: See specific crop + WPS Block**

(13) **Net contents 5 gallons.**

(14) **DIRECTIONS FOR USE**

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

(15) **PRECAUTIONARY STATEMENTS**

HAZARD TO HUMANS AND DOMESTIC ANIMALS WARNING

Warning: May be fatal if swallowed. Harmful if inhaled or absorbed through the skin. Causes temporary eye injury.

This product may be hazardous to your health. This product has been determined to cause birth defects in laboratory animals. Use of protective clothing and equipment and following the precautions below can reduce risk.

Avoid breathing spray mist. Avoid contact with skin, eyes, or clothing. Do not get in eyes or on clothing. Wear a face shield when mixing and loading. Wash thoroughly with soap and water after handling and before eating or smoking.

(16) Personal Protective Equipment. (PPE)

(17) **WARRANTY STATEMENT**

Any use of this product in a manner that is not consistent with the labeling is a violation of federal law.

(18) **STORAGE AND DISPOSAL**

STORAGE: Do not contaminate water, food or feed by storage or disposal. Do not use or store around the home environment. Avoid contact with water. In case of spill or leak, avoid breathing dust or vapors, clean up and dispose of wastes in compliance with local, State and Federal regulations.

PESTICIDE DISPOSAL: Pesticide, spray mixture or rinsate that cannot be used according to label instructions must be disposed of according to applicable Federal, State or local procedures.

CONTAINER DISPOSAL: Completely empty bag into application equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Water Protection Standard, 40 CFR Part 170. The Standard contains requirements for the protection of agricultural workers on farms, forest, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, application and emergency assistance. It also contains specific instruction and explanations pertaining to the statements on this label about personal protective equipment (PPE) and restricted entry interval (REI). The requirements on this box only apply to uses of this product that are covered by the Worker Protection Standard.

For Preplant or Preemergence (Broadcast or Banded), Chemical Fallow, Postemergence Directed Spray, and Dormant Season Applications, and "Between Cutting" Applications in Crop A: Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) or 12 hours.

For Harvest Aid and Dessication Applications: Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 24 hours.

PPE required for early entry into 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
-Protective eyewear

- mixing and loading
- application
- transporting, storing, or handling pesticides after the manufacturer's seal is broken
- care and maintenance of application and handling equipment, disposal of pesticides and their containers

Product Name - 2

Brand, trade, or product names. Each manufacturer has a brand name for its product. Different manufacturers may use different brand names for the same pesticide active ingredient. The brand name shows up plainly on the front panel of the label. Applicators should avoid choosing a pesticide product by brand name alone. Many companies use the same basic name with only minor variations to designate entirely different pesticide chemicals.
For example:

Tersan LSR	=	zinc and maneb
Tersan SP	=	chloroneb
Tersan 1991	=	benomyl
Tersan	=	thiram

Type of Formulation - 3

The front panel of some pesticide labels will tell you the product formulation. The formulation may be named or the label may show only an abbreviation, such as **WP** for wettable powder, **D** for dust, or **EC** for emulsifiable concentrate. The type of pesticide may also be given (e.g., insecticide, herbicide).

Statement of Pesticide Use Classification

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

- Insecticide for control of certain insects on fruits, nuts, and ornamentals
- Algicide
- Herbicide for the control of trees, brush, and weeds.

EPA Pesticide Registration Number - 4

An EPA registration number appears on all pesticide labels, indicating the pesticide label has been registered by the federal government. Most products will contain only two sets of numbers—for example, EPA Reg. No. 3120-280; the first set of digits, 3120, is the manufacturer's identification number and the second set, 280, is the product's unique identification number.

In some cases, special local needs (**SLN**) pesticide products may be approved by a state. These registrations are designated, for example, as "EPA, SLN No. AZ-960007." In this case, **SLN** indicates "special local need" and **AZ** indicates that the product is registered for use in Arizona. SLN numbers may not appear on the package label, but are part of the supplementary labeling.

EPA Formulator Manufacturer Establishment Number - 5

The establishment number (for example, "EPA Est. No. 5840-AZ-1") appears on either the pesticide label or the container. In the event of a problem, it identifies the facility that produced the product.

Ingredients Statement - 6

Each pesticide label must list what is in the product. The list is written so you can readily see what the **active ingredients** are and the amount of each ingredient (as a percentage of the total product).

ACTIVE INGREDIENT
Benomyl [Methyl] —(burylcarbamoyl)— 2 —benzimidazolecarbamate 50%
INERT INGREDIENTS 50%
U.S. Pat 3.631.178 *EPA Reg. No. 352-354 AA*

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

Because pesticides often have complex chemical names, many are given a shorter, common name. Only common names that are officially accepted by the Environmental Protection Agency may be used in the ingredient statement on the pesticide label. The official common name may be followed by the chemical name in the list of active ingredients.

For example, a label with "Sevin 50% WP" would read

Active ingredient:	
Carbaryl	50%
(1-Naphthyl methylcarbamate)	
Inert ingredient	50%

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

Pounds/Gallon Statement (If Liquid)

This is the pounds of active ingredient per gallon in liquid formulations. It is often included in the ingredient statement.

The ingredient statement must list the official chemical name and/or common name for each active ingredient. At the present time, the **inert ingredients** need not be named, but the label must show what percentage of the total contents they make up. Legislation requiring the identification of inert ingredients is pending.

Child Hazard Warning - 7

Unqualified claims for safety are not acceptable on any label and all labels must bear the statement **KEEP OUT OF THE REACH OF CHILDREN**.

Signal Word — DANGER, WARNING, or CAUTION - 8

The signal words DANGER, WARNING, or CAUTION must appear in large letters on the front panel of the pesticide label. The signal word indicates how acutely toxic the product is to humans. The signal word is immediately below the statement KEEP OUT OF REACH OF CHILDREN, which also must appear on every label.

The signal word is based not on the active ingredient alone, but on the contents of the formulated product. It reflects the hazard of any active ingredients, carriers, solvents, or inert ingredients. The signal word indicates the risk of acute effects from the four routes of exposure to a pesticide product (oral, dermal, inhalation, and eye) and is based on the one that is **greatest.** The signal word does not indicate the risk of delayed effects or allergic effects.

Use the signal word to help you decide what precautionary measures are needed for yourself, other handlers, and other people (or animals) who might be exposed.

- **DANGER** indicates that the pesticide is highly toxic or hazardous. The product is very likely to cause acute illness from oral, dermal, or inhalation exposure, or irritating or corrosive to the skin and/or cause serious eye damage.
- **WARNING** signals you that the product is moderately toxic or hazardous and could likely cause acute illness from oral, dermal, or inhalation exposure or could cause moderate skin or eye injury.
- **CAUTION** signals you that the product is slightly toxic or relatively nontoxic. The product has only slight potential to cause acute illness from oral, dermal, or inhalation exposure. The skin or eye irritation it would cause, if any, is likely to be slight.

Skull and Crossbones and Word POISON in Red

All highly toxic pesticides that are very likely to cause serious acute illness through oral, dermal, or inhalation exposure will carry the skull and crossbones symbol and the word POISON printed in red always with the signal word DANGER. Products that have the signal word DANGER due to skin and eye irritation potential will not carry the the skull and crossbones symbol or the word POISON.

Company Name and Address - 9

The law requires the maker or distributor of a product to put the name and address of the company on the label.

Statement of Practical Treatment - 10

Most pesticide products are required to include instructions on how to respond to an emergency exposure involving that product. The instructions usually include first aid measures and may include instructions to seek medical help.

Referral Statement

If the "statement of practical treatment" is not located on the front panel, a statement on the front panel must refer the user to the section of the label or labeling where the statement of practical treatment may be found.

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, move from contaminated area and give artificial respiration if necessary.
- If swallowed, drink large quantities of milk, egg white, or water — do not induce vomiting.

Environmental Hazards - 11

This section of the pesticide labeling will indicate precautions for protecting the environment when you use the pesticide. Some general statements appear on the labeling of nearly every pesticide. Most pesticide labeling, for example, will warn you not to contaminate water when you apply the pesticide or when you clean your equipment or dispose of pesticide wastes. The labeling will contain specific precautionary statements if the pesticide poses a specific hazard to the environment. The label may indicate that the product causes undesirable effects on the environment. In this case, the precautionary statement may tell you what to avoid doing. Some

labels indicate toxicity to bees, birds, fish, and crustaceans. Labeling may indicate limitations imposed to protect endangered species. These limitations may include reduced rates, restrictions on types of application, or a ban on a pesticide's use within the species range. The label may also tell you where additional information can be obtained.

General Environmental Statements

These statements appear on nearly every pesticide label. They are reminders of common sense actions to follow to avoid contaminating the environment. The absence of any or all of these statements **does not** indicate that you do not have to take adequate precautions.

Sometimes these statements will 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 when cleaning equipment or disposing of wastes
- Keep out of any body of water
- Do not allow drift on desirable plants or trees
- Do not apply when bees are likely to be in the area
- Do not apply where the water table is close to the surface

Restricted-Entry Interval (REI) - 12

The re-entry interval statement is printed in a box under the heading *Agricultural Use Restrictions* and will include requirements of the Worker Protection Standard (WPS). If the restricted-entry interval applies only to certain uses or locations, the heading may indicate that limitation.

Agricultural pesticide labeling contains a precaution about entering a treated area after application. This statement tells you how much time after the application must pass before people can enter a treated area. These restricted-entry intervals (REI's) are set by both EPA and regulatory agencies. Entry intervals set by the Arizona's Department of Agriculture or Structural Pest Control Commission (SPCC) are not always listed on the label. You must determine whether one has been set.

Net Contents - 13

The net contents, on the front panel of the container, are expressed as pounds, ounces, or percents for dry formulations and as gallons, quarts, pints, or fluid ounces for liquids. Liquid formulations also may list the pounds of active ingredient per gallon of product.

Directions for Use - 14

The instructions on how to use the pesticide are an important part of the labeling. This is the best way you can find out the right way to handle the product.

The use instructions will tell you

- pests the manufacturer claims the product will control
- site for which the product is intended
- in what form the product should be applied
- the correct equipment to use
- how much pesticide to use
- mixing directions
- whether the product can be mixed with other often-used products
- whether the product is likely to cause unwanted injuries or stains to plants, animals, or surfaces.
- when and how often the material should be applied

Directions for Use by Reference

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

> Use of this product in a manner inconsistent with the *Pesticide Use Bulletin for Protection of Endangered Species* is a violation of Federal law. Restrictions for the protection of endangered species apply to this product. If restrictions apply to the area in which this product is to be used, you must obtain the *Pesticide Use Bulletin for Protection of Endangered Species* for that county.

This statement probably would be the only indication on the pesticide label or in the labeling that other use directions and restrictions apply to the product. In general, this statement will have no direct impact on you the applicator. However, a product may be removed from the marketplace if it has too great an impact on endangered species.

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

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

- groundwater protection
- endangered species protection
- pesticide transportation, storage, and disposal
- worker protection
- pesticide labeling

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

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

You must:

- determine whether you are affected
- locate the applicable directions for use
- determine how to comply with the instructions and requirements in the directions for use
- comply with those instructions and requirements

Precautionary Statments - 15

The side and back panels of labels often list other precautions to take while handling the product.

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

Warning!
Keep out of reach of children. See additional warning statements on back of container.

Hazards to Humans and Domestic Animals

Route of entry statements, which immediately follow the signal word, either on the front or side of the pesticide label, indicate which route(s) of entry (mouth, skin, lungs, eyes) you must particularly protect. Many pesticide products are hazardous by more than one route of entry, 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: 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

These statements are not uniform on all labels and many variations may be found. More than one, or, in some cases, all four precautions may be stated on the same label.

Typical WARNING label statements include:

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

Statements on a WARNING label may be exactly like those found on a DANGER label or a CAUTION label. There may be a combination of the two, for example: "Harmful or fatal."
Typical CAUTION label statements include

- Harmful if swallowed
- May be harmful if absorbed through the skin
- May be harmful if inhaled
- May irritate eyes, nose, throat, and skin

CAUTION statements may vary considerably. They usually are more moderate than the statements found on a DANGER label, often using "harmful" instead of "fatal" or "poisonous"; "irritant" instead of "corrosive"; and qualifying the warnings with "may" or "may be." This is in keeping with products having a CAUTION label.

"Specific action statements" are statements that follow the route of entry statements. They recommend the specific action needed to prevent poisoning. These statements are directly related to the toxicity of the pesticide product (signal word) and route(s) of entry that must be protected.

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

(You would not deliberately swallow the pesticide, so the "Do not swallow" statement is omitted.)

CAUTION labels generally contain specific action statements that are much milder than those on the

DANGER label:

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

These statements indicate that the toxicity hazard is not as great. The specific action statements help you prevent pesticide poisoning by taking the necessary precautions and wearing the correct protective clothing and equipment.

Personal Protective Equipment Statements - 16

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

Warranty/Misuse Statement - 17

Directly under the heading "Directions for Use" on every pesticide product labeling is the following statement: "It is a violation of Federal law to use this product in a manner inconsistent with its labeling."

Storage and Disposal - 18

All pesticide labels contain general instructions for the appropriate storage and disposal of the pesticide and its container. Typical statements include:

- Not for use or storage in or around the home
- Store away from fertilizers, insecticides, fungicides, and seeds
- Store at temperatures above 32°F (0°C)
- Do not store above 100ºF for extended periods
- Do not reuse container
- Do not contaminate water, food, or feed by storage and disposal
- Open dumping is prohibited
- Triple-rinse and offer this container for recycling or reconditioning, or dispose in an approved landfill
- Use excess or dispose of in an approved landfill
- Do not reuse bag

You should try to determine the best storage and disposal procedures for your operation and location. These statements may appear in a special section of the label titled "Storage and Disposal" or under headings such as "Important," "Note," or "General Instructions." For additional information on proper pesticide disposal and storage, contact the Arizona Department of Agriculture or the Department of Environmental Quality.

Worker Protection Standard - 19

This standard contains all the requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses and handlers of agricultural pesticides. It tells you about the requirements for training, decontamination, notification and emergency assistance.

IV. Other Statements

Delayed Effects Statements

The labeling of pesticides that the EPA considers to have potential to cause delayed effects must warn you of that fact. These statements will tell you whether the product has been shown to cause problems such as tumors or reproductive problems in laboratory animals.

Allergic Effects Statement

If tests or other data indicate that the pesticide product has potential to cause allergic effects, such as skin irritation or asthma, the product labeling must state that fact. Sometimes the labeling refers to allergic effects as *sensitization.*

Physical or Chemical Hazards

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

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

NOTE: Hazard statements (hazards to humans and domestic animals, environmental hazards, and physical-chemical hazards) are not located in the same place on all pesticide labels. Some newer labels group them in a box under the headings listed above. Other labels may 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." You should search the label for statements which will help you to apply the pesticide safely and knowledgeably.

Additional Information on Restricted-Use

When a pesticide is classified as restricted, the label will state RESTRICTED-USE PESTICIDE in a box at the top of the front panel. Below this heading may be a statement describing the reason for the restricted-use classification. Pesticides that are unclassified have no designation on the product label. Only a certified pesticide applicator may use or supervise the use of restricted-use pesticides. Under federal law, there are two types of certified pesticide applicators: private applicators and commercial applicators.

Certified private applicators use or supervise the use of restricted-use pesticides to produce an agricultural commodity on property owned or rented by them or their employers, or on the property of another person with whom they trade services.

Certified commercial applicators, on the other hand, use or supervise the use of restricted-use pesticides on any property or for any purpose other than that listed for certified private applicators.

Certification requires testing for competency in the safe and effective handling and use of restricted-use pesticides. Arizona certification is more restrictive than federal certification. The state requires competency testing in both the "CORE" and "category" for commercial applicators. In addition, we require all certified applicators to complete either three (private) or six (commercial) hours of continuing education units (CEUs) per year. For complete details see the chapter on "Pesticide Laws and Regulations."

Examples of restricted-use statements on pesticide labels include:

- RESTRICTED-USE PESTICIDE due to acute toxicity and toxicity to birds and mammals. For retail sale and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification.

- RESTRICTED-USE PESTICIDE due to very high acute 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 certification. Direct supervision for this product is defined as the certified applicator being physically present during application, mixing, loading, repair, and cleaning of application equipment. Commercial certified applicators must also ensure that all persons involved in these activities are informed of the precautionary statements.

- RESTRICTED-USE PESTICIDE due to oncogenicity (e,g., tumor-causing). For retail sale and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification. The use of this product may be hazardous to your health. This product contains [active ingredient], which has been determined to cause tumors in laboratory animals.

- RESTRICTED-USE PESTICIDE due to groundwater concern. For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification. Users must read and follow all precautionary statements and instructions for use in order to minimize potential of the pesticide reaching groundwater.

V. When Do You Read the Label?

Before you buy a pesticide, read the label to determine:

- whether it is the pesticide you need for the job
- whether the pesticide can be used safely under the application conditions
- where the pesticide can be used (livestock, crops, structures, etc.)
- whether there are any restrictions for use of the pesticide
- how much product you need

Before you mix the pesticide, read the label to determine:

- what protective equipment you should use
- what the pesticide can be mixed with (compatibility)
- how much pesticide to use
- how to mix the pesticide

Before you apply the pesticide, read the label to determine:

- what safety measures you should follow
- when to apply the pesticide (including the waiting period for crops and animals)
- how to apply the pesticide

Before you store or dispose of the pesticide or pesticide container, read the label to determine:

- where and how to store the pesticide;
- how to decontaminate and dispose of the pesticide container and
- where and how to dispose of surplus pesticides by public

VI. Introduction

Learning Objectives

After you complete your studyof this subunit, you should be able to read the Material Safety Data Sheet (MSDS) and

- know why the Material Data Safety Sheet is the cornerstone of the Hazard Communication Standard;
- know what the MSDS helps evaluate;
- name the parts of the MSDS;
- list the physical and chemical characteristics on a MSDS;
- name the health hazard data;
- discuss steps to be taken if material is spilled or released;
- list control and protective measures if handling a product.

The Material Safety Data Sheet (MSDS)

ACGIH (American Conference of Governmental Industrial Hygienists) — Organization of safety professionals who recommend workplace safety guidelines.

Hazard Communication Standard — Part of OSHA that makes sure hazards of all chemicals are evaluated and information concerning these hazards is communicated to employers and employees.

Hazardous chemical — Any chemical that is a physical or health hazard.

IARC (International Agency for Research on Cancer) — Group that evaluates carcinogenicity or potential carcinogenicity of chemicals encountered.

MSDS (Material Safety Data Sheet) — Standardized list of medical, safety, and physical/chemical information prepared for chemical or chemical mixture.

NTP (National Toxicology Program) — Multiagency federal program with responsibility of coordinating research on potentially toxic chemicals and releasing information about those chemicals.

OSHA (Occupational Safety and Health Administration) — Federal organization that oversees workplace safety.

PEL (Permissible Exposure Limits)—OSHA limit for exposure to specific chemicals.

TLV (Threshold Limit Value) — Limit recommended by the ACGIH, similar to OSHA's PEL.

The Material Safety Data Sheet is required by law as part of the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard (29 CFR 1910.1200). As an agricultural applicator, you will find the MSDS is an easy reference for information on a variety of hazardous substances.

MSDSs are the cornerstone of the Hazard Communication Standard. They provide information about the chemical substances within a product, safe handling procedures, first aid measures, and procedures to be taken when the product is accidentally spilled or released. The responsibility for preparing or obtaining Material Safety Data Sheets lies with the chemical manufacturers or import-

ers. They must be provided to employers and distributors with the initial shipments and with the first shipment after an MSDS is updated. If the chemical manufacturer or importer becomes aware of new significant information regarding the hazards of a chemical, or ways to protect against the hazards, this new information must be added to the Material Safety Data Sheet within three months. Distributors must provide MSDS to their customers also.

There is no format specified for MSDSs; however, they must be in English and must include the following information:

1. Product identification. The identity on the label of the chemical used.
2. Warning statement. The warning statement that appears on the label.
3. Except for trade secrets, the specific chemical names and common names for the hazardous ingredients.
4. Physical and chemical properties. These might include appearance, odor, specific gravity, evaporation rate, solubility in water, and water reactivity, among others.
5. Fire and explosion hazard information. Information in this section might include the product's flash point (the temperature at which the product might ignite), fire extinguishing methods, and fire control tactics.
6. Reactivity data. Provides information on products or chemicals with which the subject product might be incompatible.
7. Health hazard information. The information provided here would include emergency and first aid procedures, toxicity data, and chronic toxicity data.
8. NFPA hazard rating (if available). Rating scale is from 0 (least) to 4 (severe), for fires..
9. Precautions for safe handling and use. Provides information on control and protective measures, as well as spill or leak and disposal procedures.
10. Special precautions.
11. Additional regulatory information (if any).
12. Appendix (if any).
13. Source and date information.

The MSDS can also be used for chemical emergency planning. Valuable information such as precautions for safe handling and storage, steps to be taken if the material is spilled or released, incompatibilities, and special fire fighting procedures, are contained on the MSDS.

The MSDS allows the applicator to evaluate the potential physical and health hazards of chemicals being considered or used. This allows, when possible, the selection of less hazardous substitutes.
For the purpose of preparing Material Safety Data Sheets, OSHA has defined a "hazardous chemical" as any chemical which is a "physical hazard" or "health hazard."

The hazards table below lists the physical and health hazards recognized by OSHA for inclusion on MSDSs.

VII. Parts of the MSDS

The sections of the MSDS are numbered, and each section is discussed in the following pages.

1. Product Identification

The hazardous chemical is identified on the MSDS in the same manner as shown on the label. This may be a chemical name, code name, number, or trade name.

Physical Hazards

Combustible liquid	Organic Peroxide
Compressed gas	Oxidizer
Explosive	Unstable (reactive)
Pyrophoric	Water Reactive
Flammable	
1. Aerosol	
2. Gas	
3. Liquid	
4. Solid	

Health Hazards

Carcinogen	Hemotoxin (blood)
Toxic Agent	Hepatotoxin (liver)
Highly Toxic Agent	Nephrotoxin (kidney)
Reproductive Toxin	Neurotoxin (nervous system)
Irritant	Agent that damages lungs, skin,
Corrosive (to tissue)	eyes, or mucous membranes
Sensitizer	

— CAS Number (Optional)—Chemical Abstract Service numbers provide an additional reference for information concerning specific chemicals. The number identifies the specific compound and allows identification regardless of the name or naming system used.

— Date Prepared—Gives the date the MSDS was prepared and also provides a reference when updated MSDS's have been prepared.

— Manufacturer—This section indicates the manufacturer or importer of the hazardous chemical. The person or organization shown should be an available source from which additional information on the hazardous chemical and appropriate emergency procedures can be obtained if necessary. This section also includes a mailing address and telephone number for general information, an emergency telephone number, and a telex number, if available.

2. Warning Statement

Gives warning statement that appears on label.

3. Hazardous Ingredients

The chemical and common names of all ingredients that have been determined to be reportable health hazards are listed.

If the hazardous chemical is a single substance, its chemical name and common names (synonyms) are listed. The common names listed should be those ordinarily in use for that product.

If the hazardous chemical is a mixture that has been tested as a whole to determine its hazardous properties, the chemical and common names of the ingredients that contribute to those known hazards and the common names for the mixture are listed.

If the hazardous chemical is a mixture that has not been tested as a whole, the chemical and common names are listed for all ingredients that are:

- determined to be health hazards and are present at concentrations of 1% or more of the mixture
- identified as carcinogens and are present at concentrations of 0.1% or more
- determined to be physical hazards when present in the mixtureInclusion of the percentage composition is optional. Units used for these measurements are usually milligrams per cubic meter (mg/m^3) or parts per million (ppm).

4. Physical and Chemical Characteristics

Included are data on what the material or mixture is like, how it reacts, and the conditions of testing, including the temperature scale (°F or °C) used.

— **Boiling Point**: Refers to the temperature at which a material boils, in degrees Fahrenheit (°F), under ordinary atmospheric pressure.

— **Vapor Pressure:** Indicates how much vapor the material may give off. A high vapor pressure indicates that a liquid will evaporate easily.

— **Vapor Density:** Tells how heavy the pure gaseous form of the material is in relation to air (see table below). High vapor densities pose a particular problem because these vapors will collect in the bottom of tanks.

Below 1.0 ..... Vapor is lighter than air
1.0 ..... Vapor is same weight as air
Above 1.0 ..... Vapor is heavier than air

— **Water Solubility:** Indicates by weight the solubility of the material in distilled water at 50°F. The % listed below refers to weight of total solution, that is other than water, not the % of the substance that will dissolve.

Negligible ..... Less than 0.1% soluble
Slight ..... 0.1% to 1% soluble
Moderate ..... 1% to 10% soluble
Appreciable ..... More than 10% soluble
Complete ..... Soluble in all proportions

— **Specific Gravity:** Shows how heavy the material is compared to water and, if insoluble or only partially soluble in water, tells whether it will float or sink (see table below).

Below 1.0 ..... Material is lighter than water
1.0 ..... Material is same weight as water
Above 1.0 ..... Material is heavier than water

— **Evaporation Rate:** *Caution must be used in interpreting evaporation rate data.*

— **Water Reactivity:** Indicates if the chemical reacts with water to release a gas that is flammable or presents a health hazard.

5. Fire and Explosion Hazard

Flash Point and Method: Indicates the temperature at which a liquid will give off enough flammable vapor to ignite.

6. Reactivity Data

This information will aid in safe storage and handling of hazardous or unstable substances. Instability in response to or incompatibility with water, direct sun, metals used in piping or containers, acid, alkalies, and so on, should be listed.

7. Health Hazard Data

Primary Route of Entry—Indicates potential routes of exposure to the hazardous chemical during the course of normal usage or a foreseeable emergency. A "foreseeable emergency" is one that would normally be planned for as a presumed potential occurrence determined by the nature of the work. Equipment failure and rupture of containers should be considered. If the chemical is not hazardous, this is also indicated.

Signs and Symptoms of Exposure— Describes most common sensations and symptoms of an exposed person. Symptoms can vary and many depend on individual susceptibility, concentration, and the type of material. Attention should be given to effects caused by eye contact, skin contact, inhalation, and ingestion.

Emergency First Aid Procedures—Indicates immediate temporary steps to be taken in case of eye contact, skin contact, inhalation, or ingestion. These are emergency procedures only, and the victim should be examined by a doctor as soon as possible after exposure. Included are procedures for removing contamination from skin and eyes, neutralization if recommended, treatment for inhalation including use of oxygen or artificial respiration, and what to do in case of ingestion.

Health Hazards — Indicates acute and/or chronic hazards that result from exposure to the hazardous chemical. Acute hazards are quickly apparent effects of the chemical as a result of short-term exposure and are usually of short duration. Acute effects include tissue damage or irritation, as well as lethal dose.

Chronic effects generally result from long-term exposure. The effects may not be immediately apparent and are likely to be of long duration. Long-term changes in the body should be included. Some of the characteristics of the chemicals causing chronic effects are

- Carcinogen (cancer-causing)
- Teratogen (developmental malformation)
- Mutagen (mutation-causing)
- Hemotoxin (blood)
- Lung irritant
- Hepatotoxin (liver)
- Nephrotoxin (kidney)

Medical Conditions Generally Aggravated by Exposure—Indicates medical conditions recognized as being aggravated by exposure.

8A. NFPA Rating (Optional)

The National Fire Protection Association (NFPA) has developed a system for indicating the health, flammability, and reactivity hazards of chemicals. In addition, a special precaution symbol may be used where necessary.

Rating Summary — Health

0 - **No unusual hazard:** Refers to short-term contact or inhalation hazard only.
1 - **Caution:** May be irritating.
2 - **Warning:** May be harmful if inhaled or absorbed.
3 - **Warning:** Corrosive or toxic. Avoid skin contact or inhalation.
4 - **Danger:** May be fatal on short exposure. Specialized protective equipment required.

Flammability

0 - **Minimal hazard:** Materials normally stable and will not burn unless heated.

1 - **Slight hazard:** Materials must be preheated before ignition will occur. Flammable liquids in this category will have flash points at or above 200° F.

2 - **Moderate hazard:** Material must be moderately heated before ignition will occur, including flammable liquids with flash points at or above 100° F and below 200° F.

3 - **Serious hazard:** Materials capable of ignition under almost all normal temperature conditions including flammable liquids with flash points below 73° F and boiling points at or above 100° F, as well as liquids with flash points at or above 73° F and below 200° F.

Reactivity

0 - **Minimal hazard:** Materials normally stable even under fire conditions and will not react with water.

1 - **Slight hazard:** Materials normally stable, but can become unstable at high temperatures and pressures. These materials may react with water, but will not release energy violently.

2 - **Moderate hazard:** Materials in themselves normally unstable and will readily react under violent chemical change, but will not detonate. These materials may also react violently with water.

3 - **Serious hazard:** Materials readily capable of detonation or explosive decomposition or reaction, but require a strong initiation source or must be heated under confinement.

4 - **Severe hazard:** Materials readily capable of detonation or decomposition or explosive reaction at normal temperature and pressure.

Personal Protection
(Indicated by letter designation)

- **A.** Safety Glasses
- **B.** Safety Glasses, Gloves
- **C.** Safety Glasses, Gloves, Apron
- **D.** Face Shield, Gloves, Apron
- **E.** Safety Glasses, Gloves, Dust Respirator
- **F.** Safety Glasses, Gloves, Apron, Dust Respirator.
- **G.** Safety Glasses, Gloves, Vapor Respirator
- **H.** Splash Goggles, Gloves, Apron, Vapor Respirator
- **I.** Safety Glasses, Gloves, Dust and Vapor Respirator
- **J.** Splash goggles, Gloves, Apron, Dust and Vapor Respirator
- **K.** Air Line, Hood or Mask, Gloves, Full Suit, Boots
- **X.** Ask your supervisor for guidance

8B. HMIS Rating (Optional)

9A. Control and Protective Measures

The type of personal protective equipment, the type of ventilation to be used and the precautions to be taken when using the material for its intended purpose are given.

Respirator Protection—Specifies type of respirator to be used.

Protective Gloves—Gives type of gloves including materials of construction.

Eye Protection—Indicates type of eye protection, such as full face shield or safety goggles.

Ventilation—Specifies type of ventilation required in work areas and under what conditions it is suitable.

Other Protective Clothing and Equipment— Specifies when special suits, clothing of special material and/or construction, or other special handling is required for personal protection.

Hygienic Work Practices—Indicates personal hygienic steps to be taken when handling the chemical to include washing hands after use, not smoking, or disposal or laundering of contaminated clothing.

9B. Precautions for Safe Handling

— Precautions to Be Taken in Handling and Storage: Gives any special precautions to be taken in storage and handling such as avoiding reaction hazards with oxidizing agents, temperature, ventilation, or no smoking.

— **Steps to Be Taken If Material Is Spilled or Released**: Indicates any applicable precautions to be taken in event of spills or leaks, as well as special equipment used for cleanup, such as glass or plastic scoops and types of containers. Also indicates specific absorbents, neutralization materials, decontamination materials, whether evacuation is necessary or safety personnel are required.

— Waste Disposal Methods: Gives methods for disposal of spilled solids or liquids. Methods must always follow federal, state and local regulations.

10. Special Precautions

Lists any other general precautions to be taken that have not previously been mentioned.

Glossary of Terms Used on the MSDS

The following terms have the meanings defined herein for the development and preparation of the MSDS. For additional identification and definition of hazards, refer to the regulations cited in definition.

Acute—Acting over short time period, measured in seconds, minutes, hours or days; referring to symptoms of high severity quickly coming to crisis.

Acute effects of overexposure—Adverse effects normally evident immediately or shortly after exposure to hazardous material, without implying degree of severity.

Alopecia—Loss of hair.

Analgesia—Loss of sensitivity to pain.

Anesthesia—Loss of sensation or feeling.

Anthydride—Compound which when combined with water gives acid or base.

Anhydrous—Free of water.

Anosmia—Loss of the sense of smell.

Anoxia—Lack of oxygen from inspired air.

Anorexia—Loss of appetite.

Aqueous—Water based solution.

Asphyxia—Unconsciousness due to interference with oxygenation of blood.

Asphyxiant—Vapor or gas that can cause injury by reducing amount of oxygen available for breathing.

Ataxia—Loss of the power of muscular coordination.

Atrophy—Wasting or diminution in size of part of body.
Bradycardia—Slow heartbeat. Rate below 60.

Bronchitis—Inflammation of the bronchial tubes in the lungs.

Calorie—Heat required to raise 1 gm of water from 15º to 16ºC.

Carcinogen—Chemical demonstrated to cause cancer in humans, or to cause cancer in animals and, therefore, considered capable of causing cancer in humans.

Carcinoma—Malignant tumor or cancer.

Catalyst—Substance that changes rate of chemical reaction without itself being used up.

Cataract—Loss of transparency of crystalline lens of eye or of its capsule.

Chemiluminescence—Emission of light during noncombustion chemical reaction.

Chronic—Acting over long time period, measured in weeks, months or years; referring to disease symptoms that develop slowly or that recur.

Chronic Effects of Overexposure—Adverse effects developing slowly over long time period or upon repeated prolonged exposure to hazardous material, without implying degree of severity.

Combustible—Referring to liquids having a flash point at or above 100ºF (37.8ºC) but below 200ºF (93.3ºC).

Conjunctivitis—Inflammation of membrane that lines eyelids and covers eyeballs.

Cornea—Transparent structure of external layer of eye.

Corrosive material—Chemical liquid or solid that causes visible destruction or irreversible alteration in human skin tissue at site of contact or, in case of leakage from its packaging, liquid that has severe corrosion rate on steel.

Cutaneous—Pertaining to skin.

Cyanosis—Purplish (cyanotic) coloration of skin and mucous membranes due to deficient oxygenation of blood.

Dermatitis—Inflammation of skin.

Dyspnea—Difficulty in breathing.

Edema or Swelling—Accumulation of fluid in tissues.

Electrolyte—Any substance that, in solution, conducts electric current.

Embolism—Obstruction of blood vessel by clot, mass of bacteria, or other foreign material.

Emphysema—Swelling due to presence of air in connective tissues of lungs. Inability of lungs to fully deflate when exhaling.

Epistaxis—Nosebleed; hemorrhage from nose.

Explosive—Referring to chemical that causes sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Exposure—Instance where employee is exposed to hazardous chemical in course of employment through any route of entry (inhalation, ingestion, skin contact, or absorption, etc.), and includes potential (e.g., accidental or possible) exposure.

Flash Point—Minimum temperature at which liquid gives off vapor in sufficient concentration to ignite when tested.

Foreseeable emergency—Any potential occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control of equipment that could result in uncontrolled release of hazardous chemical.

Gangrene—Death of tissue combined with putrefaction.

Gastroenteritis—Inflammation of stomach and intestines.

Hazardous chemical substance or mixture—Substance that is one or more of following: extremely toxic material, highly toxic material, toxic material, corrosive material, irritant, strong sensitizer, dangerously reactive material, extremely flammable material, combustible liquid, pyrophoric material, strong oxidizer, pressure-generating material, or compressed gas.

Health hazard—Chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.

Hematuria—Blood in urine.

Highly toxic—Referring to chemical falling within any of following categories:

1. **Danger:** A chemical that has a median lethal dose (LD_{50}) of *50 milligrams or less per kilogram of body weight* when administered orally to albino rats weighing between 200 and 300 grams each.

2. **Warning:** A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less, if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.

3. **Caution:** A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume or dust, when administered by continuous inhalation for one hour (or less, if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Hygroscopic—Absorbing moisture from air.

Hypoxia—Insufficient oxygen reaching body cells.

Inflammation—Redness and swelling of tissue due to some irritation.

Ingestion—Taking in of substance through mouth.

Inhibitor—A chemical used to prevent unwanted chemical change from occurring.

Iridocyclitis—Inflammation of both iris and ciliary body.

Irritant—Chemical substance or mixture, *not* a corrosive, that on immediate, prolonged, or repeated contact with normal living tissues induces local inflammatory response in skin, eyes, or mucous membranes.

Ketosis—Condition marked by excessive production of ketones in body.

Lacrimation—Discharge of tears.

Lavage—Washing of hollow organ, such as stomach.

LC_{50} (Median lethal concentration)—Concentration in air of gas, vapor, mist, fume, or dust for given period of time that is most likely to kill one-half of group of test animals using specified test procedure. Inhalation is route of exposure and the value LC_{50} is usually expressed as parts per million or milligrams per cubic meter (ppm or mg/m^3).

LD_{50} (Median lethal dose)—Dosage of substance or mixture that is most likely to kill one-half of group of test animals using specified test procedure. The dose is expressed as the amount of poison per unit of body weight, the most common expression being milligrams of material per kilogram of body weight (mg/kg of body weight). Usually refers to oral or skin exposure.

LEL (lower explosive limit)—Lowest concentration of gas or vapor (percentage by volume in air) that will burn or explode if ignition source is present.

Malaise—Feeling of general discomfort, distress, or uneasiness.

Metabolism—Chemical changes whereby body functions.

MSDS (Material Safety Data Sheet)—Document containing information and instructions on chemical and physical characteristics of substance, its hazards and risks, safe handling requirements, and actions to be taken in event of fire, spill, overexposure, and so on.

Mutagens—Chemicals or physical effects that can alter genetic material in an organism resulting in physical or functional changes in all subsequent generations.

Narcosis—Stupor or unconsciousness produced by narcotic drug.

Nausea—Feeling of sickness to stomach.

Necrosis—Local death of tissue.

Nystagmus—Spasmic, involuntary motion of eyeballs.

Oliguria—Low volume of urine.

Oxidizer—Chemical other than blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through release of oxygen or other gases.

Oxidizing agent—chemical that supplies oxygen in chemical reaction.

Physical hazard—Chemical for which there is scientifically valid evidence that it is combustible liquid, compressed gas, explosive, flammable, organic peroxide, oxidizer, pyrophoric, unstable (reactive), or water-reactive.

Polymerization—Chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units. Reaction often generates heat.

Pulmonary edema—Fluid in lungs.

Pyrolysis—Chemical decomposition produced by heating.

Pyrophoric material—Chemical substance or mixture that will ignite spontaneously in dry or moist air at or below 130ºF (54.4ºC).

Reactive material—Chemical substance or mixture that may vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, or temperature; and that falls within any of following categories:

1. **Explosive material**
2. **Organic peroxide**
3. **Pressure-generating material**
4. **Water-reactive material**

Reactivity—Measure of tendency of a substance to undergo chemical reaction with release of energy.

Reducing agent—Chemical that removes oxygen in chemical reaction.

Sensitizer—Chemical substance or mixture that causes substantial number of persons to develop hypersensitive, allergic, or photodynamic reaction in normal tissue upon reapplication of chemical substance or mixture.

Strong oxidizer—Chemical substance or mixture that initiates or promotes combustion in other materials, thereby causing fire either of itself or through release of oxygen or other gases.

Teratogen—Chemical that has been demonstrated to cause physical defects in developing embryo.

Threshold Limit Value (TLV$^{(R)}$)—Airborne concentration of substance which it is believed nearly all workers may be repeatedly exposed day after day without adverse effect.

Toxic—Referring to chemical within any of following toxic categories:

1. A chemical that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

2. A chemical that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.

3. A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust when administered by continuous inhalation for one hour (or less, if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Unstable—Chemical that in pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shock, or elevated pressure or temperature.

Abbreviations Used on the MSDS

AQTX	=	aquatic toxicity
atm	=	atmosphere
ca	=	(circa) about
CAR	=	carcinogenic effects
cc	=	cubic centimeter
CC	=	closed cup
CFR	=	Code of Federal Regulations
CNS	=	central nervous system
COC	=	Cleveland open cup
conc	=	concentration
cu m or m^3	=	cubic meter
CWA	=	Clean Water Act
decomp	=	decompose or decomposition
DOT	=	Department of Transportation
EPA	=	Environmental Protection Agency
FR	=	Federal Register
G.I. or GI	=	gastrointestinal
g or gm	=	gram

HW	=	hazardous waste
I	=	intermittent
inhl	=	inhalation
insol	=	insoluble
IRDS	=	primary irritation dose
IRR	=	irritant effects (systemic)
kg	=	kilogram
l	=	liter
LEL	=	lower explosive limit
LFM	=	linear feet per minute
m^3	=	cubic meter
MESA	=	Mining Enforcement and Safety Administration
mg	=	milligram
ml	=	milliliter
mm Hg	=	millimeters of mercury
MLD	=	mild irritation effects
MW	=	molecular weight
NEO	=	neoplastic effects
NIOSH	=	National Institute of Occupational Safety and Health
NOx	=	oxides of Nitrogen
OSHA	=	Occupational Safety and Health Administration
pH	=	symbol used to express acid concentration
PMCC	=	Pensky-Martens closed cup
POx	=	oxides of phosphorus
ppb	=	parts per billion
ppm	=	parts per million
ppt	=	parts per trillion
PUL	=	pulmonary systems effects
RCRA	=	Resources Conservation and Recovery Act
RQ	=	reportable quantity
SCBAF	=	self-contained breathing apparatus with full facepiece
SCC	=	Setaflash closed cup
soln	=	solution
Sox	=	oxides of Sulfur
SYS	=	systemic effects
TCC	=	Tagliabue closed cup
temp	=	temperature
TER	=	teratogenic effects
TFX	=	toxic effects
TOC	=	Tagliabue open cup
torr	=	mm Hg pressure
TSCA	=	Toxic Substances Control Act
UEL	=	upper explosive limit
>	=	greater than
<	=	less than

Chapter Two
The Pesticide Label & the MSDS — Question and Answer Review

1. **Q. Why is the MSDS sheet the cornerstone of the Hazard Communication Standard?**
   A. It provides information about the chemical substances of a product, safe handling procedures, first aid measures, and procedures to be taken when the product is accidentally spilled or released.

2. **Q. What does the MSDS allow for the evaluation of?**

   A. The MSDS allows for the evaluation of potential physical and health hazards of chemicals being considered for or presently used at a facility.

3. **Q. List the parts of an MSDS.**

   A. Identity, warning statement, hazardous ingredients, physical and chemical characteristics, fire and explosion hazard information, reactivity data, health hazard data, precautions for safe handling (including exposure control methods, spill or leak procedures, and special precautions for handling and storage), additional regulatory information (if any), appendix (if any), and source and date information.

4. **Q. List the physical and chemical characteristics on an MSDS.**

   A. The physical and chemical characteristics consist of: boiling point, vapor pressure, vapor density, water solubility, specific gravity, evaporation rate, and water reactivity.

5. **Q. Name the health hazard data listed on an MSDS.**

   A. They are primary route of entry, signs and symptoms of exposure, emergency first aid procedures, acute and chronic health hazards, and medical conditions gener ally aggravated by exposure.

6. **Q. What steps should be taken if a material is spilled or released?**

   A. These steps are listed on the MSDS and include such things as avoiding breathing gases and vapor, avoiding skin contact with the chemical, and removing sources of ignition; special equipment needed to clean up, such as glass or plastic scoops, types of containers, and specific absorbents; and neutralization and decontamination materials. Also indicated is whether evacuation is necessary or safety personnel are required.

7. Q. Explain the difference between the terms *label* and *labeling*.

A. The *label* is the information printed on or attached to the pesticide container. *Labeling* includes the label itself, plus all other information referred to on the label such as the Worker Protection Standard, endangered species maps, etc..

8. Q. What do the words "Restricted-Use Pesticide" tell you about the pesticide product?

A. "Restricted-Use Pesticide" means that the product has been shown to be likely to harm people or the environment if it is not used correctly. It may be purchased and used only by certified applicators and those under their direct supervision.

9. Q. Explain the differences between *chemical name, common name,* and *brand name*. Which of these terms should you use to most accurately identify a pesticide product?

A. The *chemical name* is a complex name that identifies the chemical components and structure of a pesticide. A *common name* is a shorter name that EPA recognizes as a substitute for the chemical name of a product. A *brand name* is the name—usually a trademark—used by a chemical company to identify a pesticide product. The common name (or the chemical name if no common name is given) is the most accurate and useful way to identify a pesticide product.

10. Q. Name and explain the meaning of the signal words and symbols you may see on a pesticide product.

A. CAUTION indicates that the pesticide is slightly toxic or relatively nontoxic. WARNING indicates that the pesticide product is moderately toxic. DANGER indicates that the pesticide product is highly toxic. POISON and the skull and crossbones indicate that the pesticide product is highly toxic as a poison, rather than as a skin or eye irritant.

11. Q. What type of hazard statement should you look for in the pesticide labeling?

A. You should look for precautions about hazards to humans (and domestic animals), environmental hazards, and physical/chemical hazards.

12. Q. What types of precautionary statements may be included in the labeling section entitled "Hazards to Humans"?

A. Acute effects precautions, delayed effects precautions, allergic effects precautions, and personal protective equipment requirements may be in the section of the labeling titled "Hazards to Humans."

13. Q. What is the meaning of the statement: "It is a violation of Federal law to use this product in a manner inconsistent with its labeling"?

A. It is illegal to use a pesticide in any way not permitted by the labeling. A pesticide may be used only on the plants, animals, or sites named in the directions for use. You may not use higher dosages, higher concentrations, or more frequent applications. You must follow all directions for use, including directions concerning safety, mixing, diluting, storage, and disposal. You must wear the specified personal protective equipment even though you may be risking only your own safety by not wearing it.

14. Q. Are the words "Keep Out of Reach of Children" on all pesticide labels?

A. Yes. All pesticide labels have the warning "Keep Out of Reach of Children."

15. Q. Does the label specify the protective equipment necessary for cautious use of each pesticide?

A. Yes. The label will sate the necessary protective equipment.

16. Q. If the intended use is not listed on the label, but you are pretty sure it works, should you go ahead and use it anyway?

A. No. Pesticides are developed to control pests on specific sites. Use of a pesticide on a site not listed on the label is illegal.

17. Q. If you use a nonregistered material and problems arise, are you liable, or is it just too bad for your client?

A. The pesticide applicator is liable for the misuse of a pesticide.

18. Q. The pesticide and the label will be registered by EPA only when what four things are protected?

A. The applicator, fish and wildlife, the environment, and the consumer are protected.

19. Q. What labels must carry an antidote statement and the sentence "Call a physician immediately"?

A. "Danger" labels.

20. Q. What directions for use can you find on the label?

A. The pests to be controlled by the pesticide, the rate for application, and the methods of application.

21. Q. What other recommendations are on the label?

A. The recommended crop and site, the equipment, quantity of pesticide, mixing directions, compatibility with other products, health precautions, and the location and timing of applications.

22. Q. Name the five different times you should read the label and give the reasons why for each one.

A. The five different times are: (1) before buying, (2) mixing, (3) applying, (4) storing, and (5) disposing of pesticides.

23. Q. On the "Misuse Statement" (i.e. Storage and Disposal), legal disposal steps are required for _____, _____ and the _____.

A. The label specifies disposal steps for the excess pesticide, rinsate, and the container.

CHAPTER 3:

PESTICIDE TYPES & FORMULATIONS

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I. Introduction

Chapter Objectives

By the time you finish this chapter, you will

- know the definition of a pesticide;
- know definitions and abbreviations for types of formulations;
- be familiar with the major families of pesticides and their modes of action;
- know what to consider in choosing the best formulation and when to use it;
- understand the dangers of various formulations and how to protect yourself.

Terms To Know

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

Active Ingredient — Chemical that controls target pest and has toxicity.

Aerosol — Fine spray produced under pressurized gas that leaves small fine droplets of pesticide suspended in air.

Agitation — Process of stirring or mixing.

Alkaline — Opposite of acidic; having pH greater than 7.

Carrier — Primary material used allowing effective pesticide dispersal; for example, talc in dust formulations.

Compatibility — Ability of two compounds to mix without affecting each other's chemical properties.

Dilute — To make less concentrated.

Emulsion — Mixture of two or more liquids that are not soluble in one another; one is suspended as small droplets in the other.

Insoluble — Does not dissolve in liquid.

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

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

Petroleum-based — Made from petroleum products, such as xylene, refined oil, or kerosene.

Soluble — Able to dissolve in another substance, usually as a liquid.

Solution — A mixture of substance without chemical change taking place.

Solvent — Liquid, such as water, kerosene, xylene, or alcohol, that will dissolve pesticide (or other substance) to form solution.

Suspension — Substance that contains undissolved particles mixed throughout liquid.

Target pest — Pest toward which control measures are being directed.

ULV (ultra-low-volume) — Concentrations that approach 100% active ingredient.

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

Many of us have used the word *pesticide*, but how often have we really thought about what it means? According to Federal law, as defined by the amended Insecticide, Fungicide and Rodenticide Act (FIFRA), a *pesticide* is any substance or mixture of substances intended for destroying, preventing or mitigating insects, rodents, nematodes, fungi or weeds, or any other form of life declared to be pests; and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Many new chemicals are being developed which do not fit our traditional views of what a pesticide is and how it should be applied. For example, are insect pheromones pesticides? What are plant growth regulators? Is dish detergent a pesticide when it is used to kill whiteflies?

Pesticides that target a particular group of organisms are given specific names to reflect their activity. The names are derived from the Latin or scientific name for the group (Table 3.1). The ending or suffix *-cide* means kill or killer. But not all pesticides end with *-cide*. Examples include: **growth regulators,** which stimulate or retard the growth of pests; **defoliants,** which cause plants to drop their leaves; **dessicants**, which speed the drying of plants for mechanical harvest or cause insects to dry out and die; **repellents** which repel pests; **attractants**, which attract pests, usually to a trap; and **chemosterilants**, which sterilize pests. **Pheromones**, are *scents* produced by animals to communicate to other members of the same species, they are used as attractants to monitor or trap insects. Finally, the term **biocide** is often referred to as a pesticide that kills a wide range of organisms and is toxic to both plants and animals.

Table 3.1. Major Pesticide Families

Pesticide Type	Used Against
Acaricide (miticide)	Mites
Algicide	Algae
Avicide	Birds (Aves)
Bactericide	Bacteria
Fungicide	Molds, mushrooms, fungal diseases (Fungi)
Herbicide	Weeds
Insecticide	Insects and related animals
Molluscicide	Snails and slugs (Mollusca)
Nematocide	Nematodes
Rodenticide	Rats, mice or other rodents

II. Pesticide Classification

Pesticides may be put into categories or "classified" in several ways. Originally classified according to the ways they entered the pest, pesticides are now also classified according to their chemical properties (Table 3.2).

Modes of Entry & Chemical Group

The ways pesticides come in contact with or enter the target are called *modes of entry*. These include contact, systemic, stomach poisons, fumigants, and repellants.

Contact pesticides must come into physical contact with the pest to be effective. Contact herbicides kill only the plant parts to which they are applied. For example, diquat bromide is a contact herbicide used to control broadleaf weeds. Contact insecticides may kill the insect when applied directly, or may kill when an insect contacts a residue on a surface.

Systemic pesticides are applied to either plants or soil and translocated or moved throughout plants. Systemic herbicides are taken up by the foliage or the roots and move throughout the target plant, and

Table 3.2: Common pesticide chemical groups.

CHEMICAL GROUP	EXAMPLE	MODE OF ACTION
INSECTICIDES		
Organochlorines	DDT, methoxychlor	Contact
Organophosphates	Malathion, ethyl-parathion, Diazinon	Contact/stomach poison
Carbamates	Methomyl (Lannate©), Carbaryl (Sevin©)	Contact/stomach poison
Botanicals	Nicotine, rotenone	Contact/stomach poison
Pyrethroids	Permethrin (Ambush©)	Contact
Fumigants	Methyl bromide	Fumigant
Insect growth regulators	Methoprene	Systemic
HERBICIDES		
Inorganics	Sodium chlorate	Contact
Organic arsenicals	MSMA, DSMA	Contact/systemic
Phenoxy	2, 4-D, MCAP, MCPP	Systemic
Amides	Pronamide (Kerb©), alachlor (Lasso©)	Contact/systemic
Dinittoanilines	Trifluralin (Treflan©), Oryzalin (Surflan©)	Contact
Triazines	Atrazine (AAtrex) Cyanazine (Bladex©) Simazine (Princep)	Systemic
FUNGICIDES		
Inorganics	Copper Sulfur	Contact
Triazines	Anilazine (Dyrene©)	Contact
Substituted aromatics	Chlorothalonil (Bravo©)	Contact

are commonly used to control established perennial weeds. Systemic insecticides (e.g., aldicarb) are applied to soil, move through the host plant, and are fed on by the target insect when it chews or sucks on the plant (Fig 3.1). If the insect does not feed on the plant, it will not be controlled.

Stomach poisons must be eaten to control the pest. Baits for insects, birds, and rodents contain toxins that must be taken internally.

Fumigants are poisons applied as liquids that turn to gas. Fumigants are used to remove stored product pests from fruits, vegetables and grains, and are used to control pests in soil.

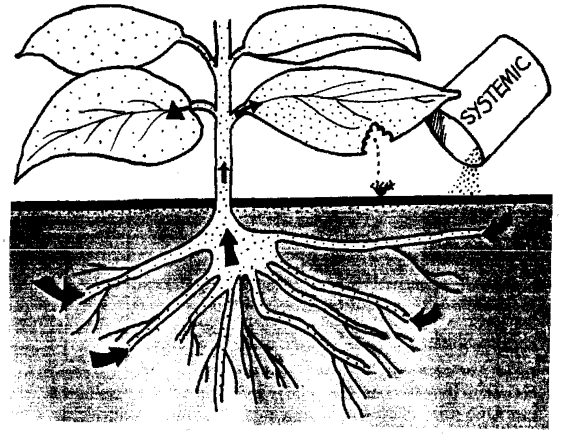

Figure 3.1 Systemic Pesticide

Repellents do not kill but are distasteful enough to keep pests away from treated areas/commodities.

III. Pesticide Types

INSECTICIDES

INORGANIC

Inorganic insecticides are naturally occurring chemical substances that do not contain the element carbon and, thus, are not derived from living things. Some of the first pesticides ever used were elements such as *sulfur* or *arsenic*. Inorganic pesticides in general are slow-acting, but have the advantage of having long-term residual activity. Sulfur is still used for thrips control in citrus.

ORGANIC

Organic insecticides contain the element carbon, which is the element common to all living things. Some organic insecticides are derived from living things, and others are synthetic (man-made). **Synthetic** insecticides are manufactured chemicals that have been modified from biological sources, and selected for biological activity, then manufactured. For example, organophosphates were initially discovered in Germany during World War II by chemists looking for a substitute for nicotine.

Chlorinated hydrocarbons (also called *organochlorines*) were the first widely used group of synthetic insecticides. Developed during World War II, they are made up of the elements carbon, hydrogen, and chlorine. An example of a chlorinated hydrocarbon is DDT (dichlorodiphenyltrichloroethane), which was used extensively throughout the world for many years. For a number of reasons, it was banned for use in the United States in 1971. In fact, Arizona was the first state to limit its use because of problems with contaminated milk in dairies.

Most pesticides are attacked by heat, microorganisms, water, or ultraviolet light after they are applied and eventually break down into compounds that are not biologically active. Chlorinated hydrocarbons, on the other hand, do not readily break down, but bind to soil particles. Because they persist for a long time, they are more likely to pollute the environment by leaching into the groundwater and by accumulating in the fatty tissues of nontarget organisms (see **bioaccumulation,** Chapter 4). Currently, **none** of the following are registered for use: *chlordane*, *methoxychlor* and *dicofol* (an acaricide).

Organophosphates were developed to replace some of the chlorinated hydrocarbons. Organophosphates break down more rapidly in the environment and are less likely to pose an environmental risk. However, they are, in general, more acutely toxic than chlorinated hydrocarbons. Organophosphates contain the element phosphorus linked to oxygen to form the phosphate group. *Methyl parathion* and *chlorpyrifos* are commonly used organophosphates.

Carbamates were first developed in the 1950's. They contain carbon atoms linked to nitrogen and oxygen. In general, they break down more rapidly

than organophosphates and have fairly high mammalian toxicity. *Aldicarb, carbofuran,* and *carbaryl* are carbamates.

Pyrethroids were developed by chemists by modifying the basic chemical structure of the botanical insecticide *pyrethrum*, originally extracted from the flowers of a chrysanthemum (Fig 3.2). Known for having a quick knockdown of insects, pyrethroids (or synthetic pyrethroids) break down under ultraviolet light. More recent pyrethroids have been modified to last longer in sunlight. Among these, *permethrin* and *fenvalerate* are examples.

Figure 3.2 Chrysanthemum

Insect Growth Regulators (IGRs) stimulate or disrupt growth or development in insects. Juvenile hormone analogues are compounds that mimic **juvenile hormone**, a natural insect hormone involved in controlling molting and other processes in insects. An example of a juvenile hormone analogue is MTDD. MTDD is a hormone-like compound in the wood of balsam fir which prevents insects from developing to the adult stage.

Biological

Biological control is the use of living organisms, particularly natural enemies, parasites, and pathogens, to control or manage pests. As a certified applicator or pesticide handler, you must be aware of predators such as the ladybird beetle, that feeds on aphids, as well as parasites that consume their hosts. But pathogens and their by-products are also used to manage insects; examples are microbial and botanical insecticides found in living organisms.

Microbial insecticides are microorganisms or microbes that control insect pests. For example, *Bacillus thuringiensis* (Bt) a bacterium sprayed onto host plants, contains a toxin known to disrupt the gut of caterpillars feeding on the plants. In addition, scientists have taken the gene that controls the production of the toxin and inserted it into cotton and other plants. Now the genetically engineered plants are able to defend themselves against lepidopteran insect pests.

Many plants contain materials that deter feeding by insects or act as **botanical** insecticides. For example, *pyrethrum,* the oily extract of certain varieties of chrysanthemum, has been put to use by humans; our modern synthetic pyrethroids are based on the chemistry of pyrethrum. It is important to note, however, that other botanical insecticides, such as *sabadilla, rotenone,* and *nicotine,* even though derived from plants, are not necessarily less toxic to humans or other animals. For example, *rotenone* is highly toxic to fish, *nicotine* is a Category I insecticide, the same category containing *methyl parathion*.

HERBICIDES

Herbicides are used to control weeds. A weed is any plant that is out of place. For example, a corn plant in a field of cotton would be a weed.

Herbicides may be selective or nonselective. A **selective** herbicide controls only specific types of plants. For example, 2,4-D will kill annual grasses and mustard in a barley field. On the other hand, **non-selective** herbicides may be used to control all the vegetation in an area.

Herbicides may be applied at different times in the plant growth cycle. **Preplant** herbicides are applied *before a crop is planted*. **Preemergence** herbicides are applied to plants *before they emerge* from the ground; **postemergence** herbicides are applied to plants that have *already emerged*.

If a herbicide is **persistent**, it can continue to be active for more than a growing season, and thus could harm susceptible plants or interfere with crop rotation.

INORGANIC

As with insecticides, the earliest herbicides were inorganic materials such as salt or ash. Arsenic salts such as *sodium arsenite* were widely used as herbicides until the 1960's. *Copper sulfate* is still used to control algae in irrigation water conveyance systems.

ORGANIC

Petroleum Oils were the first organic herbicides. Materials such as used motor oil, kerosene, and diesel, once applied to keep areas weed free, are no longer recommended because they contaminate groundwater and are a fire hazard.

Carbamates are herbicides as well as insecticides and fungicides. They are commonly used as preemergence herbicides, although some have postemergence activity (e.g., *chlorpropham*).

Triazines are commonly available as herbicides. Triazines are made up of carbons and nitrogens forming a six-sided ring. A classic example is the herbicide *atrazine*. The soil sterilant *prometryn* is also a triazine. In general, these herbicides migrate easily in the soil, which may cause leaching problems and affect adjacent plants.

Phenoxy herbicides were developed in the 1940's, and are also called "chlorphenoxy" herbicides because they contain the element chlorine. Phenoxy herbicides mimic **auxins**, natural plant hormones used as growth regulators (e.g., *2,4-D).*

Amides contain the element nitrogen. Generally simple molecules that break down readily and do not persist in the soil, amides may be used as post- or preemergence applications. Some inhibit root elongation in seedlings, and others interrupt photosynthesis (e.g., *propanil).*

Dinitroaniline (or *substituted aniline*) herbicides, like the amides, contain the element nitrogen, but the nitrogen atoms are linked to oxygen. These herbicides interfere with enzymes produced by the plant and inhibit root or shoot growth (e.g., *Treflan*©).

Substituted ureas block the photosynthesis process. Examples are *diuron* and *monuron*.

Plant growth regulators (PGRs) are also used to control weeds. Auxins, giberellins, cytokinins, ethylene generators, and growth retardants all affect growth and fruit ripening of plants.

IV. Pesticide Formulations

Pesticides come in various formulations. Formulations enable the pesticide to be applied. A pesticide formulation can be a wettable powder (WP), soluble powder (SP), or emulsifiable concentrate (EC). Pesticide formulations are broken-down into active ingredients and inert ingredients. The **active ingre-**

dients in a pesticide are the chemicals that control the target pest. Most pesticide products you buy also have **inert** (inactive) **ingredients**, which are used to dilute the pesticide or to make it safer, more effective, easier to measure, mix, or apply, and more convenient to handle. Usually the pesticide is diluted in water, a petroleum-based solvent, or another diluent. Other chemicals in the product may include wetting agents, spreaders, stickers, or extenders. (Fig 3.3)

Figure 3.3 Various Formulations

Some formulations are ready for use. Others must be further diluted with water, a petroleum-based solvent, or air (as in airblast or ULV applications) before they are applied.

A single active ingredient is often sold in several different kinds of formulations. To choose the best available formulation for your pest control situation, ask yourself the following questions about each formulation:

- Do I have the necessary application equipment?
- Can the formulation be applied safely under the conditions in the application area (e.g., drift, runoff, wind, rain)?
- Will the formulation reach your target and stay in place long enough to control the pest?
- Is the formulation likely to harm the surface to which I will apply it?

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

V. Liquid Formulations

Emulsifiable Concentrates (EC or E)

These formulations usually contain a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion. Each gallon of EC usually contains 25% to 75% (2 to 8 pounds) active ingredient. EC's are among the most versatile formulations. They are used against agricultural, ornamental, turf, forestry, structural, food processing, livestock, and public health pests. They are adaptable to many types of application equipment, including small portable sprayers, hydraulic sprayers, low-volume ground sprayers, and mist blowers. (Fig 3.4)

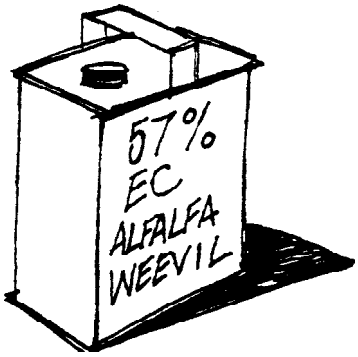

Figure 3.4 Emulsifiable Concentrates (EC or E)

Advantages:

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

Disadvantages:

- High concentration makes it easy to overdose or underdose through mixing or calibration errors
- May cause unwanted harm to plants
- Easily absorbed through skin of humans or animals
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate
- May cause pitting or discoloration of painted finishes
- Flammable (should be used and stored away from heat or open flame)
- May be corrosive
- Insoluble in water

Solutions (S)

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

Ready-to-Use (RTU). These solutions contain the correct amount of solvent when you buy them. No further dilution is required before application. These formulations, usually in petroleum-based solvents, contain small amounts (often 1% or less) of active ingredient per gallon.

Concentrate Solutions (C or LC). These must be further diluted with a liquid solvent before you apply them. Occasionally the solvent is water, but more often the solvent is a specially refined oil or petroleum-based solvent. Some uses include livestock and poultry pest control, space sprays in barns and warehouses, shade tree pest control, as well as mosquito control.

Advantages:

- No agitation necessary

Disadvantages:

- Limited number of formulations of this type available

The other advantages and disadvantages of solutions vary depending on the solvent used, the concentration of the active ingredient, and the type of application involved.

Ultra-Low-Volume (ULV). These concentrates may approach 100% active ingredient. They are designed to be used as is or to be diluted with only small quantities of specified solvents. These special-purpose formulations are used in agricultural, forestry, ornamental, and mosquito control programs. (Fig 3.5)

Advantages:

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

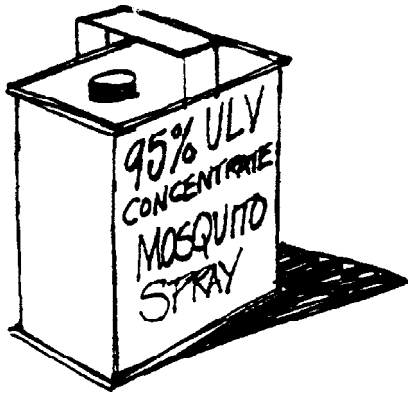

Figure 3.5 Ultra-Low-Volume (ULV)

Disadvantages:

- Difficult to keep pesticide in the target site (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

Flowables (F or L)

Some active ingredients are insoluble solids. These may be formulated as flowables in which the finely ground active ingredients are mixed with a liquid, along with inert ingredients, to form a **suspension**. Flowables are mixed with water for application and are similar to EC or wettable powder formulations in ease of handling and use. They are used in the same types of pest control for which EC's are used.

Advantages:

- Seldom clog nozzles
- Easy to handle and apply

Disadvantages:

- Require moderate agitation
- May leave a visible residue

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of aerosol formulations: the ready-to-use type, and those made for use in smoke or fog generators. (Fig 3.6)

Ready-to-Use Aerosols

These aerosol formulations are usually small, self-contained units that release the pesticide when

the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.

Advantages:

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

Figure 3.6 Aerosols

Disadvantages:

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

Formulations for Smoke or Fog Generators

These aerosol formulations are not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly to control insect pests in structures such as greenhouses and warehouses, and to control mosquitoes and biting flies outdoors.

Advantages:

- Easy way to fill entire 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

Invert Emulsions

This mixture 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. When applied, invert emulsions form large droplets that do not drift easily. Invert emulsions are most commonly used in vegetation control where drift to susceptible nontarget plants is a problem.

VI. Dry Formulations

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredient (usually 0.5% to 10%), plus a very fine dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles is variable.

A few dust formulations are concentrates and contain a high percentage of active ingredient. These must be mixed with dry inert carriers before they can be applied.

Dusts are always used dry, and they easily drift into non-target sites. They are widely used in seed treatment. Dusts also are used to control lice, fleas, and other parasites on pets and livestock.

Advantages:

- Usually ready to use, with no mixing
- Effective where moisture from a spray might cause damage
- Require simple equipment

Disadvantages:

- Easily drift off target during application
- Residue easily moved off target by air movement or water
- May irritate eyes, nose, throat, and skin
- Do not stick to surfaces as well as liquids

Baits (B)

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

Outdoors they are used to control snails, slugs, and some insects, but their main use is for control of vertebrate pests such as rodents, other mammals, and birds. (Fig 3.7)

Figure 3.7 Baits

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

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 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.

Granules (G)

Granular formulations are similar to dust formulations except that granular particles are larger and heavier. The coarse particles are made from an absorptive material such as clay, corn cobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. (Fig 3.8) The amount of active ingredient is relatively low, usually ranging from 1% to 15%.

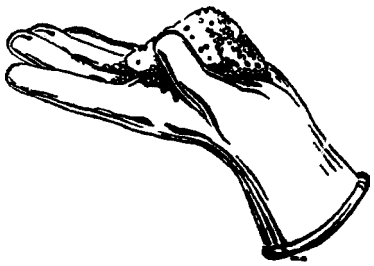

Figure 3.8 Granular Formulation

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

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

Advantages:

- Ready to use; no mixing
- Drift hazard is low, and particles settle quickly
- Little hazard to applicator (no spray, little dust)
- Weight carries the formulation through foliage to target
- Simple application equipment, such as seeders or fertilizer spreaders
- May break down more slowly than WPs or ECs through a slow-release coating

Disadvantages:

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

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 them to be applied by precision applicators such as those being used

for precision planting of pelleted seed. A few fumigants are formulated as pellets; however, these will be clearly labeled as fumigants and should not be confused with nonfumigant, granule-like pellets. (Fig 3.9)

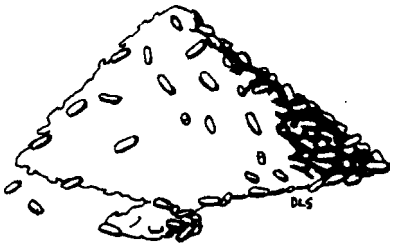

Figure 3.9 Pellets

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% active ingredient, usually 50% or more. Wettable powder particles do not dissolve in water. They settle out quickly unless constant agitation is used to keep them suspended.

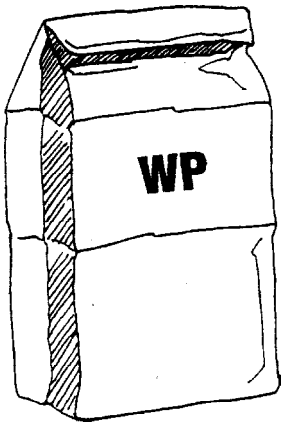

Figure 3.10 Wettable Powder

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. (Fig 3.10)

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

Disadvantages:

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

Soluble powders (SP or WSP)

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

Microencapsulated Pesticides (M)

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

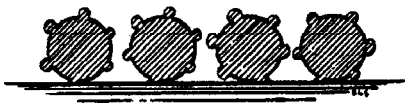

Figure 3.11 Microencapsulated

Advantages:

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

Disadvantages:

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

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

Water-dispersible granular formulations are like wettable powder formulations, except the active ingredient is prepared as granule-sized particles. Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine powder. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders except that they are more easily measured and mixed, and they cause less inhalation hazard to the applicator during pouring and mixing.

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 Flowable
DS	=	Soluble Dust
E	=	Emulsifiable Concentrate
EC	=	Emulsifiable Concentrate
F	=	Flowable

G	=	Granules
H/A	=	Harvest Aid
L	=	Flowable
LC	=	Liquid Concentrate or Low Concentrate
LV	=	Low Volatile
M	=	Microencapsulated
MTF	=	Multiple Temperature Formulation
P	=	Pellets
PS	=	Pellets
RTU	=	Ready to Use
S	=	Solution
SD	=	Soluble Dust
SG	=	Soluble Granule
SP	=	Soluble Powder
ULV	=	Ultra Low Volume
ULW	=	Ultra Low Weight or Ultra Low Wettable
WS	=	Water Soluble
WSG	=	Water-Soluble Granules
WSL	=	Water-Soluble Liquid
W	=	Wettable Powder
WDG	=	Water-Dispersible Granules
WP	=	Wettable Powder
WSP	=	Wettable Soluble Powder

VII. Fumigants

Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids when packaged under high pressure but change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and so are not formulated under pressure. Still others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor. Fumigants are used in food and grain storage facilities; regulatory pest control at ports of entry and at state and national borders; in soil, and in greenhouses, granaries, and grain bins.

Advantages:

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

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping
- Highly toxic to humans and all other living organisms
- Require the use of specialized protective equipment, including respirators
- Require the use of specialized application equipment

VIII. Adjuvants

An **adjuvant** is a chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety. Most pesticide formulations contain at least a small percentage of adjuvants. Some of the most common adjuvants are surfactants, surface active ingredients that alter the dispersing, spreading, and wetting properties of spray droplets. (Fig 3.12)

Adjuvants include:

- **Wetting Agents** – allow wettable powders to mix with water

- **Emulsifiers** – allow petroleum-based pesticides (ECs) to mix with water
- **Invert Emulsifiers –** allow water-based pesticides to mix with petroleum carrier
- **Spreaders** – allow pesticide to form a uniform coating layer over the treated surface
- **Stickers** – allow pesticide to stay on the treated surface

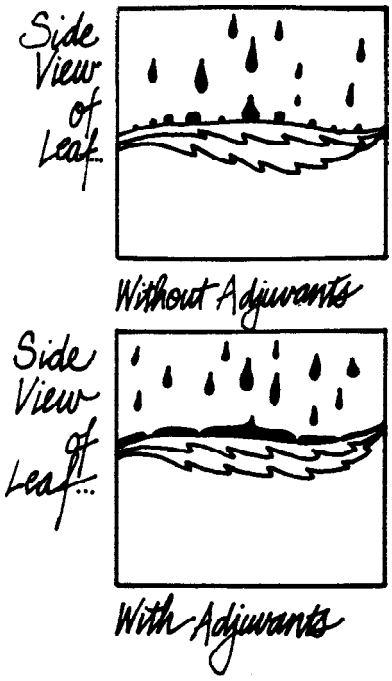

Figure 3.12 Use of Adjuvant

- **Penetrants** – allow the pesticide to get through the outer surface to the inside of the treated area
- **Foaming Agents** – reduce drift
- **Thickeners** – reduce drift by increasing droplet size
- **Safeners** – reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface
- **Compatibility Agents** – aid in combining pesticides effectively
- **Buffers** – allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity
- **Anti-Foaming Agents** – reduce foaming of spray mixtures that require vigorous agitation

IX. Pesticide Mixtures

Tank Mixing and pH

Pesticides can be tank mixed to reduce application costs and increase effectiveness while providing broader control. However, compatibility of the pesticides is important. **Compatibility** is the ability of two or more chemicals to be combined without danger. Compatibility can be influenced by the **pH** — the acidity or alkalinity — of a solution. A neutral solution has a pH of 7. Various pesticides are unstable in **alkaline** solutions (pH greater than 7), but quite stable in solutions that are slightly **acidic** (pH of approximately 6). The best pH for most pesticides is about 6, although a solution range of 6 to 7 is satisfactory. In addition, tank mixing can be influenced by various products. For example, **buffers** are substances capable of changing the pH of a water solution to a prescribed level, maintaining it even though conditions such as water alkalinity may change. **Acidifiers** are acids that can be added to spray mixtures to neutralize alkaline solutions and lower the pH.

Compatibility: The Jar Test

Pesticides should be mixed in small quantities to test for compatibility problems. You can check or verify incompatibility using a jar test. The procedure is as follows:

A. Wearing label-prescribed protective clothing, measure a pint of intended spray water into a quart glass jar;

B. Add ingredients in the following order and stir well:

1. Surfactant
2. Compatibility agents and activators
3. Wettable powders and dry flowable formulations
4. Water-soluble concentrations and solutions
5. Emulsifiable concentrations and flowable formulations
6. Soluble powders
7. Any adjuvants

C. For each ingredient (e.g., wettable power), you add 1 teaspoon per unit (pint or pound) per 100 gallons of final spray mixture;

D. After mixing, let stand for 15 minutes;

E. Stir and observe the results.

Compatible: Smooth mixture that combines well after stirring.

Incompatible: Mixture separates out, contains clumps, and is grainy in appearance. Check label and other literature for possible solutions to incompatible mixtures.

X. Chemical Changes

Pesticides may mix properly in solution but the effectiveness or toxicity of the pesticides in the mixture can change. These interactive effects are due to the chemical rather than the physical properties of the solution. For example, an **additive effect** occurs when two or more pesticides mixed together are no more toxic to the target pest than any of the pesticides used alone. **Potentiation** occurs when a pesticide becomes more toxic because something mixed with it lowers the pest's tolerance to the chemical. For example, impurities in *malathion* make it more toxic because they inactivate enzymes produced by the pest that normally detoxify malathion. **Synergism** occurs when a chemical (with or without pesticide properties) increases the toxicity of a pesticide when mixed with it. For example, *piperonyl butoxide* has no insecticidal properties but is used to increase the toxicity of pyrethrum insecticides. **Deactivation** occurs, usually in the spray tank, at the time the pesticides are combined, as when one alters the pH or causes hydrolysis.

Chapter Three
Pesticide Types & Formulations — Question and Answer Review

1. Q. What is a pesticide?

A. A **pesticide** is any chemical used to control pests. A pesticide is any substance or mixture of substances intended for destroying, preventing or mitigating insects, rodents, nematodes, fungi or weeds, or any other form of life declared to be pests.

2. Q. What is a pesticide formulation?

A. A pesticide formulation is the mixture of active and inert (inactive) ingredients that form a pesticide product.

3. Q. Is "insecticide" another word for pesticide?

A. No. **Insecticide** specifically kills insects and is just one of many types of pesticides.

4. Q. What is the difference between *active* ingredients and *inert* ingredients?

A. *Active* ingredients are the chemicals in a pesticide product that control pests. *Inert* ingredients are the chemicals in a pesticide product that are added to make the product safer; more effective; easier to measure, mix, and apply; and more convenient to handle.

5. Q. What are the common abbreviations for these types of formulations?

1. Dust _____
2. Emulsifiable concentrate _____
3. Granules _____
4. Microencapsulated _____
5. Soluble powder _____
6. Solution _____
7. Wettable powder _____

A. 1. D; 2. EC; 3. G; 4. ME; 5. S; 6. SP; 7. WP.

6. Q. What types of factors should you consider when you have a choice of formulations for a pest control task?

A. You should consider the characteristics of each formulation and which of the formulation's advantages and disadvantages are important in your application situation. You should also ask yourself the following: Do you have the right application equipment? Can you apply the formulation safely? Will the formulation reach the target and stay in place long enough to control the pest? Might the formulation harm the target site?

7. Q. If you had a choice of either a wettable powder formulation or a granular formulation for a particular pest control task, which would be best if drift were a major concern? Which would be best if you needed the pesticide to stay on a surface that is not level, such as foliage?

A. The granular formulation would be the best choice in the first situation, because granules have a much lower drift hazard than wettable powders. Granules do not stick to non-level surfaces, so the wettable powder would be the best choice in the second situation.

8. Q. If you had a choice of either a wettable powder or an emulsifiable concentrate for a particular pest control task, which would be better if you were concerned about harming the treated surface? Which would be best if you were diluting with very hard or alkaline water?

A. The wettable powder would be the best choice in the first situation, because ECs are corrosive and may cause pitting, discoloration, or other damage to treated surfaces. Because wettable powders are difficult to mix in very hard or very alkaline water, the EC formulation would be the best choice in the second situation.

9. Q. Why are adjuvants sometimes added to pesticide formulations?

A. *Adjuvants* are added to a pesticide formulation or tank mix to increase its effectiveness or safety.

10. Q. What is an adjuvant?

A. An Adjuvant is a chemical added to the pesticide mixture that helps an active ingredient do a better job.

11. Q. What type(s) of adjuvants should you consider for (1) reducing drift; (2) coating a surface evenly; and (3) for combining two or more pesticides in one application?

A. (1) Foaming agents and thickeners help to reduce drift; (2) spreaders help to coat the treated surface with an even layer of pesticide; and (3) compatibility agents aid in combining pesticides effectively.

12. Q. What is the recommended pH level for most pesticide sprays?

A. The best pH for most pesticides is about 6, although a range of 6 to 7 is satisfactory.

13. Q. Why would you choose a low-concentrate liquid formulation if you wanted to be sure of getting the right mixture?

A. Low-concentrate formulations are designed to be sprayed as purchased.

14. Q. Which formulation is most hazardous to the applicator because it is highly concentrated and absorbed easily by the skin?

A. Emulsifiable concentrate.

15. Q. How does a systemic insecticide act on a pest?

A. A systemic pesticide flows inside the plant to all of its parts and kills the insects that eat the plant.

16. Q. Define potentiation, synergism, and additive effect.

A. *Potentiation:* An increase in the toxicity of the pesticide.
Synergism: The total effect is greater than the sum of the independent effect.
Additive effect: Combining two or more pesticides, and the resulting toxicity is not more than the amount of either pesticide.

17. Q. What advantages do granules have over dusts and sprays?

A. Granules drift less and are applied with simple, often multi-purpose equipment. They can work their way through dense foliage to a target underneath.

CHAPTER 4:

PESTICIDES AND THE ENVIRONMENT

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I. Introduction

Chapter Objectives

By the time you finish this chapter, you will be able to:

- explain the meaning of the word *environment*;
- distinguish between point sources and nonpoint sources of environmental contamination by pesticides;
- list factors you should consider before you release a pesticide into the environment;
- explain why sensitive areas are important considerations for pesticide handlers;
- name the routes by which pesticides can move offsite into the environment;
- describe factors that influence whether pesticides will move offsite in the air;
- describe factors that influence whether pesticides will move offsite in water;
- describe ways that pesticides move offsite in or on objects, plants, or animals;
- recognize that nontarget plants and animals can be harmed by both pesticides and pesticide residues;
- describe harmful effects that pesticides can have on surfaces.

Terms To Know

Aquifer — An underground layer of permeable rock, sand, or gravel that contains water.

Back-siphoning — Movement of liquid pesticide mixture back through filling hose and into water source.

Bioaccumulation — Buildup of pesticide(s) in bodies of animals moving up the food chain.

Collection tray or pad — Safety system designed to contain and recover spills, rinsates, leaks, and other pesticide-containing substances.

Concentrate — Pesticide with high percentage of active ingredient.

Critical Habitat — Areas of land, water, or air space needed for endangered species survival.

Drift — Airborne movement of pesticide away from release site.

Ecosystem — System formed by interaction of community of organisms with environment.

Endangered species — Organisms whose survival as species has been designated by a Federal agency to be endangered or threatened.

Environment — Everything around us: air, soil, water, plants, houses, and buildings.

Groundwater — Water beneath earth's surface between soil particles or rock.

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

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

Offsite — Area beyond the target area where pesticide is being released.

Persistant — A term describing the enduring quality of some pesticides in the environment.

Permeability — The characteristic of a porous medium, such as soil, that identifies the ease with which gases or liquids can pass through it.

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

Precautionary statement — Statement on pesticide labeling that alerts you to possible hazards from use of pesticide product and that sometimes indicates specific actions to take to avoid the hazards.

Rinsate — Pesticide-containing liquid that results from rinsing pesticide container, pesticide equipment, or other pesticide-containing materials.

Riparian zones — A belt of trees and shrubs located adjacent to and up-gradient from water bodies.

Runoff — Horizontal flow of pesticide in liquid away from the release site across the land surface.

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

Target — Site or pest toward which control measures are being directed.

Use site — Immediate environment where pesticide is being mixed, loaded, applied, transported, stored, or disposed of, or where pesticide-contaminated equipment is being cleaned.

Volatile — Evaporating rapidly; turning easily into gas or vapor.

Watertable — The upper level of a soil zone where all the spaces between the soil particles are filled with water.

The environment is everything 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. Nor is the environment limited to the outdoors; it also includes the indoor areas in which we live and work.

The environment, then, is much more than the oceans and the ozone layer. It is air, soil, water, plants, and animals; it is houses, restaurants, office buildings, and factories and all that they contain. Anyone who uses a pesticide indoors or outdoors, in a city or in the country, must consider how that pesticide will affect the environment.

The applicator must ask two questions:

1. How will this pesticide affect the immediate environment at the site where it is being used?

2. What are the dangers that the pesticide will move off the use site and cause harm to other parts of the environment?

Pesticides can harm all types of ecosystems if they are not used correctly. The applicator is responsible for knowing and following good practices that achieve effective pest control with as little risk to the environment as possible. In addition, pesticide product labeling statements are intended to alert you to particular environmental concerns that a pesticide product poses. Remember that the lack of a particular precautionary statement does not necessarily mean that the product poses no hazard to the environment.

Both the public and the Environmental Protection Agency (EPA) are becoming increasingly concerned about harmful effects on the environment from the use of pesticides. EPA is looking closely at environmental effects as it considers new applications for product registration while, at the same time, reviewing existing pesticide registrations. In the past, hazards to humans have been the primary reason for EPA to classify a pesticide as a restricted-use product. Now, more pesticide labels list environmental effects, such as contamination of groundwater or toxicity to birds or aquatic invertebrate animals, as well as nontarget organisms, including endangered species. Thus, there is a reason for restrictions.

II. Sources of Contamination

When environmental contamination occurs, it is the result of either point source or nonpoint source pollution. **Point source pollution** comes from a specific, identifiable place or point. For example, a pesticide spill that ends up in a storm sewer is considered a point source for pollution. **Nonpoint source pollution** comes from a wide area. The movement of a herbicide after a broadcast lawn application into an irrigation canal is an example of nonpoint source pollution. Thus, point sources resulting in environmental contamination include:

- wash water from equipment and spills at equipment cleanup sites,
- improper disposal of containers, water from rinsing containers, and excess pesticides,
- leaks and spills at pesticide storage sites where they are not cleaned up correctly, and
- spills that occur while mixing concentrates or loading pesticides into application equipment.

These kinds of contamination are potentially involved with nearly every pesticide used. As a pesticide handler, especially if you use and supervise the use of restricted-use pesticides, you must become aware of the potential for environmental contamination during every phase of your pesticide operation. Many pesticide uses are restricted because of environmental concerns. Whenever you release a pesticide into the environment—whether intentionally or accidentally—consider the following:

- Are there sensitive areas at the pesticide use site that might be harmed by the pesticide?
- Are there sensitive offsite areas adjacent to the use site that might be harmed by contact with the pesticide?
- Are there conditions that might cause the pesticide to move offsite?
- Do you need to make any changes in application procedures in order to reduce the risk of environmental contamination?

III. Sensitive Areas

Sensitive areas are sites containing living things that are easily injured or contaminated by a pesticide. In Arizona these areas specifically include hospitals, schools, and parks.

Sensitive areas outdoors include, but are not limited to:

- areas where groundwater is near the surface or easily accessed (e.g., open wells, dry wells, very sandy soils);
- areas near surface water;
- areas near the habitats of endangered species;
- areas near apiaries (honeybee sites), riparian zones, wildlife refuges, or parks; and
- areas near backyard gardens, food or feed crops, or other sensitive plantings.

At times pesticides must be applied to a sensitive area to control a pest. When this is necessary, extra precautions should be taken. Practical factors to consider are time of the application (e.g., early in the morning), approaches to reduce drift, and the use of an untreated buffer zone around sensitive areas to minimize contaminating the area.

Sensitive areas have buffer zones around them created to keep highly toxic pesticides at a safe distance. For details on Buffer Zones see Chapter 8.

A sensitive area may be near a site that is used for an application, mixing/loading, storage, disposal, or equipment washing. You, the applicator, must take precautions to avoid accidental contamination of the sensitive area. For example, a permanent site for mixing/loading or equipment washing should be equipped with a collection pad or tray to catch and contain leaks, spills, or equipment waste water.

Typical pesticide labeling statements that are found under precautionary statements that alert you to these concerns include:

> **Remove all animals from building prior to treatment and keep animals out until spray has dried**
>
> **Do not use around home gardens, schools, recreational parks or playgrounds**
>
> **Do not use in or around residences**

IV. Pesticide Movement

Pesticides that move offsite may cause environmental contamination. Pesticides move in three ways:

1. In the air, through wind, air currents or vapors;
2. In the water, through runoff or leaching; and
3. On or in objects such as soil, equipment, plants, or animals (including humans) that are moved offsite.

The four factors influencing drift are:

1. Droplet or particle size
2. Height and direction of release
3. Whether the pesticide tends to form vapors
4. Wind speed and direction

Air

Airborne movement of spray droplets, vapors, or dust particles offsite from the intended site is called **drift**. Drift can happen with both ground and aerial applications. How much drift depends on such factors as the wind direction, nozzle size, nozzle pressure, pesticide formulation, how the material is applied, the volume of use, prevailing weather conditions (temperature and humidity), along with the area treated. Aerial applications of persistent pesticides such as chlorinated hydrocarbons have resulted in severe residue problems on crops over a mile away.

To reduce drift, applicators should consider the likelihood of drift before applying any pesticide. You should: (1) know your surroundings; (2) use as coarse a spray as possible and still obtain good coverage and control in order to increase droplet size; (3) do not apply in windy conditions (over 15 mph); (4) choose an application method and formulation that is less likely to cause drift; (5) use drift control/drift reducing agents; (6) apply pesticides early in the morning, but not durring morning inversions; (7) use solid cone or fan spray nozzles that produce larger droplets; and (8) know which way the wind or air is moving. In Arizona, urban and rural areas exist side by side, and drift reduction is mandatory. Sensitive areas with Pesticide Management Area (PMAs) containing buffer zones have been established to help reduce pesticide drift from agricultural crops to residential areas. The Department of Agriculture is responsible for establishing PMAs.

Vapors

Pesticide vapors move about easily in air. High volume esters and some low volume esters are extremely troublesome in diverse cropping systems and turf. Fumigant pesticides are intended to form a vapor when they are released. Persons using fumigants must take precautions to make sure the fumigant remains in a sealed container until it is released into a sealed application site. The labeling of volatile pesticides often includes warning statements that the pesticide handler should heed. Any time you release a volatile pesticide in an enclosed area, consider the hazards not only to yourself and to other workers, but also to people, animals, and plants that are in or near the release site or that may enter the area soon after the release.

Typical pesticide labeling statements that alert you to avoid drift, and thus vapors, include:

Do not apply when weather conditions favor drift from areas treated

Do not allow drift onto plants intended for food or feed
Drift from treated areas may be hazardous to aquatic organisms in neighboring areas

Water

Pesticide particles and liquids may be carried offsite in water. Pesticides can enter water through:

- drift, leaching, and runoff from nearby applications,
- spills, leaks, and back-siphoning from nearby mixing, loading, storage, rinsate, and equipment cleanup sites, and
- improper disposal of pesticides, rinsates, and containers

Runoff may occur when:

- too much liquid pesticide is applied, leaked, or spilled onto a surface, or
- too much rainwater, irrigation water, or other water gets onto a surface containing pesticide residue.

Runoff water in the outdoor environment may travel into drainage ditches, streams, ponds, or other surface water where the pesticides can be carried great distances offsite.

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

Do not contaminate water through runoff, spills, or improper disposal of excess pesticide, spray mixtures, or rinsates

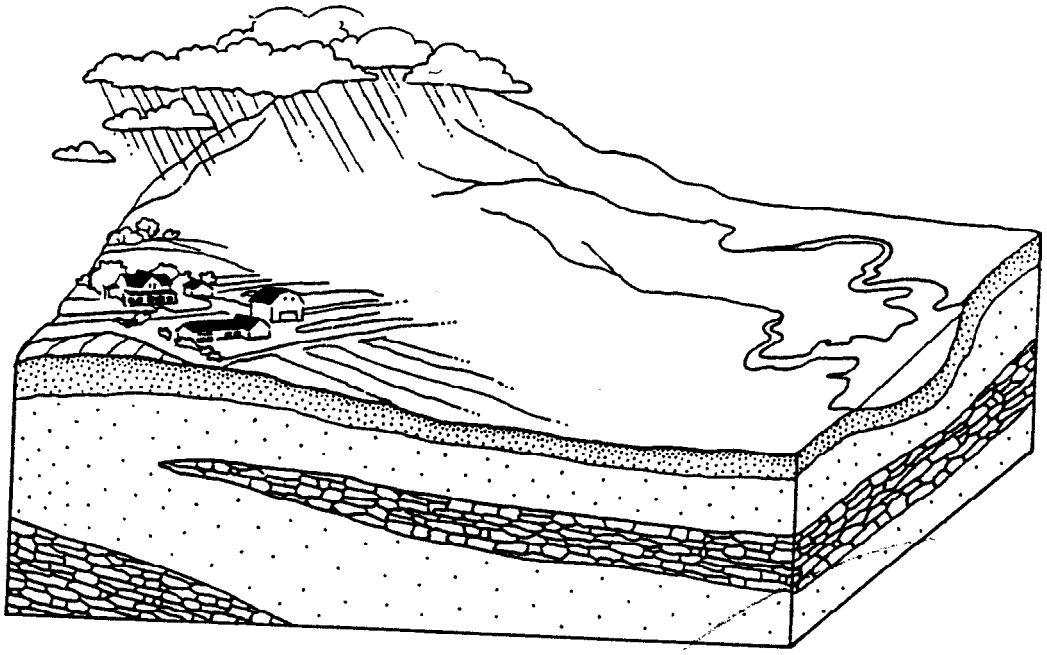

Figure 4.1 Hydrologic Cycle

Do not allow runoff or spray to contaminate wells, irrigation ditches, or any body of water used for irrigation or domestic purposes

Do not apply directly to water and wetlands (swamps, bogs, marshes, and potholes)

Maintain a buffer zone (lay-off distance) of 100 feet from bodies of water

This product is water soluble and can move with surface runoff

V. Protecting Groundwater

Groundwater is water located beneath the earth's surface. It is stored in the spaces between particles of sand, clay, and gravel below the root zone. It is also found in cracks and crevices in rock formations and large underground channels and caverns. Whether you must take special action to protect our groundwater depends mainly on the location of your use site. Groundwater contamination is of greatest concern in release sites where groundwater is close to the surface or where the soil type or the geology allows contaminants to reach groundwater easily (e.g., sandy soil, cracks in subsurface rocks). **Surface water** is just that: water found on the surface that can move several feet in a second or a minute. Groundwater may move only a few feet in a month or a year. An **aquifer** is a body of groundwater capable of providing significant quantities of water to a well or spring. Pesticide contamination of aquifers must be avoided, because these are your sources of drinking, washing, and irrigation water.

Sources of Groundwater

Groundwater is recharged (replaced) mostly from rain or snow that enters the soil. However, some water from lakes and streams and from irrigation also becomes groundwater. Water that is above the ground can move in three ways—it can evapo-

rate into the air; it can move across the surface, as in a stream or river; or it can percolate downward from the surface. Some of the water that moves downward is absorbed by plants and other organisms. A portion of the downward-moving water is held in the upper layers of the soil. The remaining water moves through the root zone and the relatively dry soil zone until it reaches a zone saturated with water. This saturated zone is the uppermost layer of groundwater and is called the water table. The water table is the dividing line between the groundwater and the unsaturated rock or soil above it.

Figure 4.2 Leaching

Pesticide Contamination of Groundwater

Water that is moving downward from the surface (leaching) containing pesticides may eventually reach the water table. There are several factors that determine whether a pesticide has the potential to reach groundwater:

- The practices (e.g., handling) followed by pesticide users
- The presence or absence of water on the surface of the site where the pesticides are released
- The physical or chemical characteristics (e.g., solubility) of the pesticides
- The type of soil (e.g., sand vs. loam or clay) at the site where the pesticides are released
- The distance from the surface to the water table and the type of geological formations through which the water must flow

By being aware of these considerations, you can considerably reduce the potential for groundwater contamination.

Practices for Pesticide Users

The best way to keep from contaminating groundwater is to follow labeling directions exactly. Be sure to note whether the labeling requires you to take any special steps to protect groundwater. In addition, remember the following:

- **Never** use more pesticide than maximum label rates. Overdosing is illegal and potentially damaging to groundwater.
- Consider whether your application method presents any special environmental risks. For example, applying herbicides in a wash for bush control during the monsoon season may not be wise because of the potential contamination of groundwater.
- Take precautions to keep pesticides from back-siphoning into your water source. Locate pesticide storage facilities at least 100 feet from wells, floodplains, sinkholes, and other sites that directly link to groundwater. This prevents groundwater contamination from runoff or fire-fighting water.

- Whenever possible, locate mixing-loading sites and equipment-cleaning sites at least 100 feet from surface water or from direct links to groundwater. This will help prevent accidental back-siphoning, runoff, and spills from contaminating the water sources. If you must locate one of these work sites near a water source, use containment methods such as dikes, sump pits, and concrete pads to keep pesticides from reaching the water.

- Do not contaminate groundwater through improper disposal of unused pesticides, pesticide containers, or equipment and container rinse water. Dispose of all pesticide wastes in accordance with county and state regulations.

Water on the Treated Surface

If there is more water on the soil surface than the soil can hold, the water, along with any soluble chemicals it contains, is likely to run off or move downward to the groundwater. Prolonged heavy rain or excessive irrigation will produce excess water on the soil surface.

Rain

If weather forecasts or your own knowledge of local weather signs cause you to expect heavy rain, you may wish to delay outdoor handling operations—including mixing, loading, application, and disposal—to prevent wash-off, surface runoff, or leaching.

Irrigation

Pesticide movement into groundwater is affected by both the amount of water used in irrigation and how soon before or after a pesticide application the irrigation is done.

Pesticide Factors

Some pesticides are more likely than others to move to groundwater. Such movement depends mainly on:

- **solubility**—some pesticides dissolve easily in water and are more likely to move into water systems
- **adsorption**—some pesticides become tightly attached (strongly adsorbed) to soil particles and are not likely to move out of the soil and into water systems
- **persistence**—some pesticides break down slowly and remain in the environment for a long time

The above factors are interrelated. Pesticides most likely to move into groundwater are usually:

- highly soluble
- moderately to highly persistent
- not strongly adsorbed or held by the soil

Most *nonpersistent* pesticides are less likely to move to groundwater, even if they are highly soluble or not strongly adsorbed to soil. A pesticide that is strongly adsorbed or held to soil is less likely to move to groundwater even if it is persistent.

The pesticide label usually does not tell you about these properties of the pesticide product. Cooperative Extension, the National Resource Conservation Service (NRCS), the Department of Agriculture, product manufacturers, your local pesticide dealer, or the Materal Safty Data Sheet (MSDS) may have specific information about the chemical properties of the pesticides you are using.

Soil Factors

Soil is also an important factor in the breakdown and movement of pesticides. Local soil maps can

be helpful in determining the types of soil in your area. The three major soil characteristics that affect pesticides are texture, permeability, and organic matter.

Soil texture is an indication of the relative proportions of sand, silt, and clay in the soil. Coarse, sandy soils generally allow water to move rapidly downward. Finer textured soils generally allow water to move downward at a much slower rate. Fine soils contain more clay, and sometimes organic matter, to which pesticides may attach.

Soil permeability is a general measure of how fast water can move downward in a particular soil. The more permeable the soil, the faster the chemicals will move. Permeable soils must be managed carefully in order to keep pesticides from reaching groundwater.

Soil organic matter influences how much water the soil can hold or bind before it begins to move downward. Soil containing high organic matter has greater capacity to stop the movement of pesticides. Soils in which plants are growing are more likely to prevent pesticide movement than dry bare soils. Arizona soils in general have very low organic matter.

Geology

The distance from the soil surface to the water table is the measure of how deep the groundwater is in a given location. If the groundwater is close to the soil surface (e.g., Yuma), pesticides are more likely to reach it. The depth to the water table does not stay the same throughout the year, but varies according to:

- how much water is added to the soil surface by rain, snow, and irrigation,
- the rate of evaporation and plant uptake,
- whether the ground is frozen, and
- how much groundwater is withdrawn by pumping.

Spring runoff, summer monsoons, and heavy winter rain events are generally the times when the water table is closest to the soil surface. The water table often drops during the summer when evaporation and plant uptake are high and large amounts of groundwater are used for irrigation and other hot weather needs.

The permeability of the layers between the soil and groundwater is also important. If surface water moves downward quickly, pesticides are more likely to leach into groundwater. Gravel deposits are highly permeable, allowing water and pesticides to move downward to groundwater. Regions with limestone deposits are particularly susceptible to contamination because water moves rapidly to the groundwater through caverns or rivers with little or no filtration or chemical breakdown. On the other hand, layers of clay can slow or prevent water and pesticides from reaching the groundwater.

Sinkholes and dry wells are especially troublesome. Surface water often flows into these openings and disappears almost directly into the groundwater. If a pesticide is released into an area that drains into a sinkhole or an abandoned well, even a moderate rain may carry some of the pesticide directly to the groundwater.

The Certified Applicator's Role

Groundwater concerns have resulted in the restriction and uses of some pesticides. As a certified applicator, you have a special responsibility to handle *all* pesticides safely in and near sites where groundwater contamination is particularly likely. Take extra precautions when using techniques that are known to cause contamination of groundwater.

When a pesticide product has been found in groundwater, or has characteristics that may pose a threat to groundwater, the pesticide product labeling may contain statements to alert you to the concern. Typical pesticide labeling statements include:

> **This chemical has been identified in limited groundwater sampling and there is the possibility that it can leach through the soil to groundwater, especially where soils are coarse or sandy and groundwater is near the surface**

On or in Objects, Plants, or Animals

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

Pesticides may stick to treated surfaces, such as food or feed products that are to be sold. To protect consumers, there are legal limits (tolerances) for how much pesticide residue may remain on crops or animal products that are sold for food or feed. It is illegal to sell products that exceed these tolerances. Pesticides that are applied to crops and animal products should not be above tolerance levels if the pesticides are applied as directed on the product label.

Illegal pesticide residues usually result when:

- too much pesticide is applied to the crop or animal
- the days-to-harvest, days-to-grazing, or days-to-slaughter directions on the pesticide labeling are not obeyed
- pesticides move out of the release site and contaminate plants or animals nearby

VI. Protecting Endangered Species

An endangered species is a plant or animal in danger of becoming extinct. There are two classifications of these plants and animals: **endangered species** and **threatened species**. Scientists believe that some pesticides may threaten the survival of some of America's endangered species if they are used where these plants and animals still exist.

A federal law, the Endangered Species Act, was aimed at preserving numerous endangered plants

Figure 4.3 EPA Endangered Species Resource

and animals. The law restricts pesticide use in areas where pesticides may jeopardize the continued existence of endangered species. The Environmental Protection Agency's objective is to remove or reduce the threat that pesticide use poses to endangered species. In order to reach the objective, EPA has put limitations on some pesticide-use patterns. Most limitations apply only to currently occupied habitat or range of each endangered species at risk. Some limitations apply where endangered species are being reintroduced into a habitat they previously occupied. Habitats, sometimes called *critical habitats*, are the areas of land, water, and air space an endangered species needs for survival. Such areas include breeding sites; sources of food, cover, and shelter; and surrounding territory that gives room for normal population growth and behavior.

Limitations on Pesticide Use

Read all pesticide labeling carefully to find out whether the use of that product requires you to take special steps to protect endangered species. The label will direct you to another source for the details about what you must do. When limitations do apply, they usually will be in effect only in specific geographic locations. Use of a particular pesticide is usually limited in a particular location when:

- the site is designated as the current habitat of an endangered species, and
- the endangered species at that site might be harmed by the use of the pesticide within (or close to) its habitat

Habitats of Endangered Species

The U.S. Fish & Wildlife Service is responsible for identifying the current habitat or range of each endangered species. For aquatic species, the restricted habitat often will include additional zones around the body of water to keep drift, runoff, or leachate from reaching the water sources. The U.S. Fish and Wildlife Service is identifying the habitats so that pesticide use will be limited only in locations where it is absolutely necessary. For this reason, limitations on pesticide use may apply to one property, while a similar adjoining property may not have these limitations.

Importance of Protecting Endangered Species

Hundreds of animals (including fish, birds, mammals, reptiles, amphibians, insects, and aquatic invertebrates) and thousands of plants have been listed as endangered or threatened species under the provisions of the Endangered Species Act. Some of these animals and plants are ones that everyone knows about, such as the bald eagle. Others are tiny, little-known creatures that may rarely be seen by anyone except trained naturalists.

Regardless of the size or apparent significance of these endangered species, it is important that each be allowed to survive. Mankind's well-being depends on maintaining biological diversity. *Biological diversity* is the variety and differences among living things and the complex ways they interact.

Diversity is necessary for several reasons listed below:

Agriculture

Nearly all of today's crops started as wild species. Genes from wild species often are used to create new hybrids that have resistance to plant diseases and insects, better climatic tolerance, and higher yields. Having different varieties available is necessary insurance against devastating crop failures caused by climate extremes or major pest outbreaks.

Medicine

Many of today's most important medicines come from obscure plant and animal species. A mold is the source of the miracle drug penicillin; tree bark is the source of quinine, a cure for malaria. Scientists are testing countless plant and animal species around the world for sources of cures for major diseases.

Preserving Choices

No one can predict which species may be essential to the future of our species. A species that is allowed to become extinct might have been the key to stopping a global epidemic or to surviving a major climate change.

Interdependence

The extinction of a single species can set off a chain reaction of harm to other species. The disappearance of a single kind of plant from an area, for example, may lead to the disappearance of other plants, certain insects, and higher animals.

Natural Balance

Extinction has always been a natural part of an ever-changing process. During most of history, species have formed at a rate greater than the rate of extinctions. Now, however, human activity is greatly speeding up the rate of extinctions. People, plants, and animals live together in a delicate balance. The disappearance of species could easily upset that balance.

Stability

The more diversity that exists in an ecosystem, the more stable it is likely to be. There is less likelihood of huge swings in populations of particular organisms. There is also less likelihood of devastation from the introduction of a new species from outside the system.

The Certified Applicator's Role

Pesticides have the potential to harm living organisms, including endangered species:

- Pesticides can kill endangered plants and animals directly
- Pesticide residues in the habitat of the endangered organisms can disrupt or destroy their sources of food and shelter
- Pesticide application, drift, runoff, and leachate can contaminate water ingested by or inhabited by endangered organisms
- Some pesticides can build up to dangerous levels in endangered predators that feed on plants or animals exposed to pesticides

As a certified applicator, you have a clearly defined legal responsibility to protect endangered species against the hazards posed by pesticides. Careful use of pesticides in and around the key habitat areas will help these limited number of plants and animals to survive.

Typical pesticide labeling statements that alert you to concerns about endangered species include:

> **Under the Endangered Species Act, it is a federal offence to use any pesticide in a manner that results in the death of a member of an endangered species. Prior to making applications, the user must determine that the endangered species are not located in or immediately adjacent to the site to be treated. If the users are in doubt whether or not endangered species may be affected, they should contact the regional U.S. Fish and Wildlife Service Office (Endangered Species Specialist) or personnel of the State Fish and Game Office. Be advised that county endangered species maps are available from the County Extension Office.**

VII. Harmful Effects on Nontarget Plants and Animals

Nontarget organisms may be harmed by pesticides in two ways:

1. The pesticide may harm the nontarget organism by immediate direct contact, or
2. The pesticide may leave a residue that causes delayed direct exposure and harm.

Harmful Effects from Direct Contact

Pesticides may harm nontarget organisms that are present during a pesticide application. Poorly timed applications can kill bees and other pollinators, or other wildlife that are active in or near the target site. Even tiny amounts of some pesticides may harm them or destroy their source of food.

Pesticides applied over large areas—such as in mosquito or biting fly areas—must be chosen with great care to avoid poisoning nontarget plants and animals. Read the warnings and directions on the pesticide labeling carefully to avoid harming nontarget organisms during a pesticide application.

Drift from the target site may injure wildlife, livestock, pets, sensitive plants, and people. For example, drift of herbicides can damage sensitive nearby plants, including crops, vegetable gardens, or ornamental plantings. Drift also can kill beneficial parasites and predators that are near the target site.

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

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

Phytotoxic. Do not spray on plants

Extremely toxic to aquatic organisms. Do not contaminate water during cleaning of equipment or disposal of wastes

Harmful Effects from Residues

A residue is the part of a pesticide that remains in the environment for a period of time following the application. Pesticides break down after they are released into an environment. The breakdown time ranges from less than a day to several years. The rate of pesticide breakdown depends mostly on the chemical structure of the pesticide active ingredient. The rate of pesticide breakdown may also be affected by environmental conditions at the release site, such as:

- surface soil type, and soil pH
- surface moisture
- presence of soil microorganisms
- temperature
- exposure to direct sunlight
- pesticide chemical composition

Persistent pesticides leave residues that stay in the environment without breaking down for long periods of time, usually over a year's time. These pesticides are sometimes desirable because they provide long-term pest control and may reduce the need for repeated applications (e.g., termiticides). However, some persistent pesticides that are applied to or spilled on soil, plants, lumber, and other surfaces, or into water, can later cause harm to sensitive plants or animals, including humans, that come into contact with them.

Labeling that indicates a particular pesticide product is likely to be persistent includes:

This product can remain phytotoxic for a year or more

When using persistent pesticides, consider whether their continued presence in the environment is likely to harm plants and animals.

When pesticides build up or accumulate in the bodies of animals moving up the food chain, this is called **biomagnification or bioaccumulation**. When the same mixing/loading site or equipment cleaning site is used frequently without taking steps to limit and clean up spills, pesticides are likely to accumulate in the soil, plants, and animals; objects that come into contact with the soil may be harmed. When pesticides accumulate in the soil, there is also a higher likelihood that the pesticides will move offsite and contaminate the surrounding environment including surface or groundwater.

Sometimes animals can be harmed when they feed on plants or animals that have pesticide residues on or in them. There is special concern for predator birds or mammals that feed on animals that have been killed by pesticides. The predators may be harmed by the pesticide residues remaining on or in the bodies of the dead animals.

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

> **Toxic to fish, birds, and wildlife. This product can pose a secondary hazard to birds of prey and mammals; or**
>
> **Bury or otherwise dispose of dead animals to prevent poisoning of other wildlife.**

Harmful Effects on Surfaces

Sometimes surfaces are harmed by pesticides or pesticide residues. Some surfaces may become discolored by contact with certain pesticides. Other surfaces may be pitted or marked by contact with some pesticides. Some pesticides can corrode or obstruct electronic systems or metal. Sometimes a pesticide will leave a visible deposit on the treated surface.

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

> **Do not spray on plastic, painted, or varnished surfaces;**
>
> **Do not spray directly into any electronic equipment or into outlets or switches, or any other location where the pesticide may foul or short-circuit contacts and circuits; or**
>
> **A visible deposit may appear on some dark surfaces.**

Chapter Four
Pesticides and the Environment — Question and Answer Review

1. Q. What is the *environment* ?

A. *Environment* is everything that surrounds us indoors and outdoors including natural elements, manmade objects, people, and other living organisms.

2. Q. Explain what is meant by *point source* and *nonpoint source contamination* of the environment by pesticides, and give an example of each.

A. *Point source pollution* comes from a specific, identifiable place or point. A pesticide spill that moves into a storm sewer is an example of point source pollution. *Nonpoint source pollution* comes from a wide area. The movement of pesticides into streams after broadcast applications is an example of nonpoint source pollution.

3. Q. Name four ways that careless pesticide handling could lead to point source pollution.

A. 1. Mismanagement of wash water and spills produced at equipment cleanup sites.
2. Improper disposal of containers, water from rinsing containers, and excess pesticides.
3. Failure to correctly clean up leaks and spills at pesticide storage sites.
4. Spilling pesticides while mixing concentrates or loading pesticides into application equipment.

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

A. 1. Whether there are sensitive areas in the environment at the pesticide use site that might be harmed by contact with the pesticide.
2. Whether there are sensitive offsite areas near the use site that might harmed by contact with the pesticide.
3. Whether there are conditions in the immediate environment that might cause the pesticide to move offsite.
4. Whether you can change any factors in your pesticide application or use site to reduce the risk of environmental contamination.

5. Q. What is a *sensitive area*? Give four examples of sensitive areas that you must be especially careful to protect when you are handling pesticides.

A. *Sensitive areas* are sites or living things in environments that are easily injured by a pesticide. Some examples of sensitive areas are places where pesticides might get into groundwater or surface water; homes, schools, playgrounds, hospitals, and other places where people are present; places

where there are animals—endangered species, bees, other wildlife, livestock, pets; places where crops, ornamental plants, or other sensitive plants are growing; and areas where food or feed is processed, stored, or served.

6. Q. List three routes by which pesticides can move offsite.

A. 1. In air, through wind or through air currents generated by ventilation systems.
2. In water, through runoff or leaching.
3. On or in objects, plants, or animals (including humans) that move or are moved offsite.

7. Q. What four factors influence whether a pesticide will move offsite in the air?

A. 1. Droplet or particle size.
2. Height and direction of release.
3. Whether the pesticide tends to form vapors.
4. Wind speed.

8. Q. Name two circumstances that might cause a pesticide to move offsite in water.

A. 1. Too much liquid pesticide is applied, leaked, or spilled onto a surface.
2. Too much rainwater, irrigation water, or wash water gets onto a surface that contains pesticide residue.

9. Q. Give some examples of ways that pesticides can move offsite on or in objects, plants, or animals.

A. Pesticides may be carried offsite if they stick to such things as shoes or clothing, animal fur, blowing dust or water—anything that moves from the use site to another location. Pesticide residues may remain on treated surfaces, such as food or feed products, when they are taken from the use site to be sold.

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

A. Nontarget plants and animals may be harmed by the pesticide residues that stay in the environment for a period of time after the release. These can be residues that remain in soil or on surfaces, or they may be residues that build up in the bodies of animals, harming those animals themselves and sometimes other animals that feed on them.

11. Q. What kinds of damage can some pesticides cause to surfaces?

A. Surfaces may become discolored, pitted or marked, corroded or obstructed, or be left with a visible deposit.

12. Q. Which pesticide handling activities pose a threat to groundwater or endangered species?

A. All handling activities may pose a threat, including mixing, loading, applying, equipment cleaning, storage, transportation, disposal, and spill cleanup.

13. Q. Why is the location of your pesticide use site the main factor that determines whether you must take special action to protect endangered species or groundwater?

A. Special limitations on pesticide use are usually in effect only in locations where endangered species live or are being introduced and in areas where groundwater is especially likely to be contaminated.

14. Q. How will you know if you must take special action to protect endangered species or groundwater?

A. The pesticide labeling will tell you if special measures are necessary, but may not contain the detailed instructions that you must follow. The labeling may instruct you to get these from another source.

15. Q. What are some factors that determine whether pesticides will reach groundwater?

A. The factors include: practices followed by pesticide users; presence or absence of water on the surface of the site where the pesticides are released; chemical characteristics of the pesticides; type of soil at the pesticide release site; location of the groundwater; its distance from the surface and the type of geological formations above it.

16. Q. How can you help to prevent pesticides from reaching groundwater?

A. Avoid using more pesticide than the labeling directs; avoid application methods that present special risks; keep pesticides from back-siphoning into your water source; locate pesticide storage facilities at least 100 feet from wells, springs, sinkholes, and other sites that directly link to groundwater; locate mix-load sites and equipment-cleaning sites at least 100 feet from surface water or from direct links to groundwater or take precautions to protect those sites; dispose of unused pesticides, pesticide containers, and equipment and container rinse water correctly.

17. Q. Explain why the amount of water on the surface of the soil at the pesticide use site is an important factor in groundwater contamination.

A. If there is more water on the soil than the soil can hold, the water (along with any pesticides it contains) is likely to move downward to the groundwater more rapidly than in unsaturated soil.

18. Q. Explain how the *solubility, adsorption,* and *persistence* of a pesticide affect its ability to move into groundwater.

A. *Solubility*—Pesticides that dissolve easily in water are more likely to move into water systems.
Adsorption—Pesticides that become tightly attached (strongly adsorbed) to soil particles are not likely to move out of the soil and into water systems.
Persistence—Pesticides that do not break down quickly remain in the environment for a long time, and are more likely to move into groundwater.

19. Q. Define drift.

A. Drift is the movement of spray droplets, dust particles, or vapor aways from the application site.

20. Q. How do pesticides reach groundwater?

A. Pesticides applied corretly to a site may be moved downward with rain or irrigation water, reaching the water table below.

21. Q. Can pesticide pollution actually aid the pests you're trying to control? How?

A. Yes. Pesticides can destroy the predators and parasite that naturally control pests.

22. Q. Name three factors that affect drift.

A. Particle size, nozzle design and orientation, pressure, temperature, humidity, evaporation, height of release, and air movement.

23. Q. What is a persistent pesticide?

A. Persistent pesticides may remain in the environment for long periods without breaking down.

24. Q. Briefly describe the hydrologic cycle.

A. Water falls to earth as precipitation. The precipitation runs off the surface to become surface water. Water also seeps through the soil to become groundwater. Water returns to the atmosphere through evaporation and transpiration. This is the hydrologic cycle.

25. Q. Name the three ways pesticides break down after application.

A. Pesticides break down through microbial degradation, chemical breakdown, and photodegradation (Ultraviolet light).

26. Q. Why do organophosphates often pose low environmental hazards?

A. Organophosphates degrade relatively quickly and thus remain in the environment for only a short period.

27. Q. Can persistent pesticides be relatively harmless to the environment?

A. Yes. Persistence is not always bad for the environment, although there have been cases when it was. Long lasting or persistent pesticides are important for long-term protection of structures from termites.

CHAPTER 5:

SAFETY

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I. Introduction

Chapter Objectives

By the time you finish this chapter, you will be able to:

- define the term *chemical-resistant* and know when a material is not chemical-resistant to a particular pesticide;
- identify factors that determine how well a coverall will protect your body;
- explain the importance of wearing gloves when you handle pesticides;
- give reasons why gloves and footwear may fail to protect you;
- explain when you should wear protective headgear and describe appropriate headgear;
- explain the term protective eyewear;
- distinguish among dust/mist filtering respirators, and air-supplying respirators;
- describe the special hazards that fumigants pose;
- explain some basic guidelines for cleaning and maintaining personal protective equipment items;
- list basic safety questions you should ask yourself whenever you or those you supervise will be handling pesticides;
- know when to read the pesticide label;
- explain some consequences of incorrect use of pesticides;
- understand the Worker Protection Standard (WPS);
- be able to correctly transport pesticides and handle small spills;
- know how to prevent and react to pesticide fires.

Terms to Know

Acute effect — Illness or injury that appears immediately or very soon after exposure to a pesticide or combination of pesticides (usually within 24 hours).

Allergic effect — Harmful effect that some people develop in reaction to exposure to substances that do not cause a similar reaction in most other people.

Chemical-resistant — Able to prevent movement of pesticide through material during period of use.

Cholinesterase — Chemical present in central nervous system whose production is affected by some pesticides. Inhibition of cholinesterase may lead to illness.

Chronic effect — Illness or injury that appears long (usually several years) after exposure to a pesticide or combination of pesticides.

Closed system — Mixing and loading system designed to prevent pesticides, from coming into contact with handlers or other persons during mixing and loading.

Concentrate — Pesticide with high percentage of active ingredient.

Delayed effects — Illness or injury that appears shortly, but usually more than 24 hours, after exposure to a pesticide or combination of pesticides.

Developmental effect — Illness or injury that occurs to a fetus in the womb of woman who has been exposed to a pesticide or combination of pesticides.

Dose response — Concept that pesticide's effect on the target varies directly with amount of

exposure to that pesticide, either by volume or by time of exposure.

Drift — Airborne movement of pesticide away from the release site.

Exposure — Coming in contact with pesticide; getting pesticide on surface or in or on an organism.

Hazard — Risk of harmful effects from pesticides.

Heat stress — Illness that occurs when your body is subjected to more heat than it can cope with.

HEPA (High-efficiency particulate air) — Filtration that must, by law, capture 99.97% of all particles down to 0.3 micron, about 240 times smaller than the width of a human hair.

LD_{50} (Median lethal dose) — Dose of pesticide experimentally determined to be lethal to half (50%) of test animals exposed to it.

NIOSH (National Institute for Occupational Safety and Health) — Federal agency established by Occupational Safety and Health Act of 1970. NIOSH is part of Centers for Disease Control and Prevention (CDC) and is responsible for conducting research and making recommendations for prevention of work-related illness and injury.

Personal Protective Equipment (PPE) — Devices and clothing worn to protect human body from contact with pesticides or pesticide residues.

Porous surface — Surface with tiny openings that allows liquid to be absorbed or to pass through.

Reproductive effect —Injury to reproductive system of men or women due to exposure to pesticide or combination of pesticides.

Rinsate — Pesticide-containing water (or other liquid) that results from rinsing pesticide container, pesticide equipment, or other pesticide-containing materials.

Sensitization — Body's process of learning to recognize chemical as foreign substance, which may result in allergic reaction upon repeated exposure to that chemical.

Signal word — Word on pesticide label that identifies pesticide's toxicity category.

Toxicity — Measure of pesticide's ability to cause harmful effects.

Worker Protection Standard (WPS) — Legislation that protects agricultural workers from pesticide exposure. Applies to agricultural workers and pesticide handlers.

A certified applicator has a legal obligation to follow all pesticide label directions in such a manner that the environment, the public, non-target species, and the applicator are not placed at elevated risk. Safety must be the number one concern during all phases of work.

The goal of certification is to protect applicators, the public, and the environment by improving the applicator's knowledge. Once you have demonstrated competence and awareness of the risks involved, you will be certified to buy and use certain pesticides that have the potential to adversely affect humans, animals, plants, and the environment. The responsibility certified applicators show in handling restricted-use products will greatly influence whether these important materials remain available for pest control. Always keep in mind that pesticides can be dangerous if improperly used, stored, or discarded.

Most pesticides are designed to harm or kill pests. Because some pests have systems similar to the human system, some pesticides can also harm or kill humans. Fortunately, humans can usually avoid harmful effects by avoiding pesticide exposure.

Pesticides are tools and, like all tools, they must be handled with care and respect.

Humans may be harmed by pesticides in two ways.

- **Pesticide poisoning** is caused by ingested or absorbed pesticides that harm internal organs or other systems inside the body.
- **Pesticide-related injuries** are usually caused by exposure to pesticides that are external irritants.

When you prepare to use a pesticide, you need to consider other factors in addition to toxicity. Pesticides that are chemically similar to one another can cause the same type of harmful effects. These effects may be mild or severe, depending on the pesticide involved and the amount of overexposure. The *pattern* of illness or injury, however, caused by each chemical group is usually the same. Some pesticide chemical families can cause both external irritation injuries and internal poisoning illnesses.

Some pesticides are highly toxic to humans; only a few drops in the mouth or on the skin can cause extremely harmful effects or even death. While other pesticides are less toxic, too much exposure to them also will cause harmful effects. The simple formula listed below illustrates how to determine risk:

Hazard = Toxicity x Exposure

Hazard is the risk of harmful effects from pesticides. Hazard depends on both the **toxicity** of the pesticide and the **exposure** you will receive in any situation. The objective is to reduce your risk by reducing your exposure to and/or the toxicity of the pesticide you use. To avoid pesticide poisoning, the cardinal rule to follow is ***exercise caution***. Familiarize yourself with the entire section on safety; in a pesticide emergency, *you cannot count on having the time to consult a book for information.*

II. Safe Practices

Pouring and mixing undiluted chemicals is the most dangerous time when using pesticides. When you handle pesticides, remember these important safety practices:

1. Read and refer to the label often and follow the precautions.
2. Never work alone.
3. ***Always*** wear label specified protective clothing.
4. Keep children and unauthorized people away from areas where pesticides are loaded, stored, mixed, or applied.
5. Don't drink intoxicating beverages when working with pesticides.
6. Make sure your equipment is clean, calibrated, and working properly.
7. Mix pesticides outdoors or, if you must work indoors, make sure the area is well lighted and ventilated.
8. Do not destroy the label when opening bags or cans. Replace caps and close containers tightly.
9. Avoid eating, drinking, smoking, and touching your face while mixing or handling materials.
10. Measure materials correctly for the recommended rate. Don't mix or pour chemicals at eye level or on the edge of a table or pickup bed.
11. Pour liquid, powder, or dust slowly to avoid splash, spill, or drift. When transferring concentrates from drums, use either thread tabs or drum pumps.

12. If pesticides are splashed or spilled, immediately remove contaminated clothing; thoroughly wash skin with soap and water; put on fresh, clean protective clothing; clean up the spill.

13. Always apply pesticides under appropriate weather conditions.

14. Carry at least five gallons of clean water on tractors and other application equipment for washing eyes and skin in case of emergencies.

15. After handling pesticides, always wash hands, arms, and face thoroughly ***before*** you eat, drink, smoke, or use the restroom.

16. Never leave pesticides unattended in a truck, field, or at an operation site.

III. Pesticide Poisoning

Exposure

When a pesticide comes into contact with a surface or an organism, that contact is called a **pesticide exposure**. For humans, a pesticide exposure means getting pesticides in or on the body. The toxic effect of a pesticide exposure depends on how much pesticide is involved and how long the exposure remains there.

Types of Exposure

Pesticides contact your body in four main ways:

1. Oral exposure (when you swallow a pesticide)
2. Inhalation exposure (when you inhale a pesticide
3. Ocular exposure (when you get a pesticide in your eyes)
4. Dermal exposure (when you get a pesticide on your skin)

Dermal Exposure

Absorption through the skin during mixing, loading, or disposal is the most common cause of pesticide poisoning. The skin more readily absorbs liquid formulations than powders, dusts, or granules. ***If you spill or splash a pesticide on yourself, wash immediately!*** Wash before touching your face or eyes and before using the restroom.

Oral Exposure

Ingesting a pesticide can cause illness, injury, or death. Most accidental consumption of pesticides occurs when applicators do not wash their hands before eating or smoking; or when they eat food

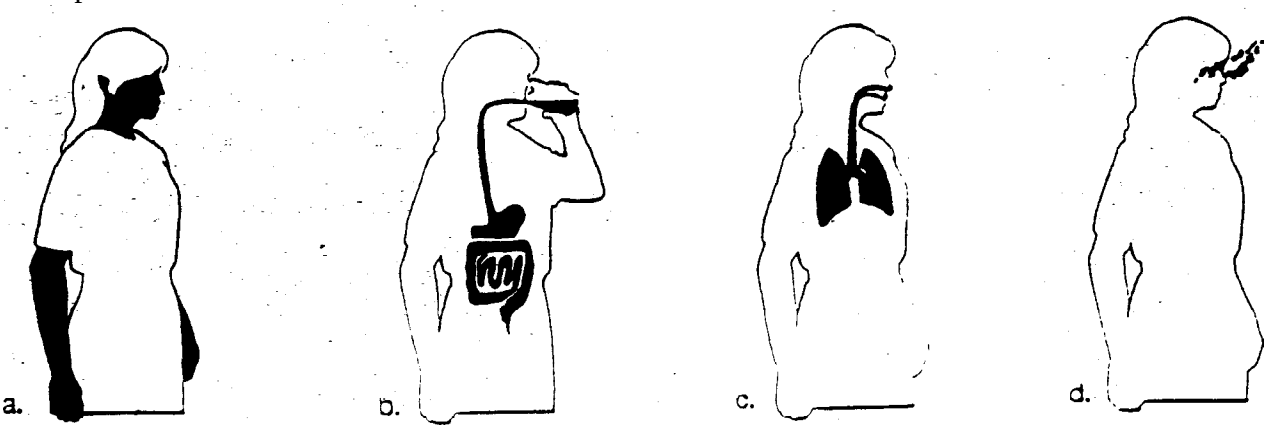
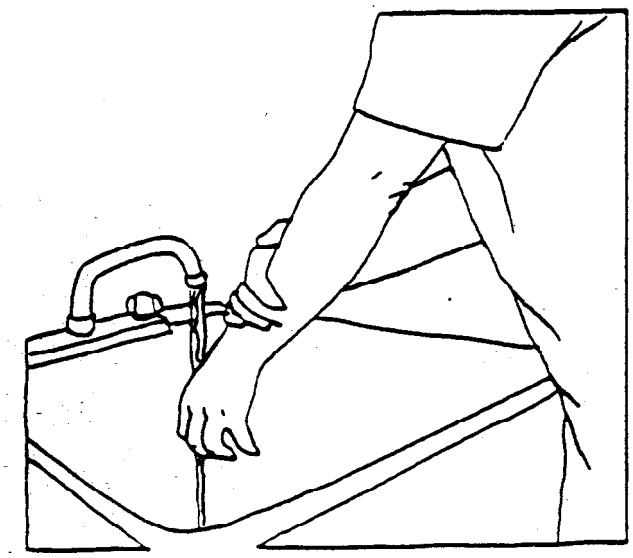


Figure 5.1 Four common ways pesticides enter the body: a) dermal, b) oral, c) respiratory, d) ocular.



that has pesticide residues on it. Serious acute pesticide injuries can result from drinking from a contaminated unmarked container that once held food or drink, such as a soft drink bottle. Therefore, ***always store pesticides in the original, labeled containers.*** Never clear a spray line or nozzle with your mouth, and don't eat or smoke while working with pesticides.

Respiratory Exposure

Pesticides inhaled into the lungs, especially vapors and fine particles, are rapidly absorbed into the bloodstream and pose a great poisoning danger. ***Always use protective devices called for on the label.*** Change respirator filters and cartridges as often as the manufacturer suggests. If you smell pesticides or have difficulty breathing, replace the filter or cartridge immediately. If no other guidelines are available, change cartridge filters every eight hours. Mix pesticides outside and in well-ventilated areas; stand at a 90° angle (sideways) to the wind when mixing or loading pesticides.

Eye (Ocular) Exposure

Because the eyes absorb chemicals very rapidly, getting pesticides in your eyes can damage eyesight and eye tissues and even cause serious illness or death. ***Wear goggles or other eye protection while measuring or mixing concentrated pesticides, or when applying highly toxic pesticides.*** Keep protective equipment clean and available at all times.

The amount of pesticide absorbed through your skin (and eyes) and into your body depends on:

- the pesticide itself and the material used to dilute the pesticide. Emulsifiable concentrates, oil-based liquid pesticides, and oil-based diluents (such as xylene) are, in general, absorbed most readily. Water-based pesticides and dilutions (such as wettable and soluble powders and dry flowables) ususally are absorbed less readily than the oil-based liquid formulations but more readily than dry formulations. Dusts, granules, and other dry formulations are not absorbed as readily as liquids.

- the area of the body exposed. The genital area tends to be the most absorptive. The scalp, ear canal, and forehead are also highly absorptive.

- the condition of the skin exposed. Cuts, abrasions, and skin rashes allow absorption more readily than intact skin. Hot, sweaty skin will absorb more pesticide than dry, cool skin.

Poisoning Symptoms

Anyone who works with pesticides needs to be thoroughly familiar with common poisoning symptoms and basic first aid procedures. Watch for early warning signs; you may be able to save a person's life by immediately and completely removing the exposure source.

Never work alone when handling hazardous materials, and watch each other carefully for any unusual behavior. Pesticide poisoning symptoms often resemble the flu or other common illnesses (even a hangover), but if these symptoms appear after contact with pesticides, consult a physician. Take the label with you to the doctor's office.

Causes of Exposure

One of the best ways to avoid pesticide exposure is to avoid situations and practices where exposures commonly occur.

Oral exposures often are caused by:
- not washing hands before eating, drinking, smoking, or chewing
- mistaking the pesticide for food or drink
- accidentally applying pesticides to food
- splashing pesticide into the mouth through carelessness or accident

Inhalation exposures often are caused by:
- prolonged contact with pesticides in closed or poorly ventilated spaces
- breathing vapors from fumigants and other toxic pesticides
- breathing vapors, dust, or mist while handling pesticides without appropriate protective equipment
- inhaling vapors present immediately after a pesticide is applied; for example, from drift or from reentering the area too soon
- using a respirator that fits poorly or using an old or inadequate filter, cartridge, or canister

Dermal exposures often are caused by:
- not washing hands after handling pesticides or their containers
- splashing or spraying pesticides on unprotected skin or eyes
- wearing pesticide-contaminated clothing (including boots and gloves)
- applying pesticides in windy weather
- wearing inadequate personal protective equipment while handling pesticides
- touching pesticide-treated surfaces

Eye exposures often are caused by:
- splashing or spraying pesticides in eyes
- applying pesticides in windy weather without eye protection
- rubbing eyes or forehead with contaminated gloves or hands
- pouring dust, granule, or powder formulations without eye protection

Poisoning symptoms fall into three groups:

Mild Symptoms
- Fatigue
- Blurred vision
- Headache
- Nausea and vomiting
- Excessive sweating or salivation
- Dizziness
- Stomach cramps and diarrhea

Moderate Symptoms
- Weakness
- Chest discomfort
- Inability to walk
- Constricted eye pupils
- More severe form of mild symptoms

Severe Symptoms
- Unconsciousness
- Secretions from mouth and nose
- Coma
- Muscle twitches
- Difficulty in breathing

VI. Toxicity

Toxicity is a measure of the ability of a pesticide to cause harmful effects. Toxicity depends on:

- type and amount of active ingredient(s)
- type and amount of carrier or solvent ingredient(s)
- type and amount of inert ingredient(s)
- type of formulation, such as dust, granule, powder, or emulsifiable concentrate

Toxicity is the innate capacity of a material to cause injury or death. It is an inherent property of the material like color, reactivity, or melting point. It cannot be changed. Toxicity is often expressed in terms of an LD_{50} value.

LD_{50}

The toxicity of a particular pesticide is measured by subjecting laboratory animals (usually rats, mice, rabbits, and dogs) or tissue cultures to different dosages of the active ingredient and of the formulated product over various time periods. These toxicity studies help to estimate the risk that the pesticide may pose in causing harmful effects in humans. However, some people react more severely or more mildly than estimated. Be alert to your body's reaction to the pesticides you are handling. Some people seem to be especially sensitive to individual pesticides or to groups of similar pesticides.

Toxicity studies are guidelines for estimating and comparing the toxic effects of one or more pesticides. To determine the toxicity of a material, researchers give laboratory animals short term exposure to doses of the pesticide to be tested. These doses are administered orally, as well as put on the skin, eyes, and in the air that the test animals breathe. The animals are then studied for toxic effects. Toxic effects produced from a single exposure are referred to as **acute toxicity**.

Concentrations of pesticides are administered to test animals in ever increasing doses until it is determined that a specific amount of a pesticide will kill half of the animals tested. The **lethal dose** for 50% of the animals tested is called the LD_{50} value for that product. The *smaller* the LD_{50} value, the *less* chemical was used to kill half the test animals, and thus, the *more* toxic the material. If the pesticide was administered orally, than the toxicity level is expressed as an **oral LD_{50}**. If the pesticide is placed on the skin, than the data represents a **dermal LD_{50}**, and if on the eyes, an **ocular LD_{50}** is obtained. LD_{50}s for different chemicals can only be compared if the same test animal is used. For precise measurements in these tests, a measured weight of pesticide is used for a measured weight of test animal. For the tests described above, the units are *milligrams toxicant per kilogram test animal* (mg/kg). Because there are a million milligrams in a kilogram, *parts per million* (ppm) may be used.

LC_{50}

To determine the **acute inhalation toxicity**, the measure of how toxic a pesticide is to breathe, researchers add a known amount of pesticide to a known volume of air. The amount of pesticide that has to be added to the air to kill half of the test animals is the **lethal concentration** for 50% of the animals tested, or the **LC_{50}**. The lower the LC_{50}, the more toxic the material. LC_{50} is measured in *milligrams of toxicant per liter of air* (mg/l) or *parts per million* (ppm). Sometimes the measurement is expressed in *milligrams per cubic meter* (mg/m^3).

Chronic toxicity is used when pesticides are tested with small amounts of pesticide administered repeatedly over time. These tests may run days, weeks, months or even years. Since the tests may

vary, there is no standard unit of measure and an oral toxicity rating may look like this: "4 milligrams of pesticide were fed to mice daily for 6 months. No symptoms of poisoning appeared."

Signal Words and Categories of Acute Toxicity

Based on LD_{50}, LC_{50}, and other considerations, each pesticide is classified into a **toxicity category** and assigned a corresponding **signal word**. The signal word appears in bold print on the face of all pesticide labels. This enables the applicator to make a rapid determination of the degree of toxicity associated with each pesticide. The word is *not* a precise measurement.

The public often believes that "natural" pesticides are safer or less toxic than man-made or synthetic pesticides. The origin of the pesticide typically has little to do with its toxicity. Botulin, a toxin produced by the bacterium *Clostridium botulinum*, is one of the most toxic poisons known (one milligram can kill an estimated 500 people), while some of the synthetic pyrethroids are categorized as relatively nontoxic to humans. The toxicity of a given pesticide is related to its mode of action on the target organism and the chemical group to which that pesticide belongs. Table 5.1 will assist in interpreting the signal word on a pesticide label.

First Aid and Emergency Procedures

When someone has been exposed to pesticides, certain actions are immediately necessary. If you're alone with the victim, start first aid as quickly as possible. Be sure you don't contaminate yourself in the process! If someone else is also there, one of you can begin first aid while the other calls the poison center at one of the following numbers:

FIRST AID

Poison Control Center Numbers
Toll Free Hotline: 1-800-362-0101
In Tucson: 626-6016

Make sure you take the label or container with you to the physician or Emergency Room.

REMEMBER: Speed is essential in administering first aid for pesticide poisoning!

Immediate action for those exposed to pesticides includes:

For Dermal Exposure

- Remove clothing.
- Drench skin with water.
- Wash skin and hair quickly and thoroughly with soap and water; don't forget fingernails.

For Oral Exposure

- Call the Poison Control Center or a physician and ***check label*** for precautions.
- Give milk or water immediately, unless the patient is unconscious, convulsing, or unable to swallow. Induce vomiting only if the label directs you to!
- Get patient to hospital as quickly as possible.

For Respiratory Exposure

- If the victim is in an enclosed area, get fresh air into the area or carry the patient to fresh air immediately. *Do not enter the contaminated area yourself without an air-supported respirator.*
- Loosen all tight clothing.
- Give mouth-to-mouth resuscitation or CPR if breathing has stopped or is irregular.

Table 5.1. LD_{50} Categories.

Category	SignalWord	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)	InhalationLC_{50} (mg/L)	Probable lethal dose (150 lb man)
I. Highly Toxic	DANGER or DANGER	From 0 to 50	From 0 to 50	From 0 to 0.2	A few drops to one teaspoon
II. Moderately	WARNING	From 50 to 500	From 200 to 2,000	From 0.2 to 2	Over one teaspooon
III. Slightly Toxic	CAUTION	From 500 to 5,000	From 2,000 to 20,000	From 2 to 20	Over one ounce to one pint/ or one pound

For Eye (Ocular) Exposure

- Immediately wash eyes with a gentle stream of clean running water for 15 minutes or more. Don't use chemicals or drugs in the wash water.
- Encourage the patient to blink as much as possible.
- Obtain medical care.

V. Harmful Effects

Pesticides can cause three types of harmful effects: **acute effects, delayed effects**, and **allergic effects**.

Acute Effects

Acute effects are illnesses or injuries that may appear immediately after exposure to a pesticide (usually within 24 hours). Acute effects can be measured more accurately than delayed effects, and they are more easily diagnosed than effects that do not appear until long after the exposure. Acute effects are usually obvious and are often reversible if appropriate medical care is given promptly.

Pesticides cause four types of acute effects:

1. Oral
2. Inhalation
3. Dermal
4. Eye

Oral

Your mouth, throat, and stomach can be burned severely by ingestion of some pesticides. Other pesticides that you swallow will not burn your digestive system, but will be absorbed and carried in your blood throughout your body and may cause you harm. For some pesticides, swallowing even a few drops from a splash or wiping your mouth with a contaminated glove can make you very ill.

Inhalation

Your entire respiratory system can be burned by some pesticides, making it difficult to breathe. Other pesticides that you inhale may not harm your respiratory system, but are carried quickly in your blood throughout your whole body.

Dermal and Skin Irritation

Contact with some pesticides may cause your skin to itch, blister, crack, or change color. Other pesticides can pass through your skin and eyes and get into your body. Once inside your body, these pesticides are carried throughout your system.

Eye

Some pesticides that get into your eyes can cause temporary or permanent blindness or severe irritation. Other pesticides may not irritate your eyes, but may pass through them and into your body. These pesticides can travel throughout your body, causing you harm.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides. Often the term *chronic effects* is used to describe delayed effects, but this term is applicable only to certain types of delayed effects.

Delayed effects may be caused by:

- **repeated exposure** to a pesticide, a pesticide group, or a combination of pesticides over a long period of time, or
- **single exposure** to a pesticide (or combination of pesticides) that causes a harmful reaction that does not become apparent until much later.

Some pesticides cause delayed effects only with **repeated exposure** over a period of days, months, or even years. For example, if a rat eats a large amount of the pesticide *cryolite* at one time, the pesticide passes through the rat's system quickly and is eliminated without harmful effects. However, if the rat regularly eats small amounts of *cryolite*, it soon becomes ill and dies. *Cryolite* does not readily dissolve in water. The small amount of pesticide that is absorbed into the rat's system from a one-time exposure is not enough to cause illness. But if that same small amount is absorbed day after day, enough poison will be absorbed into the rat's system to cause illness and death.

Sometimes repeated exposures to a pesticide or family of pesticides will result in a delayed effect, but a larger exposure will cause an acute effect. Organophosphate and carbamate pesticides inhibit cholinesterase, a chemical in the nervous system of humans. A large exposure causes immediate acute illness. Smaller exposures cause no apparent problem at first. They inhibit the cholinesterase, but not enough to cause immediate illness. Small, repeated exposures to these pesticides over several days or weeks may greatly reduce cholinesterase levels in the body. At that point, even a small exposure to a pesticide with relatively low cholinesterase-inhibiting properties may trigger severe illness.

A person who is repeatedly exposed to two or more specific chemicals may become ill even though any one of the chemicals alone would have had no harmful health impact. Some organophosphate pesticides have been shown to have this effect when they are used in combination.

In some cases, a **single exposure** to a pesticide (or combination of pesticides) could adversely affect the exposed person's health after a period of time. For example, large exposures to the herbicide *paraquat* may cause severe or fatal lung injury that does not appear for 3 to 14 days after the initial exposure. After an exposure, paraquat slowly builds up in the lungs and destroys lung cells.

Some kinds of harmful effects may not occur unless a certain set of circumstances is present. Although these effects can occur after the first exposure, the likelihood is small. Continuous or frequent exposures over a long period of time make it more likely that all the necessary factors will be present. Genetic changes that result in the development of cancer or other delayed effects are in this category.

Types of delayed effects include:

- chronic
- developmental and reproductive
- systemic

Chronic Effects

Chronic effects are illnesses or injuries that appear a long time, usually several years, after exposure to a pesticide. Some delayed effects that are suspected to result from pesticides' chronic toxicity include:

- production of tumors (oncogenic effect)
- production of malignancy or cancer (carcinogenic effect)
- changes in the genes or chromosomes (mutagenic effect)

Typical precautionary statements on pesticide labeling include:

> **CANCER HAZARD WARNING STATEMENT: THIS PRODUCT CONTAINS AN INGREDIENT WHICH HAS BEEN DETERMINED TO CAUSE TUMORS IN LABORATORY ANIMALS.**
>
> **NOTE: THIS PRODUCT HAS BEEN SHOWN TO CAUSE CANCER IN LABORATORY ANIMALS.**

Developmental and Reproductive Effects

A **developmental effect** is an injury or illness that occurs to a fetus in the womb of a woman who has been exposed to a pesticide or pesticides. These effects include:

- birth defects (teratogenic effect)
- illness or death (miscarriage or stillbirth) to a fetus (fetotoxic effect)

A **reproductive effect** is an injury to the reproductive system of exposed men or women. These effects include

- infertility or sterility in men or women
- impotence in men

Some developmental or reproductive effects are thought to occur immediately after exposure to a pesticide or combination of pesticides, but they may not be apparent for some time after the exposure. For example, a birth defect may be seen only after the birth of a child, which may be several months after the exposure. Other developmental or reproductive effects are thought to result from repeated exposures to a pesticide or combination of pesticides over a period of time.

A typical precautionary statement on pesticide labeling is:

> **THIS PRODUCT MAY BE HAZARDOUS TO YOUR HEALTH. THIS PRODUCT HAS BEEN DETERMINED TO CAUSE BIRTH DEFECTS IN LABORATORY ANIMALS.**

Systemic Effects

A delayed systemic effect is an illness or injury to a system in the body that does not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides. Such effects include:

- blood disorders (hemotoxic effects), such as anemia or an inability to coagulate
- nerve or brain disorders (neurotoxic effects), such as paralysis, nervous excitation, behavioral changes, tremors, blindness, and brain damage
- skin disorders, such as rash, irritation, discoloration, and ulceration
- lung and respiratory disorders, such as emphysema and asthma
- liver and kidney disorders, such as jaundice and kidney failure

Typical precautionary statements on pesticide labeling include:

MAY PRODUCE KIDNEY AND LIVER DAMAGE UPON PROLONGED EXPOSURE.

INHALATION MAY CAUSE DELAYED LUNG, NERVE, OR BRAIN INJURY.

LIQUID OR VAPOR MAY CAUSE SERIOUS SKIN OR EYE INJURY WHICH MAY HAVE A DELAYED ONSET.

Determining Delayed Effects

Because of the time delay between the exposure and the observable effect, and because many other types of exposures may have occurred during the delay, it is sometimes hard to identify the cause of a delayed effect. Although some pesticides may cause delayed effects in laboratory animals, further studies are needed to determine whether these pesticides will affect humans the same way.

When there is clear evidence that a pesticide may cause chronic, developmental, reproductive, or systemic effects in humans, the EPA will determine what steps are appropriate in a special review to reduce or eliminate the risk. Such actions include:

- removing the pesticide from use
- requiring label warning statements about the possible effect
- requiring specific personal protective equipment or safety systems during handling of the pesticide
- requiring changes in dosages, method, or frequency of application, and waiting times before entry or harvest/slaughter/grazing
- restricting the use to certified applicators

Avoiding Delayed Effects

Scientists, pesticide manufacturers, and the EPA cannot yet be sure what the delayed effects of too much exposure to individual pesticides or combinations of pesticides may be. It may be years before there are clear answers on the effects of all the pesticides and combinations of pesticides in use today. Meanwhile, it makes good sense to reduce your exposure to all pesticides as much as possible.

Allergic Effects

Allergic effects are harmful effects that some people develop in reaction to exposure to substances that do not cause the same reaction in most other people. Allergic reactions are not thought to occur during a person's first exposure to a substance. The first exposure causes the body to develop repelling response chemicals to that substance. A later (the second, third, or more) exposure results in the allergic response. This process is called **sensitization**, and substances that cause people to become allergic to them are known as **sensitizers**.

Certain substances cause many people to develop an allergic reaction. Poison ivy, for example, causes a severe skin rash in many people. Other substances cause allergic reactions in only a few people. Turfgrass, for example, causes a severe skin rash in relatively few people.

Types of Allergic Effects

Some people are sensitized to certain pesticides. After being exposed once or a few times without effect, they develop a severe allergy-like response upon later exposures. These allergic effects include:

- systemic effects, such as asthma or even life-threatening shock
- skin irritation, such as rash, blisters, or open sores
- eye and nose irritation, such as itchy, watery eyes, and sneezing

Unfortunately, there is no way to tell which people may develop allergies to which pesticides. Certain people seem to be more chemically sensitive than others and develop an allergic response to many types of chemicals in their environment. These persons may be more likely to develop allergies to pesticides.

Typical precautionary statements on pesticide labeling include:

> **THIS PRODUCT MAY PRODUCE TEMPORARY ALLERGIC SIDE EFFECTS CHARACTERIZED BY REDNESS OF THE EYES, MILD BRONCHIAL IRRITATION, AND REDNESS OR RASH ON EXPOSED SKIN AREAS. PERSONS HAVING ALLERGIC REACTION SHOULD CONTACT A PHYSICIAN.**
>
> **MAY BE A SKIN SENSITIZER.**

Avoiding Allergic Effects

Depending on how severe the allergic reaction is, persons with allergies to certain pesticides may have to stop handling or working around those pesticides. They may be unable to tolerate even slight exposures. Sometimes persons with allergies to certain pesticides can continue to work in situations where those pesticides are present by reducing their exposure to them.

Dose Response

The effect of a pesticide is dependent on a variety of factors. The most important factor is **dose response,** which means that the greater the exposure to a dose, the greater the effect of the chemical. Dose can be regulated by changing the volume of the pesticide in contact with the target, or by changing the length of time that the target is in contact with or exposed to the pesticide. For most pesticides, there is a minimum exposure level below which the pesticide will have no adverse effects. Likewise, for any pesticide (or any chemical at all), there is a level that is sure to have a toxic effect. The most interesting examples can be found in many of our modern pesticides that at certain low levels are used as or derived from medicines. It can be stated simply: "The dose makes the poison!"

Shock

Shock is the body attempting to shut down to prevent itself from being injured further. If untreated or ignored, the victim can die from shock even if the injuries were not life-threatening. Typically, symptoms are pale skin that is cold and clammy, eyes that are blank and lackluster with dilated pupils, breathing that is shallow, and irregular, pulse that is rapid, weak and irregular. In addition the victim may have fainted. Take immediate action:

Procedure for Shock Victims

- Keep the victim flat on back with feet elevated 1 to 1 ½ feet, unless victim is vomiting.
- Keep the victim warm but do not overheat.
- Keep the victim quiet, but reassure often through touch and speech.
- Get medical attention immediately.

VI. Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is clothing and devices worn to protect the human body from contact with pesticides or pesticide residues. Personal protective equipment includes such items as coveralls or protective suits, footwear, gloves, aprons, respirators, eyewear, and headgear.
Ordinary shirts, pants, shoes, and other regular work clothing are usually not considered personal

protective equipment, although the pesticide labeling may require you to wear specific items of work clothing during some activities.

To prevent or reduce exposure to pesticides, you need to wear personal protective equipment. **You are legally required to follow all personal protective equipment instructions that appear on the label or in labeling.**

Remember, just because the pesticide labeling addresses those requirements for equipment, do not rule out the need for *more* protection. No pesticide label instructions can cover all situations. Your common sense, the information on the label about precautions for humans, and the task you will be performing will help you to assess your potential hazard and to select the amount and kind of personal protective equipment you need for each handling job.

Pesticide labels list the **minimum** personal protective equipment you must wear while handling the pesticide. Sometimes the labeling lists different requirements for different activities. For example, more personal protective equipment may be required for mixing and loading than for application.

To reduce the discomfort of protective clothing, anticipate the environmental conditions in which you will be working. If the temperature is very high, try to schedule application for early mornings hours. Wear undergarments made of a breathable fabric, such as cotton. When the temperature is low, wear warm clothes under the protective equipment. Schedule breaks that are long enough to get out of the protective equipment if the application job is lengthy or trade-off jobs with a co-worker.
Be aware that various body areas absorb the pesticide parathion at different rates; experiments emphasize the importance of wearing protective clothing to prevent dermal exposure (Figure 5.2). You may desire to starch clothing during the wash process. Studies have shown that starching clothing adds an element of protection.

Protective Clothing

Some pesticide labeling requires you to wear chemical-resistant personal protective equipment. You must select a material that will be resistant for the period of time you will be exposed to the pesticide. Most chemical-resistant personal protective equipment items are made of plastic or rubber but these materials are not equally resistant to all pesticides and in all circumstances.

Factors Affecting Chemical Resistance

How chemical-resistant a material will be in your pesticide handling situation depends on the length of exposure, the exposure situation, and the chemical to which the material is exposed.

Length of Exposure

Not all types of materials that are resistant to a particular pesticide will protect you for the same amount of time. Some materials will keep the pesticide out for a fairly long time. Others will allow the pesticide to go through the material to your skin fairly quickly. Thin materials, such as disposable plastic gloves, shoe covers, or aprons, may be as much protection as you need for tasks that can be done in a few minutes. Longer jobs usually require items made of a heavier material, or more frequent changes of PPE.

Chemical resistance is often stated in terms of exposure time. For example, neoprene is resistant to acetone for 30 minutes or less and to diesel fuel for more than 4 hours. If you wear neoprene

gloves while handling pesticides with an acetone solvent, you must change the gloves at least every 30 minutes; otherwise, the pesticide and the acetone will work their way through the gloves and onto your hands.

Exposure Situation

Even a chemical-resistant material will not continue to protect you if it becomes damaged during the pesticide-handling task. For tasks that involve handling sharp or pointed objects or walking through rough terrain, for example, a heavy-duty or sturdy material probably would be necessary to ensure chemical resistance barrier.

Type of Chemical

Very few materials will protect you from all pesticide products. The level of chemical resistance may depend not only on what the active ingredient is, but also on whether the pesticide is liquid or dry and what diluents or solvents are used.

Choosing Chemical-Resistant Materials

Always read the pesticide label and labeling to see if it tells you what materials are resistant to the pesticide product. If it does not, look for another source of help in making a selection. The Environmental Protection Agency, the Structural Pest Control Commission, Arizona Cooperative Extension, pesticide producers, or personal protective equipment manufacturers may issue guidance about which materials are resistant to particular pesticides. When no outside advice is available, you must use your own best judgment in selecting a material.

When you must select a chemical-resistant material, there are some general guidelines to follow:

- Do not use cotton, leather, canvas, and other absorbent materials. These are not chemical-resistant, even to dry formulations; powders and dusts sometimes move through cotton and other woven materials as quickly as wet formulations and may remain in the fibers even after three launderings
- Do not use hats that have a cloth or leather sweatband, or cloth or cloth-lined gloves, footwear, and aprons. These are difficult or impossible to clean after pesticide gets on them, and they are too expensive to be disposed of after each use

Chemical-resistant Suits and Hoods

The best choice of materials for chemical-resistant suits and hoods is generally:

- rubber or plastic, such as butyl, neoprene, or polyvinyl chloride (PVC)
- nonwoven fabric coated with plastic or another barrier material

Read the packaging for the suits carefully to be sure that they are “chemical-resistant,” “chemical-protective,” or “liquid-proof.”

Other Chemical-Resistant Items

For other chemical-resistant items, such as gloves, footwear, aprons, and hats, you can choose from many types of materials.

- Foil-laminate materials are resistant to most pesticides, although many pesticide handlers consider them uncomfortable to wear and difficult to use while performing many tasks.
- Plastic or rubber materials are resistant to dry pesticides (dusts, granules, and some baits) and to water-based pesticides (wettable powders, soluble powders, some solutions, dry flowables or water-dispersible granules, and microencapsulated pesticides).
- Whether materials are resistant to *non*-water-based liquid pesticides depends on the type

of solvent used.

Pesticides that do not dissolve in water are often mixed with other solvents to form liquid formulations. Liquid pesticides that are not water-based include emulsifiable concentrates, ultra-low-volume and low-volume concentrates, low-concentrate solutions, flowables, aerosols, and invert emulsions. Common solvents are xylene, fuel oil, petroleum distillates, and alcohol. When xylene is in a formulation, it must be listed in the ingredient statement on the front panel of the pesticide label.

When Pesticide Solvent is Unknown

Because some solvents do not have to be listed in the ingredient statement, you may not be able to choose a chemical-resistant material on the basis of what is in the formulation. For these pesticides, select sturdy foil-laminate, butyl, or nitrile materials. Then watch for signs that the material is not chemical-resistant. Sometimes it is easy to see when a 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 these changes occur, discard the items and choose another type of material.

Protecting Your Skin

The skin is the part of your body that usually gets the most exposure when you are handling pesticides. Pay particular attention to covering as much of your skin as possible. Remember that personal protective equipment protects the applicator only if the pesticide remains on the *outside* of the material. Once the pesticide gets on the inside and next to your skin, the material works against you. It holds the pesticide tightly next to your skin for as long as it is worn. When this happens, more pesticide will get on your skin, cause irritation, or go through your skin and into your body than if you were not wearing the protective equipment.

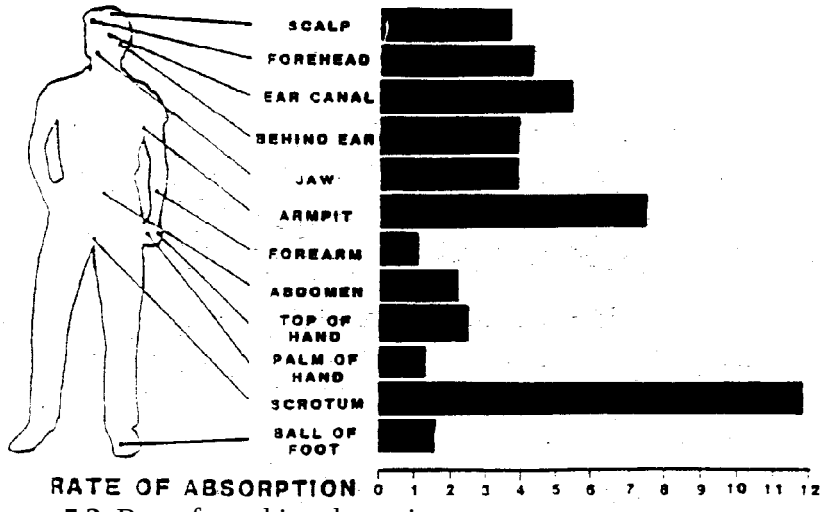


Figure 5.2 Rate of parathion absorption.

Body Protection

Any time you handle pesticides, wear at least a long-sleeved shirt and long-legged pants. In many instances the pesticide labeling will require you to wear a coverall, a chemical-resistant suit, or a chemical-resistant apron.

Long-Sleeved Shirt and Long-Legged Pants

Long-sleeved shirt and long-legged pants should be made of sturdy material. Fasten the shirt collar completely to protect the lower part of your neck.

Coveralls

Coveralls should be made of sturdy material such as cotton, polyester, a cotton-synthetic blend, denim, or a nonwoven fabric. One-piece coveralls look like jump suits or flight suits. Two-piece coveralls look like surgeons' suits. When wearing a coverall, close the opening securely so the entire body except the feet, hands, neck, and head are covered. If you wear a two-piece coverall, do not tuck it in at the waist; the shirt should extend well below the waist of the pants and fit loosely around the hips.

When handling pesticides that are highly or moderately toxic dermally or are skin irritants, always wear a coverall over another set of clothing that covers your body at least from shoulders to thighs. An entire set of clothing such as a long-sleeved shirt and long-legged pants worn under the coverall is ideal. Sometimes the pesticide labeling will specify a particular type of clothing to be worn under the coverall.

Several factors determine how well a coverall will protect you. Each layer of clothing and each layer of air between the pesticide and your skin provides added protection. That is why the coverall should fit loosely. If it fits tightly, there will not be a layer of air between it and your skin, and any pesticide getting through the coverall will be in direct contact with your skin.

The design and structure of coveralls also affect how well they will protect you. Well-designed coveralls have tightly–constructed seams and snug, overlapping closures that do not gap or become unfastened readily. This construction makes it harder for pesticides to get through these areas onto your inner clothing and your skin.

Chemical-Resistant Suit

Some pesticide labeling requires handlers to wear a chemical-resistant suit. This usually indicates that the pesticide is very hazardous, either for acute effects or for delayed effects, and that extra precaution is necessary to prevent the pesticide from getting on you.

If you expect to be in a situation where a large amount of pesticide could be deposited on your clothing, consider wearing a chemical-resistant suit even if the pesticide labeling does not require you to do so. Even pesticides that are applied dry, such as dusts or granules, can get through ordi-

nary fabric and harm you.
Chemical-resistant suits made of rubber or plastic often are referred to as "rainsuits." They may be sold as one-piece coveralls or as two-piece outfits consisting of a jacket and overalls. Chemical-resistant suits made of coated nonwoven fabric usually are sold as one-piece coveralls.

The biggest drawback to chemical-resistant suits is that they may make you uncomfortably warm. Unless you are handling pesticides in cool or climate-controlled environments, heat stress becomes a major concern. Wearing a chemical-resistant suit in even moderate temperature and humidity conditions can cause you to become overheated very quickly. Take extra precautions to avoid heat stress by drinking plenty of water and taking frequent rest breaks to cool down.

Chemical-Resistant Apron

The pesticide label may require you to wear a chemical-resistant apron while you are mixing and loading the pesticide and while you are cleaning pesticide equipment. Consider wearing an apron whenever you are handling pesticide concentrates. It will protect you from splashes, spills, and billowing dust. Wearing an apron over the coveralls or long-sleeved shirt and long-legged pants maybe required for the application or other handling activities.

Choose an apron that extends from your neck to at least your knees. Some aprons have attached sleeves and gloves. This style is especially protective because it protects your arms, hands, and front; it eliminates the potential gap where the sleeve and glove or sleeve and apron meet.

An apron can sometimes be a safety hazard. It can get caught in machinery or get in your way in some situations. At those times, you may choose to wear a chemical-resistant suit instead.

Hand and Foot Protection

Pesticide handlers have the greatest pesticide exposure on their hands and forearms. As a result, most pesticide labeling will require you to wear chemical-resistant gloves at all times while handling the pesticide. Wear chemical-resistant gloves any time you may get pesticides on your hands.

Pesticide handlers also often get pesticides on their feet. Never wear canvas, cloth, or leather foot coverings because they are difficult or impossible to clean adequately. Use chemical-resistant materials when pesticides or pesticide residues, especially concentrates, may get on your footwear.

Some pesticide labeling requires you to wear chemical-resistant footwear. Such footwear can be shoes, shoe covers, or boots. If a pesticide is likely to get on your lower legs or feet, consider wearing chemical-resistant boots. The boots should extend past your ankle and at least halfway up to your knee.

One situation where you should *not* wear chemical-resistant gloves and footwear is during the handling of fumigants, such as methyl bromide, because the gloves and footwear can trap the gas near the skin and cause burns. The labeling on these fumigants will instruct you not to wear chemical-resistant gloves and footwear or other chemical-resistant clothing.

Wear Gloves and Footwear Correctly

Always start out with gloves and footwear that you know are new or freshly cleaned. Don't choose a pair just because they are close by. They may already have pesticides on the inside and will not protect your hands or feet.

If pesticides get inside your gloves or footwear, you must take them off right away, wash your hands or feet, and put on a clean pair of gloves or footwear. Keep several pairs of gloves and footwear available and change to a clean set whenever you suspect the inside has become contaminated.

Avoid Contaminating the Inside of Gloves and Footwear

Even when you are wearing gloves and footwear, you can get pesticides on your hands and feet unless the gloves and footwear are:

- chemical-resistant to the pesticide being handled
- worn correctly
- in good condition
- cleaned and cared for
- replaced often

Contamination often happens when handlers remove their gloves briefly to adjust equipment, open a pesticide container, wipe their face, and so on, and then put the gloves on again over their contaminated hands. If you must remove your gloves during a handling activity, wash your gloves thoroughly before taking them off, and wash your hands thoroughly and dry them before you put the gloves back on again.

Applicators also sometimes make the mistake of putting on footwear with contaminated hands.

This may transfer the pesticide from your hands to your socks and feet.

You must keep pesticides from running down your sleeves or pants legs and into your gloves and footwear. For many jobs, you will be working some of the time with your arms raised and some of the time with them lowered. 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. Some gloves have a method of tightening the cuff to your sleeve so the pesticide cannot run down into the glove.

Place sleeves *outside* the gloves to keep pesticides from running down the sleeves and into the gloves. Use gloves that go up over your wrist and at least halfway to your elbow.

For jobs when you will be exposed to pesticides on your legs, put your pants legs *outside* the boots so the pesticide will not travel down your leg and collect in the boots or shoe covers.

Head and Neck Protection

If you will be exposed to pesticides from above, wear something to protect your head and neck. A chemical-resistant hood or wide-brimmed hat will help keep pesticides off your head, neck, eyes, mouth, and face. Plastic "safari" hats with plastic sweatbands are a good choice. They are relatively cool in hot weather. Other more flexible hats and hoods are also available in chemical-resistant materials. Many chemical-resistant jackets or coveralls can be purchased with attached protective hoods.

Protecting Your Eyes

When the pesticide labeling requires you to wear protective eyewear, this means you are to wear goggles, a face shield, or safety glasses with shields at both the brow and sides. Eyes are very sensitive to chemicals in some pesticide formulations, especially concentrates, and temporary blindness caused by an accident may delay or prevent self-treatment. Eyes also readily absorb some pesticides.

Shielded safety glasses or full-face shields are a good choice in many handling situations because they are comfortable, do not cause fogging or sweating, and give good eye protection for many exposure situations. Face shields that are cupped inward towards your throat give better protection from splashes than straight face shields. However, if you're in an open cab during an airblast application, flagging directly under an aerial application, or in any other situation where you will be enveloped in a spray, mist, or dust, wear goggles that fit tightly against your face.

Either goggles or shielded safety glasses can be worn with a half-face respirator. Full-face respirators are supplied with their own face shield, so additional eye protection is not required.

Wearers of contact lenses must exercise extra care when handling pesticides. Many of the solvents contained in various formulations can dehydrate or otherwise damage the lenses. Pesticides may absorb into or become trapped under them, increasing exposure to the wearer. **The use of contact lenses should be avoided when using pesticides**. If they must be worn, eye protection should be worn over them, even when it is not specified on the label.

Protecting Your Respiratory Tract

The respiratory tract—the lungs and other parts of the breathing system—is much more absorbent than the skin. You must wear a respirator when the pesticide labeling directs you to do so. Even if the labeling does not require it, you should consider wearing a respiratory protective device:

- if you are in an enclosed area and the pesticide you are handling has a label precautionary statement such as "do not breathe vapors or spray mist," or "harmful or fatal if inhaled"
- if you will be exposed for a long time to pesticides that are in or near your breathing zone

Wearing a respirator is an important safety issue. OSHA has drafted a series of specific regulations regarding the use of respirators. These regulations include all respiratory protection ranging from filter (dust) masks to self-contained breathing apparatus (mask with "air" tanks). These regulations cover selection of respirator type, training in use, fit and maintenance, medical certification, inspection of devices, and storage. The false security provided by a defective, poorly maintained, or ill-fitting respirator may be more hazardous than wearing no respirator at all. Respirators are not a replacement for making every effort to provide adequate ventilation. If, however, it is not feasible to change chemicals, equipment, or application technique, or provide adequate ventilation for the work area, respirators must be used.

Some fumigants and pesticide formulations contain an additive that will warn you if you begin to inhale the pesticide. Such warning agents often are used when the active ingredients in the pesticide are highly toxic ones that you would otherwise not be able to detect. The additive may have a characteristic odor or be a mild irritant to alert you that you should put on a respirator or that your respirator is no longer protecting you. The warning agent can help you determine when you should use a respirator for products whose labeling does not require respiratory protection in all situations.

Some pesticide labeling lists the type of respirator you should wear when handling the product. Other labels require the use of a respirator, but do not specify the type or model to be used. NIOSH and MSHA approve respirators as adequate for certain types of uses. When the pesticide labeling requires you to use a respirator, you must wear

one that is **approved by NIOSH and MSHA**. If the respirator has more than one part, *all* the parts must be approved.

Studies have shown that, because many pesticide handlers do not use respirators correctly, they are not being well protected. Before you use a respirator, you should be trained in the correct procedures for selecting, fitting, cleaning, sanitizing, inspecting, and maintaining respiratory protective equipment.

There are two basic types of respirators:

1. **Air-supplying respirators**, which supply you with clean, uncontaminated air from an independent source
2. **Air-purifying respirators**, which remove contaminants from the air around you

Air-Supplying Respirators

Air-supplying respirators are used in a few specialized situations where other types of respirators are not protective enough. Use an air-supplying respirator when the pesticide labeling tells you to. In addition, you should use one when handling pesticides:

- when the oxygen supply is low
- during fumigation in enclosed areas, such as greenhouses or other buildings

Supplied-Air Respirators

These respirators pump clean air through a hose to the face mask. You are limited to working within the distance the hose can reach from the supply of clean air.

Self-Contained Breathing Apparatus

This type of respirator supplies clean air from cylinders that you carry with you, usually on your back. This lets you move more freely and over a wider area than you can with a supplied-air respirator. Get training from competent instructors before using self-contained breathing equipment. These devices contain a limited air supply (usually about 30 to 45 minutes), which may be used up even more quickly in high temperatures or with excessive exertion.

Air-Purifying Respirators

In most situations where pesticide handlers need to use a respirator, some type of air-purifying respirator provides enough protection. Air-purifying respirators will not protect you from fumigants, extremely high concentrations of vapor or when the oxygen supply is low.

Functions of Air-Purifying Respirators

Air-purifying respirators remove contaminants from the air in two ways:

- by filtering dusts, mists, and particles
- by removing gases and vapors

Sometimes you will need only a respirator that filters dusts and mists from the air; at other times, you will need one that removes gases and vapors as well.

Wear a dust/mist-filtering respirator if the pesticide labeling tells you to or if you will be exposed to pesticide dusts, powders, mists, or sprays in your breathing zone. Wear a respirator that also removes vapors if the pesticide labeling tells you to or if you will be exposed to gases or vapors in your breathing zone.

Styles of Air-Purifying Respirators

Air-purifying respirators are of three basic styles:

1. Dust/mist masks, which usually are shaped filters that cover the nose and mouth to filter out dusts, mists, and particles
2. Devices consisting of a body and one or more cartridges that contain air-purifying materials
3. Devices consisting of a body and a canister that contains air-purifying materials

Cartridges may contain either dust/mist-filtering material or vapor-removing material. For pesticide handling tasks where vapor removal is needed, a prefilter must be used with the vapor-removing cartridge. The prefilter removes dusts, mists, and other particles before the air passes through the vapor-removing cartridge. A few vapor-removing cartridges have an attached prefilter, but most are sold separately. Separate prefilters are preferred for use with pesticides because they often need to be replaced before the vapor-removing cartridge is used up.

Some cartridge-type respirators are one-piece units with cartridges permanently attached to the facepiece. After use, the entire unit is discarded. Other cartridge respirators are two-piece units with removable cartridges and a body that can be cleaned and reused. The dust/mist filtering or vapor-removing cartridges and the prefilters can be replaced when they lose their effectiveness.

Canisters contain both dust/mist-filtering and vapor-removing material. Canisters contain more air-purifying material than cartridges. They last much longer and may protect you better in situations where the concentration of gas or vapor in the air is high. They are also much heavier and more uncomfortable to wear.

Canister-type respirators are often called "gas masks." They usually have the canister connected directly to the facepiece or worn on a belt and connected to the facepiece by a flexible hose. The body is designed to be cleaned and reused. The canisters can be replaced when necessary.

Both canisters and cartridges are color-coded so that they can quickly be identified as to the type of contaminant they will remove from the air.

Selecting and Using Dust/Mist-Filtering Devices

Pesticide handlers must wear dust/mist-filtering masks or cartridges with NIOSH/MSHA approval number prefix TC-21C. You must wear one that has their stamp of approval. **Nonapproved** filters are not as protective and are **not acceptable**.

Look for a dust/mist mask that is held in place by *two* straps. One-strap styles are not approved by NIOSH and MSHA, because they do not keep the respirator adequately sealed against the face.

When you wear a dust/mist filter—either a mask, cartridge, or prefilter—you will have more trouble breathing as more dusts, mists, and other particles become trapped in the filter material. When breathing becomes too difficult, replace the filter. Eight hours of use is usually the limit for these filters. During continual use, you may need to change filters twice a day, or even more often in dusty or dirty conditions. Do not use a dust/mist mask when the pesticide will completely soak the mask and be held close to the skin and breathing passages. Replace the mask if it gets soaked or loses its shape.

Dust masks work best when using relatively small amounts of a directed dust, when particles may

be present in enclosed areas, or when a secondary particle may become airborne from your work activities.

HEPA-rated masks are designed to remove near microscopic dust particles and should be worn if the dust contains or may contain a biohazard.

Selecting and Using Vapor-Removing Devices

Vapor-removing devices are rated by NIOSH for the types of gases and vapors they will remove. For pesticide handling tasks where vapor protection is needed, NIOSH requires that an organic-vapor–removing material and a pesticide prefilter be used.

Pesticide handlers must use either

- **cartridge approved for organic vapor removal plus a prefilter approved for pesticides (NIOSH/MSHA approval number prefix for both is TC-23C)**
- **canister approved for pesticides (NIOSH/MSHA approval number prefix is 14G)**

When you wear a vapor-removing respirator, remember that vapor-removing materials gradually lose their ability to hold more gases and vapors. Their useful life can vary greatly depending on:

- amount of particles in the air
- concentration of vapor being filtered
- amount of absorbent material they contain
- breathing rate of the wearer
- temperature and humidity
- length of time they have been stored before use and between uses

If you notice an odor, taste, irritation, or dizziness, that is a signal that you are no longer being protected. Some vapor-removing materials have a "service life indicator" to tell you when the material is nearly used up. The instructions on some other materials will tell you to replace them after a specific number of hours of use. If there are no instructions about replacement, change the cartridge or canister after about 8 hours of use.

Combination respirators are also available that are both HEPA-rated and vapor-removing

Air-Delivery Systems

Air-purifying respirators draw air through the filters and vapor-removing materials in one of two ways. Ordinary air-purifying respirators depend on the wearer's lung power to draw air through the purifying material with each breath. Powered air-purifying respirators (PAPR) assist the wearer by pulling the air through mechanically. Dust/mist masks and most cartridge and canister respirators are nonpowered air-purifying respirators.

If you have a respiratory problem, even a temporary problem such as a cold or allergy, you cannot wear nonpowered cartridge and canister respirators. You need strong lung pressure to draw the air through the purifiers into your lungs. Even a person with normal lung capacity cannot wear these respirators for long periods of time, because they tend to be hot, uncomfortable, and exhausting.

Before you use these respirators, have a medical examination to make sure that you do not have a medical condition that would prevent you from using such devices. If you have trouble breathing while you are wearing your respirator even though you have used and cared for it correctly, see your physician to find out whether you have a health problem.

Powered air-purifying respirators use a blower to draw air to the user. PAPR should not be confused with air-supplying respirators, because they do not supply clean air. The air is cleaned by cartridges or canisters, as it is with other air-purifying respirators. These respirators are available as lightweight backpacks, or they may be mounted on or in application equipment where the power is supplied by the vehicle's electrical systems.

Fitting Air-Purifying Respirators

Respirators fit wearers in one of two ways. Most must seal tightly to the face; others are loose-fitting.

Face-sealing respirators must form a tight seal against your face to be effective. Otherwise, pesticides can leak in around the edges. People with beards cannot wear this style of respirator because a tight seal cannot be formed through the hair. These respirators must be fitted to each wearer and are not interchangeable among handlers.

Dust/mist masks are face-sealing respirators. They fit over your nose and mouth and have a clip that you press around the bridge of your nose to help form a seal. Most cartridge and canister respirators are also face-sealing respirators. **Full-face styles** form and keep a tight seal better than half-face styles.

Many pesticide handlers are not being adequately protected while wearing face-sealing cartridge and canister respirators because they often break the seal by pulling the respirator away from their face to get temporary relief from the heat, sweat, itching, or difficult breathing. Once the seal is broken in the exposure area, the respirator's ability to protect you is greatly reduced. Face-sealing cartridge and canister respirators are most useful for short-term tasks.

Your face-sealing respirator should be tested before you wear it in a situation where you may inhale pesticides. There are two types of tests to ensure that the respirator is operating correctly and that you are being protected: **fit tests** and **fit checks**.

Have a **fit test** before you use your cartridge or canister respirator the first time, and then be retested periodically.

The two main types of fit tests are:

1. Testing whether the wearer can detect a test substance by irritation, odor, or taste
2. Measuring the actual amount of a test substance that gets inside the facepiece

A **fit check** is an on-the-spot check that you should do to make sure the respirator is still working correctly. Do a fit check each time you wear a face-sealing respirator.

There are two methods for checking the seal of the facepiece against your face. To check by the first method:

- Close off the inlet of the canister or cartridge (cover it with your palm, replace the caps, or squeeze the breathing tube so that it does not allow air through)
- Inhale gently so that the facepiece collapses slightly
- Hold your breath for about 10 seconds

If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator probably fits tightly enough and will work correctly. This method does not work for dust/mist masks.

To check by the second method, close the exhalation valve with your palm and exhale gently into the facepiece. If slight pressure builds up in-

side the facepiece without any evidence of outward leakage, the respirator probably fits tightly enough and will work correctly. This method is not appropriate for respirators with an exhalation valve cover that would have to be removed first.

Another on-the-spot fit check is to use a test substance to determine whether you can detect an odor, taste, or irritant. This fit check tests both the facepiece seal and whether a vapor-removing cartridge or canister is still working.

Loose-fitting respirators are powered air-purifying respirators that constantly pump air through a cartridge or canister into a loose-fitting helmet-like or hood-like head covering. The positive outward pressure caused by the steady outflow of air prevents contaminants from entering the headpiece. The purified air circulates over the user's head, face, and neck and provides some cooling.

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 an airflow rate of at least 6 cubic feet per minute.

Because loose-fitting respirators do not have to form a seal on your face, people with facial hair can use them safely. These respirators do not require extra lung power and are not nearly as tiring or as hot as face-sealing respirators.

Loose-fitting respirators are much more expensive than face-sealing respirators. In some situations, however, they are the only safe option. For example, you might have to use one if you have facial hair that prevents an adequate seal with the respirator facepiece.

In many situations, loose-fitting respirators are a good choice. For example, you might choose to use one:

- to avoid the need for fit tests and fit checks
- if you will be exposed to pesticides for several hours at a time
- if you are working in situations where heat stress is a concern

Personal Protective Equipment for Handling Fumigants

Fumigants are pesticides that are applied as a gas or that readily form a gas when they are applied. Their pesticidal action is in the gaseous form. Fumigants are very highly toxic to plants and animals, including humans. Use extreme caution and wear appropriate personal protective equipment whenever you handle fumigants. Personal protective equipment requirements for protection from fumigants are often very different from the requirements for other types of pesticides. **Follow labeling directions for each fumigant exactly.**

- You must wear the respirator listed on the fumigant labeling during any handling activity, including removing tarps or other coverings when exposure to the gas is likely. Inhaling even small amounts of some fumigant gases can be fatal or cause severe injury.

- Never work alone with fumigants, especially in enclosed areas. Arrange to be monitored at all times by another handler who has immediate access to an appropriate respirator in case rescue is needed.

- Use an air-supplying respirator while handling a fumigant indoors or in any enclosed area. In enclosed areas such as greenhouses, bins, vaults, and chambers there may not be enough oxygen for you to breathe. Cartridge and

canister respirators will not protect you in these situations.

Some fumigants readily penetrate plastic, rubber, and leather. These fumigants may be trapped **inside** gloves, boots, or tight-fitting coveralls and cause severe skin irritation or lead to poisoning through skin absorption. The labels on these fumigants will tell you the appropriate personal protective equipment to wear while handling them. Such labels often will tell you to wear loose-fitting clothes and "breathable" footwear such as canvas or other fabric. The labels may tell you not to wear any gloves or to wear cotton or other absorbent gloves.

Disposables and Reusables

Personal protective equipment items either should be disposable or should be easy to clean and sturdy enough for repeated use.

Disposables

Disposable personal protective equipment items are not designed to be cleaned and reused. Discard them when they become contaminated with pesticides.

Chemical-resistant gloves, footwear, and aprons that are 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 flexibility and will not tear the thin plastic.

Nonwoven (including coated nonwoven) coveralls and hoods usually are designed to be disposed of after use. Most are intended to be worn for only one workday's exposure period. The instructions with some coated nonwoven suits and hoods may permit you to wear them more than once if each period of use is short and they do not get much pesticide on them. Be especially alert when reusing these items, and be ready to change them whenever there are signs that pesticides could be getting through the material or that 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, and they should be replaced often.

Reusables

Some personal protective equipment that you buy may be designed to be cleaned and reused several times. However, do not make the mistake of reusing these items when they are no longer protecting you.

Rubber and plastic suits, gloves, boots, aprons, capes, and headgear often are designed to be cleaned and reused, but even these reusables should be replaced often. Wash them thoroughly between uses. Before you put them on, inspect reused items carefully for signs of wear or abrasion. If they show **any** sign of wear, throw them out. Check for rips and leaks during cleaning by using the rinse water to form a "balloon" or by holding the items up to the light.

Even if you can see no signs of wear, replace reusable chemical-resistant items regularly. The ability of chemical-resistant materials to resist the pesticide decreases each time the items are worn and after repeated exposure to pesticides.

A good rule of thumb is to throw out gloves that have been worn for about 5 to 7 days of work. Extra-heavy-duty gloves, such as those made of butyl or nitrile rubber, may last as long as 10 to 14

days. Because hand protection is the most important concern for pesticide handlers, make glove replacement a high priority.

Fabric coveralls are designed to be cleaned after each day's use and reused. However, absorbent materials such as cotton, polyester, cotton blends, denim, and canvas cannot be cleaned adequately after they are drenched or thoroughly contaminated with concentrated pesticides labeled with the signal word "DANGER" or "WARNING." **Always** discard any such clothing or footwear. They cannot be safely reused.

Most protective eyewear and respirator bodies, facepieces, and helmets are designed to be cleaned and reused. These items may last many years if they are good quality and are maintained correctly.

Maintaining Personal Protective Equipment

When you finish an activity where you are handling pesticides or are exposed to them, remove your personal protective equipment immediately after the activity is completed. Wash the outside of your gloves with detergent and water **before** you remove them. Also consider washing the outside of other chemical-resistant items before you remove them. This helps you avoid contacting the contaminated part of the items while you are removing them and helps keep the inside surface uncontaminated. If any other clothes have pesticides on them, change them also. Determine whether the items should be disposed of or cleaned for reuse.

- Place reusable items in a plastic bag or hamper away from your other personal clothes and away from the family laundry, and place disposables in a separate plastic bag or container. Pesticide contaminated PPE could injure persons who touch them.
- Do not allow children or pets near your personal protective equipment, work clothing, and other work items.
- Do not allow contaminated gloves, boots, respirators, or other equipment to be washed in streams, ponds, or other bodies of water.
- Clean *all* reusable personal protective equipment items between uses.

Even if reusables were worn for only a brief period of exposure to pesticides during that day, wash them before you wear them again. Pesticide residues that remain on the personal protective equipment are likely to continue to move slowly through the personal protective equipment material, even chemical-resistant material. If you wear that personal protective equipment again, pesticide may already be on the inside next to your skin. Also, personal protective equipment that is worn several times between laundering 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.

Washing Personal Protective Equipment

Wash pesticide-contaminated items separately from uncontaminated clothing and laundry. Otherwise, the pesticide residues can be transferred onto the other clothing or laundry and can harm you or your family.

Alert the Persons Who Do the Washing

Be sure that the people who clean and maintain your personal protective equipment and other work clothes know that they can be harmed by touching the pesticide that remains on the contaminated items. Tell them that they should:

- wear gloves and an apron, especially if handling contaminated items regularly or handling items contaminated with highly toxic pesticides
- work in a well-ventilated area, if possible, and avoid inhaling steam from the washer or dryer

Washing Procedure

Follow the manufacturer's instructions for cleaning chemical-resistant items. If the manufacturer instructs you to wash the item but gives no detailed instructions, or offers no cleaning instructions at all, follow the procedure below. Some chemical-resistant items that are not flat, such as gloves, footwear, and coveralls, must be washed twice—once to thoroughly 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. They should be dried and aired as directed below.

The best procedure for washing non-chemical-resistant items, such as cotton, cotton/polyester, denim, canvas, and other absorbent materials, and most chemical-resistant items is:

- **rinse** in a washing machine or by hand (wear gloves)
- **wash only a few items at a time** so there will be plenty of agitation and water for dilution
- **wash in a washing machine**, using a heavy-duty liquid detergent and hot water for the wash cycle
- **rinse twice** using two entire rinse cycles and warm water
- **use two entire machine cycles** to wash items that are moderately to heavily contaminated
- **run the washer through at least one additional entire cycle** without clothing, using detergent and hot water, to clean the machine after each batch of pesticide-contaminated items, and before any other laundry is washed

Drying Procedure

Hang the 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, remaining pesticide residues evaporate or breakdown. You may wish to buy two or more sets of equipment at a time so you can leave one set airing in a clean place while you are using the other set. Due to the danger of exposure, do not hang items in enclosed living areas.

Using a clothes dryer is acceptable for fabric items, if it is not possible to hang them to dry. However, over a period of time, the dryer has the potential to become contaminated with pesticide residues.

Maintaining Eyewear and Respirators

Wash goggles, face shields, shielded safety glasses, and respirator bodies and facepieces after each day of use. Use a detergent and hot water to wash them thoroughly. Sanitize them by soaking for at least 2 minutes in a mixture of 2 tablespoons of chlorine bleach in a gallon of hot water. Rinse thoroughly to remove the detergent and bleach. Dry thoroughly or hang them in a clean area to dry.

Pay particular attention to the headbands. Headbands made of absorbent materials should be replaced with chemical-resistant headbands. After each day of use, inspect all headbands for signs of wear or deterioration and replace 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 zip-closable sturdy plastic bag works well for storage.

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

If you remove your respirator between handling activities:

- wipe the respirator body and facepiece with a clean cloth
- replace caps, if available, over cartridges, canisters, and prefilters
- seal the entire respirator in a sturdy, airtight container, such as a zip-closable plastic bag. If you do not seal the respirator immediately after each use, the disposable parts will have to be replaced more often. Seal cartridges, canisters, prefilters, and filters in a separate bag. They will continue to collect impurities as long as they are exposed to the air

At the end of any work day in which you have worn a reusable respirator:

- remove the filter or prefilter. Most filters should be discarded. A few are designed to be washed and reused
- take off the cartridges or canisters. Discard them or, if still usable, replace their caps and seal them in an airtight container, such as a zip-closable plastic bag
- clean and store respirator as directed above

Discard disposable respirators according to manufacturer's instructions. Do not try to clean them.

INTERPRETING LABELING PPE STATEMENTS

Labeling Statement	Acceptable PPE
Long-sleeved shirt and long-legged pants	Long-sleeved shirt and long-legged pants, or Woven or nonwoven coverall, or Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Coverall worn over short-sleeved shirt and pants	Coverall worn over short-sleeved shirt and short pants, or Coverall worn over long-sleeved shirt and long-legged pants, or Coverall worn over another coverall, or Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Coverall worn over long-sleeved shirt and long-legged pants	Coverall worn over long-sleeved shirt and long-legged pants Coverall worn over another coverall, or Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Chemical-resistant apron worn over coverall or over long-sleeved shirt and long-legged pants	Chemical-resistant apron worn over coverall or over long-sleeved shirt and long-legged pants, or long-sleeved shirt and long-legged pants Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Chemical-resistant protective suit	Plastic- or other barrier-coated coveralls, or Rubber or plastic suit
Waterproof suit or liquid-proof suit	Plastic- or other barrier-coated coveralls, or Rubber suit or plastic suit
Waterproof gloves to remain intact throughout the task being performed	Any rubber or plastic gloves sturdy enough
Chemical-resistant gloves	Barrier-laminate gloves, or Other gloves that glove selection charts or guidance documents indicate are chemical-

	resistant to the pesticide for the period of time required to perform the task
Chemical-resistant gloves such as butyl or nitrile	Butryl gloves, or Nitrile gloves, or Other gloves that glove selection charts or guidance documents indicate are chemical-resistant to the pesticide for the period of time required to perform the task
Shoes	Chemical-resistant shoes, or Chemical-resistant boots, or Chemical-resistant shoe coverings (booties)
Chemical-resistant footwear	Chemical-resistant shoes, or Chemical-resistant boots, or Chemical-resistant shoe coverings (booties)
Chemical-resistant boots	Chemical-resistant boots
Chemical-resistant hood or wide-brimmed hat	Rubber- or plastic-coated safari-style hat, or Rubber- or plastic-coated firefighter-style hat, or Plastic- or other barrier-coated hood, or Rubber or plastic hood, or Full hood or helmet that is part of some respirators
Protective eyewear	Shielded safety glasses, or Face shield, or Goggles, or Full-face style respirator
Goggles	Goggles, or Full-face style respirator
Dust/mist filtering respirator	Dust/mist respirator, or Respirator with dust/mist filtering cartridge, or Respirator with organic vapor-removing cartridge and pesticide prefilter, or Respirator with canister approved for pesticides, or Air-supplying respirator

Cartridge respirator	Respirator with organic vapor-removing cartridge and pesticide prefilter, or Respirator with canister approved for pesticides, or Air-supplying respirator
Canister respirator (gas mask)	Respirator with canister approved for pesticides, or Air-supplying respirator
Air-supplying respirator or Self-contained breathing apparatus (SCBA)	Air-supplying respirator or Self-contained breathing apparatus (SCBA)

VII. How Carbamates and Organophosphate Affect the Nervous System

Carbamate and organophosphate insecticides kill pests by interrupting certain complex chemical reactions in their nervous systems by inhibiting the cholinesterase in their bodies. Certain nerve-related poisoning symptoms can also appear in people after repeated or intense contact with these pesticides.

The nervous system (including the brain) in humans and animals is made up of numerous cells that act as a huge communication network for transmitting messages or stimuli as electrical impulses throughout the body. Between the individual nerve cells are gaps, or **synapses**; when an impulse arrives at such a gap, it is carried across to the next cell by a chemical called **acetylcholine**. Once the stimulus is across the synapse, this acetylcholine carrier is broken down by the enzyme **cholinesterase**. The cholinesterase itself breaks down and the synapse returns to a normal condition, ready again to pick up a stimulus.

If a carbamate or organophosphate insecticide is inhibiting the cholinesterase enzyme, an overload of acetylcholine builds up; the stimuli keep jumping the synapse, causing continuous muscle contractions or tremors. The end result is nervous system poisoning, and possible death, for insects and humans.

VIII. Cholinesterase Testing

Cholinesterase is an enzyme that is vital for your nervous system to function properly. If you frequently handle carbamate and/or organophosphate pesticides, you may wish to set up a regular cholinesterase-testing program with your doctor. The first step will be to test for your current level of cholinesterase. The test should be done twice during a period with no exposure to pesticides so that an average baseline can be determined. Once

these tests establish a baseline reading, simple periodic blood tests, as prescribed by the physician, will show whenever the amount falls below that level. If you register a depressed level, you may have been overexposed to carbamates or organophosphate and should avoid further contact until your cholinesterase returns to the baseline. If you are an applicator working with highly toxic carbamate and/or organophosphate chemicals, have your cholinesterase level tested at regular intervals during the spray season to check for possible overexposure.

IX. Available Antidotes

The antidotes **atropine** and **2-PAM** can be given by a physician, or on the advice of the Poison Control Center, to restore the cholinesterase to normal. Because both these antidotes affect the nervous system and the heart, **NEVER** ***administer them without medical instruction.***

Avoiding Heat Stress

Several factors work together to cause heat stress. Before you begin a pesticide-handling task, think about whether any of the factors listed below are likely to present a problem

- heat factors—temperature, humidity, air movement, and sunlight
- workload
- personal protective equipment
- water
- scheduling adjustments

Consider what adjustments you may need to make in the task itself or in the workplace conditions, including:

Heat Factors and Workload

High temperatures, high humidity, and direct sunlight increase the likelihood that heat stress will occur. Air currents provide a cooling effect. Because hard work causes the body to produce heat, you are more likely to develop heat-related illness when you are working on foot than when you are driving a vehicle or flying an aircraft. You are even more likely to become overheated while lifting or carrying heavy containers or equipment.

- Use fans and ventilation systems and provide shade whenever possible to reduce the heat.
- Allow time for adjustment to the heat factors and workload. People who have become used to working in the heat are less likely to be affected by heat stress.
- Schedule frequent breaks when the heat stress risk is high.

Personal Protective Equipment

Pesticide-handling tasks often require that you wear extra layers of clothing or chemical-resistant suits and other protective equipment. This equipment keeps pesticides from getting on the skin, but it also interferes with the natural body cooling that happens when sweat evaporates from the skin. You can get overheated very quickly when you are wearing personal protective equipment.

- Choose personal protective equipment designed to be as cool as possible or to provide a cooling effect, such as a powered air-purifying respirator or, when appropriate, back-vented coveralls.
- Try not to schedule pesticide applications during the hottest part of the day. Use this time for nonchemical control strategies, and other activities not requiring extra layers of protective clothing.

- Respirators and filters can reduce air flow, speeding up the effects of heat stress.

Water

Evaporation of sweat from the skin helps to cool the body and maintain a constant core temperature. Under the conditions that may lead to heat stress, the body produces a large amount of sweat. Unless the water that is lost in sweat is replaced, the body can no longer regulate its temperature correctly. Under conditions of high temperature, strong air currents, heavy workload, or direct sunlight, a loss of as much as 1 gallon of water per hour is possible.

- Make every effort to drink plenty of water or "sports drinks" during heat stress conditions. Do not rely on a feeling of thirst to tell you whether your body has enough water. You can lose a dangerous amount of water even before you begin to feel thirsty. You also may stop feeling thirsty long before you drink enough fluids to replace what you have lost.
- Drink plenty of water before and after work.

Scheduling Adjustments

By taking the above steps, you will prevent most heat stress problems. But you must be ready for times when, regardless of your efforts, you or the handlers you supervise get dangerously hot. When this happens, you must:

- adjust work/rest cycles—decrease the length of work periods and increase the length of rest periods
- try to schedule tasks requiring the heaviest workload or the most personal protective equipment during the coolest part of the work day
- stop work—under extremely hot conditions; you may need to stop work until conditions improve

Signs and Symptoms of Heat Stress

Mild forms of heat stress will make you feel ill and impair your ability to do a good job. You may get tired sooner, feel weak, be less alert, and be less able to use good judgment. Severe heat stress is a serious illness. Unless victims are cooled down quickly, they can die. Severe heat stress is fatal to more than 10% of its victims, even young, healthy adults. Many who survive suffer permanent damage. Sometimes the victims remain highly sensitive to heat for months and are unable to return to the same work.

Learn the signs and symptoms of heat stress and take immediate action to cool down if you suspect you may be suffering from even mild heat stress. Signs and symptoms may include:

- fatigue (exhaustion, muscle weakness)
- headache, nausea, and chills
- dizziness and fainting
- severe thirst and dry mouth
- clammy skin or hot, dry skin
- heavy sweating or complete lack of sweating
- altered behavior (confusion, slurred speech, quarrelsome or irrational attitude)

First Aid for Heat Stress

It is not always easy to tell the difference between heat stress illness and pesticide poisoning. The signs and symptoms are similar. Don't waste time trying to decide what is causing the illness. Get medical help.

First aid measures for heat stress victims are similar to those for persons who are overexposed to pesticides:

- Get the victim into a shaded or cool area
- Carefully remove all personal protective equipment and any other clothing that may be making the victim too warm

- Cool victim as rapidly as possible by sponging or splashing skin, especially face, neck, hands, and forearms, with cool water or, when possible, immersing in cool water
- Have the victim, if conscious, drink as much cool water as possible
- Keep the victim quiet until help arrives

Severe heat stress or heat stroke is a medical emergency! Brain damage and death may result if treatment is delayed.

X. Worker Protection Standard and Reentry Times

The Worker Protection Standard (WPS) is legislation issued by the U.S. Environmental Protection Agency. It covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries, and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use such pesticides, or (2) employ workers or pesticide handlers who are exposed to such pesticides. The WPS applies to you:

- If you own or manage a farm, forest nursery, or greenhouse where pesticides are used in the production of agricultural plants
- If you hire or contract for the services of agricultural workers to do tasks related to the production of agricultural plants
- If you operate a business in which you (or people you employ) apply pesticides used for the production of agricultural plants on any farm, forest, nursery, or greenhouse
- If you operate a business in which you (or people you employ) perform task as a crop advisor

If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide to your employees and, in some cases, to yourself and to others:

- information about exposure to pesticides, including pesticide safety training for workers and handlers, a pesticide safety poster to be displayed for workers and handlers, access to labeling information, and access to specific information that is centrally located giving the application list of pesticide treatments on the premises.

- protection against pesticide exposure; employers are required to prohibit handlers from applying a pesticide in a way that will expose workers or other persons, exclude workers from areas being treated with pesticides, exclude workers from areas that remain under a restricted-entry interval (REI), protect early-entry workers, notify workers about treated areas, and protect handlers during handling tasks.

- ways to reduce exposure to pesticides. These include decontamination sites with ample water, soap and towels, and emergency assistance, as well as making transportation available to a medical care facility if there is pesticide-related injury or poisoning.

During a **restricted-entry interval (REI)**, workers are not allowed to enter a treated area or contact anything treated with the pesticide to which the REI applies. Specific product labels show the required number of hours that must pass before an unprotected person may safely enter the treated area. Always keep in mind that no one should enter a treated site without the proper protective clothing until all applied pesticides have completely dried or dusts have settled.

XI. Transportation, Disposal, Storage, Decontamination, and Spills

Introduction

When you transport, store, or dispose of pesticides and their containers, you must take safety precautions. You can prevent many pesticide accidents, and reduce the severity of others, if you are prepared before you start these tasks. Before you begin any pesticide-handling task, know what to do in case of spills and have the proper spill cleanup equipment on hand.

Pesticide Transportation

You are responsible for the safe transport of pesticides in your possession. Carelessness in transporting pesticides can result in broken containers, spills, environmental contamination, and harm to yourself and others. Accidents can occur even when you are transporting materials a short distance. Do all you can to prevent a mishap, but be prepared in case of emergency. Before transporting pesticides, you should know what to do if a spill occurs. If any pesticide is spilled in or from the vehicle, take action right away to make sure the spill is cleaned up correctly.

Vehicle Safety

The safest way to transport pesticides is in the back of a truck. Flatbed trucks should have side and tail racks. Steel or plastic-lined beds are best, because they can be more easily cleaned if a spill occurs.

Keep the following guidelines in mind:

- **Never** carry pesticides in the passenger section of any vehicle. Hazardous vapors may be released and make the driver and other passengers ill. Pesticides may cause illness or injury if they spill on you or your passengers. It is nearly impossible to completely remove spills from the fabric of seats and floor mats. They can cause future contamination if they are not cleaned up correctly.

- **Never** allow children, other passengers, and pets to ride with pesticides.

- **Never** transport pesticides with food, clothing, or other things meant to be eaten by or in contact with people or animals. The risk of contamination is too high. Even small amounts of pesticide could contaminate these highly sensitive items. A spill could cause major injury.

- **Never** leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are responsible and liable if curious children or careless adults are accidentally poisoned by the pesticides. Whenever possible, transport pesticides in a locked compartment.

- **Transport** highly volatile pesticides in **separate** trips from other chemicals. Spills, or even fumes from opened containers, can make the other chemicals worthless.

Transporting Pesticide Containers

Every time you transport pesticides, follow these six basic procedures:

1. Transport pesticides only in containers with intact, undamaged, and readable labels

2. Inspect containers before loading to be sure that all caps, plugs, and other openings are tightly closed and that there are no pesticides on the outside of the containers

3. Handle containers carefully to avoid rips or punctures

4. Anchor all containers securely to keep them from rolling or sliding. Packing or shipping containers provide extra cushioning

5. Protect paper and cardboard containers from moisture, because they become soggy and split easily when wet

6. Protect pesticides from extreme temperatures during transport. Extremely hot or cold temperatures can damage pesticide containers by causing them to melt or become brittle. Such temperatures also may reduce the usefulness of the pesticides

7. Carry safety equipment with you at all times

Labeling Statements About Transportation

Typical pesticide labeling instructions about transportation include:

> **DO NOT SHIP WITH FOOD, FEEDS, DRUGS, OR CLOTHING.**
>
> **DO NOT TRANSPORT DAMAGED OR LEAKING CONTAINER.**
>
> **IN CASE OF A TRANSPORTATION EMERGENCY INVOLVING A SPILL, FIRE, OR EXPOSURE, CALL [TELEPHONE NUMBER] 24 HOURS A DAY.**
>
> **DO NOT TRANSPORT IN OR ON VEHICLES CONTAINING FOODSTUFFS OR FEEDS.**

Pesticide Storage

Many pesticide handlers use existing buildings or areas within existing buildings for pesticide storage. However, if large amounts of pesticides will be stored, it is best to build a special storage building just for pesticide needs. It is suggested that, as pesticides are received and stored, they be dated on the container for future reference.

Establish a Storage Site

A correctly designed and maintained pesticide storage site:

- protects people and animals from accidental exposure
- protects the environment from accidental contamination
- prevents damage to pesticides from temperature extremes and excess moisture
- protects the pesticides from theft, vandalism, and unauthorized use
- reduces the likelihood of liability

Secure the Site

Keeping out unauthorized people is an important function of the storage site. Whether the storage site is as small as a cabinet or closet or as large as an entire room or building, keep it securely locked. Post signs on doors and windows to alert people that pesticides are stored there. Post **NO SMOKING** warnings.

Prevent Water Damage

Choose a storage site where water damage is unlikely to occur. Water from burst pipes, spills, overflows, excess rain or irrigation, or flooding streams can damage pesticide containers and pesticides. Water or excess moisture can cause:

- metal containers to rust
- paper and cardboard containers to split or crumble
- pesticide labeling to peel, smear, run, or otherwise become unreadable

- dry pesticides to clump, degrade, or dissolve
- slow-release products to release their pesticide
- pesticides to move from the storage site into other areas

If the storage site is not protected from the weather, or if it tends to be damp, consider placing metal, cardboard, and paper containers in sturdy plastic bags or cans for protection. Large metal containers, which may rust when damp, often can be placed on pallets within the storage site.

Control the Temperature

The storage site should be indoors, whenever possible. Choose a cool, well-ventilated room or building that is insulated or temperature-controlled to prevent freezing or overheating. The pesticide labeling may tell you at what temperatures the product should be stored. Freezing temperatures can cause glass, metal, and plastic containers to break. Excessive heat can cause plastic containers to melt, some glass containers to explode, and some pesticides to volatilize and drift away from the storage site. Temperature extremes can destroy the potency of some pesticides.

Provide Adequate Lighting

The storage site should be well lighted. Pesticide handlers using the facility must be able to see well enough to:

- read pesticide container labeling
- notice whether containers are leaking, corroding, or otherwise disintegrating
- clean up spills or leaks completely

Use Nonporous Materials

The floor of the storage site should be made of sealed cement, glazed ceramic tile, no-wax sheet flooring, or other easily cleaned material. Carpeting, wood, soil, and other absorbent floors are difficult or impossible to decontaminate in case of a leak or spill. For ease of cleanup, shelving and pallets should be made of nonabsorbent materials such as plastic or metal. If wood or fiberboard materials are used, they should be coated or covered with plastic or polyurethane or epoxy paint.

Provide Clean Water

Each storage site must have an immediate supply of clean water. Potable running water is ideal. If running water is not practical, use a carboy or other large sealable container with clean water. Changing the water in a container at least once each week will ensure that it remains safe for use on skin and eyes. Keep an eyewash dispenser immediately available for emergencies.

Prevent Runoff

Inspect the storage site to determine the likely path of pesticides in case of spills, leaks, drainage of equipment wash water, and heavy pesticide runoff from fire fighting or floods. Pesticide movement away from the storage site could contaminate sensitive areas, including surface water or groundwater. If your storage site contains large amounts of pesticides, you may need to use a collection pad to contain pesticide runoff.

Maintain the Storage Site

Know Your Inventory

Keep an up-to-date inventory logbook of the pesticides you have in storage. Each time a pesticide is added to or removed from the storage site, update the inventory list. The list will help you keep track of your stock and will be essential in a fire or flood emergency. The inventory list also will aid in insurance settlements and in estimating future

pesticide needs. Make sure the logbook is stored in a separate facility, and not with the pesticides themselves.

Do not store unnecessarily large quantities of pesticides for long periods of time. Buy only as much as you will need for a year at most. Pests, pesticides, or pesticide registrations may change by the next year and make the pesticides useless. Some pesticides have a relatively short shelf life and cannot be carried over from year to year.

Prevent Contamination

Store only pesticides, pesticide containers, pesticide equipment, and a spill cleanup kit at the storage site. Do not keep food, drinks, tobacco, feed, medical or veterinary supplies or medication, seeds, clothing, or personal protective equipment (other than personal protective equipment necessary for emergency response) at the site. These could be contaminated by vapors, dusts, or spills and could cause accidental exposure to people or animals.

Keep Labels Legible

Store pesticide containers with the label in plain sight. Costly errors can result if the wrong pesticide is chosen by mistake. Labels should always be legible. They may be damaged or destroyed by exposure to moisture, dripping pesticide, diluents, or dirt. You can use transparent tape or a coating of lacquer or polyurethane to protect the label. If the label is destroyed or damaged, request a replacement from the pesticide dealer or the pesticide formulator immediately.

Keep Containers Closed

Keep pesticide containers securely closed whenever they are being stored. Tightly closed containers help protect against:

- spills
- cross-contamination with other stored products
- evaporation of liquid pesticides or the solvent
- clumping or caking of dry pesticides in humid conditions
- dust, dirt, and other contaminants getting into the pesticide, causing it to be unusable

Use Original Containers

Store pesticides in their original containers. Never put pesticides in containers that might cause children and other people to mistake them for food or drink. You are legally responsible if someone or something is injured by pesticides you have placed in unlabeled or unsuitable containers.

Watch for Damage

Inspect containers regularly for tears, splits, breaks, leaks, rust, or corrosion. When a container is damaged, put on appropriate personal protective equipment and take immediate action. If the damaged container is an aerosol can or fumigant tank that contains pesticides under pressure, use special care to avoid accidentally releasing the pesticide into the air. When a container is damaged:

- use the pesticide immediately at a site and rate allowed by the label, or
- transfer the pesticide into another pesticide container that originally held the same pesticide and has the same label still intact, or
- transfer the contents to a sturdy container that can be tightly closed. If possible, remove the label from the damaged container and attach it to the new container. Otherwise, temporarily mark the new container with the name, active ingredient (a.i.), sig-

nal word, and EPA registration number of the pesticide, and attach a copy of the label from the pesticide dealer or formulator (whose telephone number is usually on the label) as soon as possible, or

- place the entire damaged container and its contents into a suitable larger container. Immediately attach a copy of the label to this container. However, consider this last option carefully. Many times the label on the leaking container becomes illegible. The pesticide is useless and becomes a disposal problem unless you know the name and registration number and can get a copy of the label.

Store Volatile Products Separately

Volatile pesticides, such as some types of *2,4-D*, should be stored apart from other types of pesticides and other chemicals. A separate room is ideal. Vapors from opened containers of these pesticides can move into other nearby pesticides and chemicals and make them useless. The labeling of volatile herbicides, for instance, usually will direct you to store them separately from seeds, fertilizers, and other types of pesticides.

Isolate Waste Products

If you have pesticides and pesticide containers that are being held for disposal, store them in a special section of the storage site. Accidental use of pesticides meant for disposal can be a costly mistake. Clearly mark containers that have been triple rinsed or cleaned by an equivalent method because they are more easily disposed of than unrinsed containers.

Consider Shelf Life

Mark each pesticide container with the date of purchase before it is stored. Use older materials first. If the product has a shelf life listed in the labeling, the purchase date will indicate whether it is still usable. Excessive clumping, poor suspension, layering, or abnormal coloration may be indications that the pesticide has broken down. However, sometimes pesticide deterioration from age or poor storage conditions becomes obvious only after application. Poor pest control or damage to the treated surface can occur. If you have doubts about the shelf life of a pesticide, call the dealer or manufacturer for advice.

Labeling Statements about Storage

Typical pesticide labeling instructions about storage include:

STORE AT TEMPERATURES ABOVE 32ºF

DO NOT CONTAMINATE FEED, FOODSTUFFS, OR DRINKING WATER DURING STORAGE

STORE IN ORIGINAL CONTAINER ONLY

DO NOT STORE NEAR IGNITION SOURCES SUCH AS ELECTRICAL SPARKS, FLAMES, OR HEATED SURFACES

Pesticide Disposal

Pesticide users are responsible for correctly dealing with empty pesticide containers, excess usable pesticides, and waste materials that contain pesticides or their residues. There is growing concern about the serious harm to humans and the environment that incorrect disposal of pesticide wastes can cause.

Excess Pesticides

The best solution to the problem of what to do with excess pesticides is to take steps to avoid having them:

- buy only the amount needed for a year or a season
- calculate carefully how much diluted pesticide is needed for a job and mix only that amount
- use all the mixed pesticide in accordance with labeling instructions

If you have excess pesticides that are usable, first try to find a way to use them as directed on the label. The best option is to apply the pesticide on a site listed in the use directions on the pesticide label, under the following two conditions:

1. The total amount of pesticide active ingredient applied to the site, including all previous applications, must not exceed the rate and frequency allowed on the label
2. You must comply with other application instructions specified on the label

If you have pesticide products in their original containers that you cannot use, you may be able to find another pesticide applicator who can. Or you may be able to return them to a dealer, formulator, or manufacturer.

Most container rinsates should not become excess pesticides, because they can be added into the tank during the mixing process. You also may be able to add some rinsates from equipment cleaning, spill cleanup, and other activities to a tank mixture that contains the same pesticide, as long as doing so will not violate labeling instructions. Some rinsates will contain dirt, cleaning agents, or other substances that will make them unusable, however.

Pesticide Wastes

Excess pesticides and rinsates that cannot be used must be disposed of as wastes. Other pesticide wastes include such things as contaminated spill cleanup material and personal protective equipment items that cannot be cleaned and reused. Whenever possible, avoid creating pesticide wastes that require disposal.

Sometimes pesticide wastes can be disposed of in a landfill operating under an EPA, Arizona, tribal, or local permit for hazardous wastes. However, Arizona currently does not have a hazardous waste facility. Sanitary landfills are not suitable. Some regions have pesticide incinerators for disposing of pesticide wastes. Never burn, bury, or dump excess pesticides, and never dispose of them in a way that will contaminate public or private groundwater or surface water or sewage treatment facilities.

Pesticide wastes that cannot be disposed of right away should be marked to indicate the contents and then stored safely and correctly until disposal is possible.

Labeling Statements about Waste Disposal

Typical pesticide labeling instructions about disposal of pesticide wastes include:

> **DO NOT CONTAMINATE WATER BY DISPOSAL OF WASTES**
>
> **PESTICIDE WASTES ARE TOXIC. IMPROPER DISPOSAL OF EXCESS PESTICIDE IS A VIOLATION OF FEDERAL AND STATE LAW. IF THESE WASTES CANNOT BE DISPOSED OF BY USE ACCORDING TO LABEL INSTRUCTIONS, CONTACT THE ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY**

Containers

Try to avoid the need to dispose of pesticide containers as wastes. For example, you may be able to:

- use containers that are designed to be refilled by the pesticide dealer or the chemical company

- arrange to have the empty containers recycled or reconditioned
- use soluble packaging

If you have containers that you must dispose of, be sure to rinse them. Rinsed containers are easier to dispose of than unrinsed containers.

Refillable Containers

Some types of containers are designed to be refilled with pesticide repeatedly during their lifetime, which may be many years. They usually are not designed to be triple-rinsed or pressure-rinsed by the pesticide user. When necessary, they are cleaned by the pesticide dealer or chemical company before refilling. Common types of refillable containers include minibulks and small-volume returnables.

Recyclable and Reconditionable Containers

You may be able to take your rinsed metal or plastic containers to a facility that can recycle them. Some 55 gallon and 30 gallon drums can be returned to the dealer, manufacturer, or formulator to be reconditioned and reused.

Soluble Containers

Soluble containers are designed to be placed, unopened, into the mixing tank. The solvent (usually water) dissolves the container inside the tank. Only original outer packaging remains, and it may be disposed of as nonhazardous waste in a sanitary landfill.

Triple-rinsed or Pressure-Rinsed Containers

Containers that have been correctly triple-rinsed or pressure-rinsed usually may be disposed of as regular trash in a sanitary landfill, unless prohibited by the pesticide labeling. Mark the containers to show that they have been rinsed.

Unrinsed Containers

To dispose of unrinsed containers, you may take them to an incinerator or landfill operating under an EPA, state, or tribal permit for hazardous waste disposal. If this is not possible, check with the Arizona Department of Agriculture, tribal, or local authorities to find out what to do. Otherwise, you may need to store the containers until you have a safe and proper way to dispose of them.

Burnable Containers

The labeling of some paper, cardboard, and plastic containers may list "burning, if allowed by State and local authorities" as a disposal option for pesticide containers. However, open burning of pesticide containers and waste pesticides is a questionable practice and may be in violation of federal regulations that could take precedence over the instructions on the pesticide labeling. Because of possible air pollution hazards and the risks of liability, your best option is to use another disposal method for these containers. Check with county ordinances before attempting to burn.

Labeling Statements about Container Disposal

Typical pesticide labeling instructions about disposal of pesticide containers include:

> **DO NOT REUSE EMPTY CONTAINERS**
>
> **OFFER FOR RECYCLING OR RECONDITIONING, OR PUNCTURE AND DISPOSE OF IN A SANITARY LANDFILL, OR INCINERATE**
>
> **DISPOSE OF BAG IN A SANITARY LANDFILL OR BY INCINERATION**

Spill Management

A spill is any accidental release of a pesticide. As careful as people try to be, pesticide spills can and do occur. The spill may be minor, involving only a dribble from a container; or it may be major, involving large amounts of pesticide or pesticide-containing materials such as wash water, soil, and absorbents.

You must know how to respond correctly when a spill occurs. Stopping large leaks or spills is often not simple. If you cannot manage a spill by yourself, get help. Even a spill that appears to be minor can endanger you, other people, and the environment if not handled correctly. Never leave a spill unattended. When in doubt, call for assistance (e.g. **Chemtrec**).

The faster you can contain, absorb, and dispose of a spill, the less chance there is that it will cause harm. Clean up most spills immediately. Even minor dribbles or spills should be cleaned up immediately to keep unprotected persons or animals from being exposed. A good way to remember the steps for a spill emergency is the "three **Cs**: **Control, Contain, Clean up**.

C1: Control the Spill Situation

Protect Yourself

Put on appropriate personal protective equipment before contacting the spill or breathing its fumes. If you do not know how toxic the pesticide is or what type of personal protective equipment to wear, don't take a chance! Wear foil-laminate apron, footwear, and gloves; eye protection; and a respirator.

Stop the Source

If a small container is leaking, place it into a larger chemical-resistant container, such as a plastic drum or bag. If a spray tank is overflowing, stop the inflow and try to cap off the tank. If a tank, hopper, or container has burst or has tipped over and is too heavy to be righted, you will not be able to stop the source.

Protect Others

Isolate the spill site by keeping children, other unprotected people, and animals well back. Rope off the site if necessary. If you suspect the spill contains a highly volatile or explosive pesticide, you may need to keep people back even farther. Warn people to keep out of reach of any drift or fumes. Do not use road flares or allow anyone to smoke if you suspect the leaking material is flammable.

Stay at the Site

Do not leave the spill site until another knowledgeable and correctly protected person arrives. Someone should be at the spill site at all times until the spill is cleaned up.

C2: Contain the Spill

Confine the Spill

As soon as the source of the leak is under control, move quickly to keep the spill in as small an area as possible. Do everything you can to keep it from spreading or getting worse. For small spills, use containment snakes to surround the spill and keep it confined. For larger spills, use a shovel, a rake, or other tool or equipment to make a dike of soil, sod, or absorbent material.

Protect Water Sources

Keep the spill out of any body of water or any pathway that will lead to water, such as a ditch, floor drain, well, or sinkhole. If the spilled pesticide is flowing toward such an area, block or redirect it.

Absorb Liquids

Liquid pesticide spills can be further contained by covering the entire spill site with absorbent materials, such as spill pillows, fine sand, vermiculite, sawdust, clay, kitty litter, shredded newspaper, or absorbent pads.

Cover Dry Materials

Prevent dry, dusty pesticide spills, such as dusts, powders, or granules, from becoming airborne by covering them with a sweeping compound or a plastic covering or by very lightly misting the material with water. Do not mist too much, because water may release the pesticidal action or may cause the pesticide to form clumps and be unusable.

> **WARNING**: Pesticides that are **oxidizers**, such as calcium hypochlorite (a common sanitizer) and some herbicides and desiccants that contain chlorites, should **not** be contained with sawdust, shredded paper, or sweeping compounds. These absorbent compounds combine with the oxidizer to create a fire hazard and could burst into flame.

C3: Clean Up

After you have contained the spill, you must pick up the spilled material and decontaminate the spill site and any contaminated items or equipment.

Clean Up the Spill

For spilled liquid pesticides, sweep up the absorbent material containing the pesticide and place it into a heavy-duty plastic drum or bag. Keep adding the absorbent material until the spilled liquid is soaked up and removed.

Spills of dry pesticides should be swept up for reuse if possible. Avoid contaminating the spilled materials with soil or other debris, so it can be used in the usual application equipment and will not clog the nozzles or hopper openings. However, if the dry spill has become wet or full of debris, it must be swept up and placed in a heavy-duty plastic drum or bag for disposal.

Decontaminate the Spill Site

Once you have collected as much of the spilled material as possible, decontaminate the spill site as well as you can. **Do not hose down the site with water** unless the spill is on a containment tray or pad.

If the surface on which the pesticide has spilled is nonporous, such as sealed concrete, glazed ceramic tile, or no-wax sheet flooring, use water (or the chemical listed on the label to dilute the pesticide) and a strong detergent to remove the residues of the spill from the surface. Do not allow any of the wash solution to run off the site being cleaned. Place fresh absorbent material over the wash solution until it is all soaked up. Then sweep up the absorbent material and place it in a plastic drum or bag for disposal as an excess pesticide.

If the surface upon which the pesticide has spilled is porous, such as soil or unsealed wood, you may have to remove the contaminated surface and dispose of it as an excess pesticide. Depending on the size of the spill and the toxicity of the pesticide, however, sometimes the site can be successfully neutralized.

Neutralize the Spill Site

The label of a few pesticides will instruct you to neutralize a spill of that pesticide. Sometimes an authority, such as the pesticide manufacturer or Chemtrec, will also instruct you to neutralize the spill site. Follow the instructions carefully.

Neutralizing a spill often consists of mixing full-strength bleach with hydrated lime and working this mixture into the spill site with a coarse broom. Fresh absorbent material is then spread over the spill site to soak up the neutralizing liquid. This material is swept up and placed in a plastic drum or bag for disposal. You may be instructed to repeat the process several times to make sure that the site is thoroughly neutralized.

Soil is sometimes neutralized by removing and disposing of the top 2 to 3 inches and then neutralizing the remaining soil. You may be instructed to mix activated charcoal into the soil or to cover the spill site with 2 or more inches of lime and cover the lime with fresh topsoil.

Sometimes you may be instructed to cover minor spills with activated charcoal. The activated charcoal can adsorb or tie up enough pesticide to avoid adverse effects to plants and animals that come in contact with the soil in the future. However, activated charcoal is not effective for large spills.

Decontaminate Equipment

Clean any vehicles, equipment, and personal protective equipment that were contaminated by the spill or during the containment and cleanup process. Use a strong mixture of chlorine bleach, dishwasher detergent, and water to clean the vehicles and equipment. Wash personal protective equipment thoroughly, following manufacturers' instructions and the guidelines in the personal protective equipment unit of this manual. Remember particularly that porous materials, such as brooms, leather shoes, and clothing, cannot be cleaned effectively if they are thoroughly saturated with pesticide. They should be discarded.

Decontaminate Yourself

As soon as you are finished with the spill and equipment cleanup, wash yourself thoroughly with detergent and water. Wash any part of your skin that might have been exposed, and always wash your face, neck, hands, and forearms.

Spill Follow-Up

For all large spills, and any spills that take place off your property, keep records of your containment and cleanup activities and your conversations with authorities and the public about the spill. Photographs help to document any damage as well as the cleanup process.

Spill Assistance

Chemtrec, the Chemical Transportation Emergency Center, is a public service of the Chemical Manufacturing Association. Located in Washington, D.C., Chemtrec is staffed 24 hours a day by competent, trained personnel who are able to advise you how to manage chemical emergencies (**1-800-424-9300**).

When you request help from Chemtrec or any other source, have the product label on hand. Many pesticide labels list an emergency telephone number that gives you direct access to the manufacturer and people who know how to manage emergencies for that product.

If the spill occurs on a highway or public road, call the Arizona Department of Public Safety immediately. Authorities are trained for such emergencies and will be able to assist you in your cleanup. Local and state authorities require that you notify them of a pesticide spill.

If the spill may expose the public to pesticides or pesticide residues, contact the Department of Public Safety. If anyone is poisoned by coming in contact with the spill or if you suspect that an exposure may lead to poisoning, call the hospital emergency room and provide them with the brand name, active ingredients, and any other labeling

information about human health hazards, signs and symptoms of poisoning, and antidotes.

Labeling Statements About Spill Management

Typical pesticide labeling instructions about spill procedures include:

> **IF CONTAINER IS BROKEN OR CONTENTS HAVE SPILLED, CLEAN UP IMMEDIATELY. BEFORE CLEANING UP, PUT ON FULL-LENGT TROUSERS, LONG-SLEEVED SHIRT, PROTECTIVE GLOVES, AND GOGGLES OR FACE SHIELD. SOAK UP SPILL WITH ABSORBENT MEDIA SUCH AS SAND, EARTH, OR OTHER SUITABLE MATERIAL AND DISPOSE OF WASTE AT AN APPROVED WASTE DISPOSAL FACILITY**
>
> **IF THE CONTAINER IS LEAKING OR MATERIAL IS SPILLED, CAREFULLY SWEEP MATERIAL INTO A PILE. REFER TO PRECAUTIONARY STATEMENTS ON LABEL FOR HAZARDS ASSOCIATED WITH THE HANDLING OF THIS MATERIAL. DO NOT WALK THROUGH SPILLED MATERIAL. KEEP UNAUTHORIZED PEOPLE AWAY.**

Spill Kit

Keep a spill cleanup kit immediately available whenever you handle pesticides or their containers. If a spill occurs, you will not have the time or the opportunity to find all of the items.

The kit should consist of

1. telephone numbers for emergency assistance
2. sturdy gloves, footwear, and apron that are chemical-resistant to most pesticides, such as foil-laminate gear
3. protective eyewear
4. appropriate respirator, if any of the pesticides require the use of one during handling activities or for spill cleanup
5. containment "snakes" to confine the leak or spill to a small area
6. absorbent materials, such as spill pillows, absorbent clay, sawdust, pet litter, activated charcoal, vermiculite, or paper to soak up liquid spills
7. sweeping compound to keep dry spills from drifting or wafting during cleanup
8. shovel, broom, and dustpan (foldable brooms and shovels are handy, because they can be carried easily)
9. heavy-duty detergent
10. fire extinguisher rated for all types of fires
11. any other spill cleanup items specified on the labeling of any products you use regularly
12. sturdy plastic container that will hold the quantity of pesticide from the largest pesticide container being handled and that can be tightly closed

All of these items can be stored in the plastic container and kept clean and in working order until a spill occurs.

EPA

The Environmental Protection Agency (EPA) regulates wastes under the Resource Conservation and Recovery Act (RCRA). EPA issues a list of materials that are considered hazardous. However, RCRA applies to certain flammable, corrosive, reactive, or toxic wastes, even if they are not on the list. Therefore, some other pesticides could be "regulated hazardous wastes" under RCRA. States and tribes often have their own hazardous waste laws, which may be more stringent than RCRA. Contact your state or tribal authority for applicable requirements.

"Wastes" include unrinsed containers, excess pesticides and pesticide dilutions, and rinse and wash water that contain a listed chemical and cannot be used. Triple-rinsed pesticide containers are not considered hazardous waste under RCRA, however. They can be disposed of in sanitary landfills.

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. Such users must register as a generator of hazardous waste, obtain an ID number from EPA, state, or tribe and follow certain disposal requirements.

To find out if a pesticide is listed in RCRA, call

EPA RCRA Hotline 1-800-424-9346
8:30 a.m.–7:30 p.m. EST
Monday through Friday

SARA (Title III)

If you are involved in a pesticide spill, you may need to comply with the provisions of two laws administered by the Environmental Protection Agency (EPA). Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) requires you to report any accidental release (such as a spill) of any extremely hazardous substance. Reporting is required if all the following occur:

- the pesticide was spilled
- the pesticide is covered under SARA Title III
- the spill quantity was greater than the "reportable quantity" specified in the law
- the spill created offsite exposure

If such an accident occurs, you must:

- notify the state emergency response commission (SERC)
- notify the local emergency planning committee (LEPC)
- report the release to the National Response Center (**1-800-424-8802**)

In addition, any spill that has the potential to get into groundwater or surface water must be reported to EPA under the authority of the Clean Water Act.

If you do not know whether the spill is large enough to be a "reportable quantity" under SARA Title III or whether the spill might get into groundwater or surface water, call your local, State, or tribal pesticide agency or the EPA regional office for help.

To get emergency help from Chemtrec (Chemical Transportation Emergency Center), call

1-800-424-9300 (24 hours a day)

XII. Pesticide Fire Hazards

Some common myths regarding pesticides and fires include the belief that inert ingredients in pesticides are not dangerous, and that pesticides are made less toxic by the high temperatures in a fire. *These are false.* The facts are that although pesticides such as wettable powders and water-based liquids are *usually* not flammable, when heat decomposes some powdered or liquid products, toxic gases may be released. Also, common solvents and diluents in liquid emulsion concentrates or petroleum solutions, such as xylene and kerosene, pose a fire hazard if stored or handled incorrectly. Such products are capable of igniting and fueling a fire.

Physical Hazards

A pesticide fire can produce fumes and vapors which may be highly toxic when inhaled. The combustion products of pesticides can be more toxic than the original product.

While skin absorption is a common route in pesticide poisoning, inhaling the vapors and fumes from a pesticide fire are more significant problems. One or two breaths of a concentrated smoke can cause serious and immediate problems. Massive exposure to a low toxicity pesticide can be as serious as a minor exposure to a highly toxic pesticide.

In addition, pesticide storage containers, often large metal drums, can explode in a fire. **Aerosols**, which are packaged in pressurized cans, are highly explosive when exposed to excessive heat or fire. **Pressurized containers**, such as those containing fumigants, release pressure through a relief valve when they are heated. If flames contact the cylinder, or if the regulator is broken, they can rupture and be propelled considerable distances by the ejection of toxic gas. These "rocketing" containers can cause serious physical injury. Never store these pressurized containers near heat sources such as steam pipes, heaters, or in direct sun.

Powdered sulfur is a flammable solid capable of an explosion. A pile of powdered sulfur will burn in an ever-increasing circle with little or no visible flame, producing highly toxic sulfur dioxde as a combustion product. In addition, if powdered materials form a dust cloud, the hazard for dermal and inhalation exposure is increased.

Environmental Hazards

Toxic gases, fumes, and vapor from a pesticide fire are capable of moving considerable distances, endangering people, animals, plants, nontarget insects, and water supplies. An added hazard is the runoff water used to control the fire. Pesticides can be carried in the runoff water, entering storm sewers, washes, drainage ways, irrigation ditches, and other surface waters. Damage to the local environment can become widespread.

Safety Measures

There are several things that can be done to minimize the danger of a pesticide fire:

- A well-planned storage facility is the first step in fire safety
- Store pesticides in a locked facility, with posted warning signs. Limit those having access. If possible, keep the storage facility away from other buildings
- Post "No Smoking" signs on the building. Do not allow smoking in or near the structure. Keep smoke detector at least 3 feet from the ventilator
- Design your storage facility with an impermeable floor and a concrete berm. This will contain any runoff water
- Do not store combustible material within 30 ft. of the storage structure
- Be sure floor drains lead to a sump or see that floor drains are sealed
- Do not store pesticides with fuels such as gas cans and propane tanks
- There should be no open flame of any size in a pesticide storage facility
- Do not perform metal cutting, welding, or grinding in the vicinity
- Do not burn anything within 100 feet of a storage facility
- Do not store ammonium nitrate fertilizers with

or near pesticides. In addition to the cross-contamination possibilities, ammonium nitrate releases large amounts of oxygen when it burns, adding fuel to a fire

- Ventilate or cool your storage facility to minimize heat buildup
- Be sure that electrical circuits meet the provisions of the National Electrical Code
- Use light fixtures that have an explosion proof UL rating. Locate all fuse boxes, breaker panels, and disconnects outside of the storage facility. If possible, install a warning light which activates in case of a fire
- Keep a fire extinguisher both inside and outside of the facility. These should have a 20-pound capacity, disperse dry chemical, and have an ABC rating

Good preparation includes knowing the fire hazard involved with the pesticides you commonly use and its flammability characteristics. Information about the flammability of a product is located under the chemical hazard section on the product label. MSDS sheets usually contain additional, detailed information on fire safety.

XIII. Poison Control Centers in Arizona

Good Samaritan Regional Poison Center
1130 E. MacDonald, Suite A5
Phoenix, AZ 85006
(800) 362-0101 or (602) 253-3334

Arizona Poison Control Center
1501 N. Campbell Ave.
Tucson, AZ 85724
(520) 626-6016

Chapter Five
Safety — Question and Answer Review

1. Q. What is the most common route of pesticide poisoning for applicators?

A. The most common cause of pesticide poisoning for applicators is through skin contact.

2. Q. Pesticides may enter the body in four different ways. Name them.

A. Pesticides may enter the body through skin contact (dermal), through inhalation, through the mouth (orally); or through eye contact (ocular).

3. Q. Name and define the two types of pesticide exposure.

A. Acute exposure causes severe immediate short-term health effects and chronic exposure.

4. Q. What does LD_{50} mean?

A. The lethal dose of a chemical for 50 percent of a test population occurs over a long time period. It is caused by many small, repeated exposures but may result in severe health effects.

5. Q. What are the LD_{50} numbers which correspond to the following signal words? Highly toxic? Moderately toxic? Slightly toxic?

A. Highly toxic pesticides carry an LD_{50} of 0+ to 50. Moderately toxic pesticides carry an LD_{50} of 50+ to 500. Slightly toxic pesticides have an LD_{50} from 500+ and greater.

6. Q. Are the symptoms of pesticide poisoning very different from all other types of poisoning?

A. No. Symptoms of pesticide poisoning are similar to those of other types of poisoning or other diseases, such as the flu.

7. Q. What are some symptoms of mild and acute or severe pesticide poisoning?

A. Mild pesticide poisoning symptoms include headaches, fatigue, soreness in joints, irritation of nose and throat. Acute poisoning symptoms include fever, intense thirst, vomiting, muscle twitches, pinpoint pupils, and unconsciousness.

8. Q. What is the very first thing you should do when someone has been poisoned?

A. Call an ambulance or doctor. If you are alone with the victim, you must see that he is breathing and that he is not further exposed to poison.

9. Q. What should you consider before using pesticides?

A. Before pesticides are applied, you should know the pest, extent of damage, weather conditions, conditions of the treatment area, plus take tilme to read the label and take all precautions.

10. Q. How should you clean your washing machine after laundering pesticide soiled clothing?

A. Run a complete, empty cycle. Use hot water and detergent.

11. Q. When you are planning to work with pesticides, where should you look for information on the protective clothing that is necessary?

A. On the pesticide label or the MSDA (Material Safety Data Sheet).

12. Q. What material should gloves and boots worn during pesticide handling be made of?

A. Both gloves and boots should be made of chemically resistant material.

13. Q. Name five ways of avoiding exposure while applying pesticides.

A. Wear protective gear during pesticide application.
Always use only the labeled amount of pesticide during your applications.
Do not work in drift spray, or runoff unless you are properly protected.
If chemicals spill on your gloves, be careful not to wipe your hands on your clothing.
Wash pesticide-soiled clothing with detergent and water.

14. Q. Name three ways to cut down accidents commonly caused by equipment.

A. Choose the safest equipment for your pesticide application.
Do not allow children or unauthorized people near the pesticide equipment.
Use your equipment correctly; calibrate often.
Take good care of your equipment.

15. Q. Explain what "reentry interval" means.

A. The **reentry interval** is the period of time that should pass between treatment and returning to a treatment area. Safe reentry intervals may be on the pesticide label. When no reentry times are available, always wait until sprays dry, dusts settle, and vapors disperse. If you must reenter an area soon after spraying, be sure to wear all the necessary protective clothing as required on the label.

16. Q. What should you do for an accidental pesticide spill?

A. Have some kind of absorptive material available. Have bleach or hydrated lime for decontamination. Keep soap detergent and water close at hand. Have a change of clothes available.

17. Q. Explain the terms *hazard, toxicity,* and *exposure,* and tell how they relate to one another.

A. *Hazard* is the risk of harmful effects from pesticides. *Toxicity* is a measure of the ability of a pesticide to cause harmful effects. *Exposure* is the total amount of pesticide that gets on or in the body. HAZARD = TOXICITY x EXPOSURE.

18. Q. Which route of exposure should you, as a pesticide handler, be most concerned about?

A. Exposure to the skin is the most common route of exposure for pesticide handlers.

19. Q. What three factors determine how much pesticide will be absorbed through your skin (and eyes) and into your body?

A. 1. The pesticide itself and the material used to dilute the pesticide.
2. Which area of the body is exposed.
3. The condition of the skin that is exposed.

20. Q. How can you avoid harmful effects from pesticides?

A. Avoiding and reducing exposures to pesticides will reduce the harmful effects from pesticides. You can avoid exposures by using safety systems, such as closed systems and enclosed cabs, and you can reduce exposures by wearing appropriate personal protective equipment, washing exposed areas often, and keeping your personal protective equipment clean and in good operating condition.

21. Q. What legal responsibility do you have for wearing the personal protective equipment that the pesticide labelling lists for your handling situation?

A. By law, you must wear **at least** the personal protective equipment listed on the label for the handling task you will be performing. You are allowed to wear additional or more protective personal protective equipment.

22. Q. Define the term *chemical resistant.*

A. *Chemical resistant* — Able to prevent movement of the pesticide through the material during the period of use.

23. Q. How can you tell when a material is not chemical-resistant to the pesticide you are handling?

A. The material may change color; become soft or spongy; swell or bubble up; dissolve or become like jelly; crack or get holes; become stiff or brittle.

24. Q. What factors determine how well your coverall will protect your body?

A. A coverall is most protective if it
1. fits loosely so there is a layer of air between it and the skin or inner clothing;
2. is worn over another layer of clothing, because each layer of clothing adds aprotective layer of air as well as a layer of fabric;
3. has tightly constructed seams and snug overlapping closures that do not gap or become unfas tened readily.

25. Q. When should you wear chemical-resistant gloves? Why are gloves so important to a pesticide handler?

A. Wear chemical-resistant gloves any time you may get pesticides on your hands, except for some fumigants whose labels may direct you *not* wear gloves. The hands are by far the most likely route of exposure for a pesticide handler.

26. Q. If you need to remove your gloves during the handling activity, what steps should you take to remove them and put them back on?

A. 1. Wash gloves thoroughly before taking them off.
2. Wash hands thoroughly and dry them before putting the gloves on again.

27. Q. Why do pesticides sometimes get on your skin even when you are wearing gloves and protective footwear?

A. The items may not be chemical-resistant to the pesticide being handled; they may not be worn correctly; they may not be in good condition; or they may not have been cleaned correctly or replaced soon enough.

28. Q. When should you wear protective headgear? What type of headgear should you use?

A. Whenever you may be exposed to pesticides from above, wear protective headgear to help keep pesticides off your head, neck, eyes, mouth, and face. Wear a chemical-resistant hood or wide-brimmed hat. Plastic "safari" hatw with plastic sweatbands are a good choice.

29. Q. When the pesticide labeling calls for "protective eyewear," what should you wear?

A. Wear goggles, a face shield, or safety glasses with brow and side shields.

30. Q. What are the differences among *dust/mist-filtering respirators, vapor-removing respirators,* and *air-supplying respirators*?

A. *Dust-mist-filtering respirators* are masks or cartridges that filter dust, mists, and particles out of the air around you. *Vapor-removing respirators* use a cartridge or canister to remove pesticide gases and vapors from the around around you. *Air-supplying respirators* provide you with clean air either from an air tank or from a location where the air is not contaminated with pesticides.

31. Q. What special hazards do fumigants pose for pesticide handlers?

A. Fumigants pose a serious inhalation hazard to pesticide handlers. Some fumigants also can cause severe skin burns if they are trapped next to the skin by tight clothing or chemical-resistant personal protective equipment.

32. Q. If the chemical-resistant gloves you have selected are reusable, how often should you routinely replace them? Under what conditions should you replace chemical-resistant items immediately?

A. Throw out most reusable gloves that have been worn for about 5 to 7 days of work. Extra-heavy-duty gloves, such as those made of butyl or nitrile rubber, may last as long as 10 to 14 days. Replace chemical-resistant items immediately if they show any sign of wear or have holes, tears, or leaks.

33. Q. What should you do with a coverall that has highly toxic pesticide concentrate spilled on it?

A. Dispose of the coverall. It cannot be adequately cleaned.

34. Q. What should you tell the people who will be laundering your clothing about how to protect themselves from pesticides?

A. Tell them to
1. wear chemical-resistant gloves and apron, especially if handling contaminated items regularly or handling items contaminated with highly toxic pesticides.
2. work in a well-ventilated area and do not inhale steam from the washer and dryer.

35. Q. What should you do with your respirator between handling tasks?

A. Seal the respirator in a clean, airtight container, such as a sturdy zip-closable plastic bag. If possible, put caps over the opening on the cartridges or canisters.

36. Q. What should you do when you are finished using your respirator for the day?

A. 1. Discard any masks, filters, or respirators that cannot be reused.

2. Take off the prefilters and cartridges or canisters. Discard them or, if still usable, replace their caps and seal them in an airtight container, such as a zip-closable plastic bag.
3. Wash the respirator body, facepiece, and any reusable filters. Soak them for at least 2 minutes in a mixture of 2 tablespoons of chlorine bleach in a gallon of hot water. Rinse thoroughly. Dry thoroughly or hang them in a clean area to dry.
4. Store the respirator and any reusable cartridges, canisters, filters, and prefilters in an airtight container in an area where they are protected from dust, sunlight, extreme temperatures, excessive moisture, and pesticides or other chemicals.

37. Q. How will you know when to replace dust/mist masks, prefilters, and dust-mist-filtering and vapor-removing canisters and cartridges?

A. 1. Change dust/mist masks, cartridges, and prefilters immediately if you have trouble breathing. They usually need to be changed at least every 8 hours.
2. Change vapor-removing canisters or cartridges immediately if you smell, taste, or feel irritation from pesticide vapors. Change them whenever any "service life indicator" tellsyou that you should, or after the time limit set by the manufacturer. Otherwise, replace them after about 8 hours of use.

38. Q. If heat stress is a concern, what five factors might you need to adjust?

A. 1. Heat factors.
2. Workload.
3. Personal protective equipment.
4. Amount of water consumed.
5. Work schedule.

39. Q. What precautions should you take when your transport pesticides in a vehicle?

A. 1. **Never** carry pesticides in the passenger section.
2. **Never** allow children, other passengers, and pets to ride with pesticides.
3. **Never** transport pesticides with food, clothing, or other things meant to be eaten or to come in contact with people or animals.
4. **Never** leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck.
5. **Transport** highly volatile pesticides in *separate* trips from other chemicals.

40. Q. What steps should you take to protect pesticide containers during transport?

A. 1. Transport containers with intact, undamaged, and readable labels.
2. Inspect containers to be sure that all openings are tightly closed and that there are no pesticides on the outside of the containers.
3. Handle containers carefully.

4. Anchor all containers securely.
5. Protect paper and cardboard containers from moisture.
6. Protect pesticides from extreme temperatures.

41. Q. What four types of persona protection, beyond what you need during application, should you consider wearing while mixing or loading pesticides?

A. 1. Front protection.
2. Face protection.
3. Protection from dusts.
4. Protection from vapors.

42. Q. What should you do with an empty pesticide container?

A. 1. If the container is rinsable, rinse it as soon as it is empty.
2. Return all empty pesticide containers to the pesticide storage area or the container holding area when you finish your task.
3. Puncture, break, or crush empty containers that cannot be refilled, reconditioned, recycled, or returned to the manufacturer.
4. Dispose of containers in accordance wilth labeling directions and with any laws or regulations that apply.

43. Q. When a pesticide container is damaged, what actions can you take?

A. 1. Use the pesticide immediately at a site and rate allowed by the labeling.
2. Transfer the pesticide into another pesticide container that originally held the same pesticide and has the same label still intact.
3. Transfer the contents to a sturdy container that can be tilghtly closed and fasten the label to the outside fo the new container.
4. Place the entire damaged container and its contents into a suitable larger container.

44. Q. If you have excess pesticide materials that are still usable, what can you do with them?

A. 1. Apply them to site listed on the labeling.
2. Find another pesticide handler who can legally use them.
3. Return them to the dealer, formulator, or manufacturer.

45. Q. If you have pesticide wastes (other than empty containers), what can you do with them?

A. Store until safe and proper disposal is possible. Arizona does not have a hazardous waste disposal site.

46. Q. List three ways to avoid the need for disposing of empty pesticide containers as wastes.

A. 1. Use refillable containers.
2. Recycle or recondition the containers.
3. Return them to the dealer, formulator, or manufacturer.

47. Q. What do the "three Cs" of spill management stand for?

A. "Control," "Contain," "Clean up."

48. Q. What should you do to control a spill situation?

A. 1. Protect yourself.
2. Stop the source of the spill.
3. Protect others.
4. Stay at the site.

49. Q. How should you contain a spill?

A. 1. Confine the spill.
2. Protect water sources.
3. Absorb liquids.
4. Cover dry materials.

CHAPTER 6:

CALIBRATION & MIXING

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I. Introduction

Chapter Objectives

By the time you finish this chapter, you will be able to:

- explain why it is important to apply the correct amount of pesticide;
- describe how to determine how much pesticide to apply;
- describe how to figure application rates;
- identify ways that application rates are expressed;
- explain why it is important to calibrate equipment;
- explain which types of pesticides must be diluted before application;
- explain what information you must find in the pesticide labeling or in other recommendations before you can dilute the pesticide correctly;
- explain what information you must know before you can calculate how much of the dilute pesticide mixture to prepare.

Terms to Know

Active ingredient — Chemical in pesticide product that controls target pest and has toxicity.

Calibration — Measurement and adjustment of your application equipment to ensure it is delivering proper amount of pesticide.

Concentrated — Having high percentage of active ingredient.

Diluent — Anything used to dilute pesticide.

Dilute — To make less concentrated.

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

Fumigant — Pesticide that is vapor or gas or forms vapor or gas when applied and whose pesticidal action occurs in gaseous state.

Phytotoxic (phytotoxicity) — Poisonous to plants.

Target site — Site toward which control measures are being directed.

Calibration refers to the adjustment of equipment to ensure that the correct amount of pesticide is applied to a specific area. Failure to properly calibrate equipment is a frequent cause of ineffective pesticide application, when too little is applied, and always carries the potential for illegal residues, when too much pesticide is applied.

To calibrate your equipment, you must first determine the appropriate rate of application. You may have to adjust ground speed or sprayer pressure, change nozzle sizes, or modify application patterns to achieve the desired rate of application. It is important to check equipment periodically, especially nozzles. Nozzles can wear out over a short period of time, resulting in uneven spray patterns. Because operators fail to understand how rapidly equipment may perform inaccurately and become worn, most of them do not calibrate their sprayers often enough.

This chapter discuses the basic principals involved in the calibration of most types of equipment (see Table 6.1 for conversions) and calculations necessary for accurate pesticide application.

Table 6.1: Useful Conversion Factors for Calibration

STANDARD MEASURE	METRIC CONVERSIONS
LENGTH	
	1 in = 25.4 mm = 2.54 cm
1 ft = 12 in	1 ft = 304.8 mm = 30.48 cm
1 yd = 3 ft	1 yd = 914.4 mm = 91.44 cm = 0.914 m
1 mi = 5,280 ft	1 mi = 1,609 m = 1.61 km
	1 mm = 0.03937 in
	1 cm = 0.394 in = 0.0328 ft
	1 m = 39.37 in = 3.281 ft
	1 km = 3,281 ft = 0.6214 mi
AREA:	
1 sq in = 0.007 sq ft	1 sq in = 6.45 cm^2
1 sq ft = 144 sq in = 0.000023 ac	1 sq ft = 929 cm^2
1 sq yd = 1,296 sq in = 9 sq ft	1 sq yd = 8,361 cm^2 = 0.8361 m^2
1 ac = 43,560 sq ft = 4,840 sq yd	1 ac = 4,050 m^2 = 0.405 h
	1 cm^2 = 0.155 sq in
	1 m^2 = 1,550 sq in = 10.76 sq ft
	1 h = 107,600 sq ft = 2.47 ac
VOLUME:	
1 tsp = 0.17 fl oz	1 fl oz = 29.5 ml = 0.0295 l
1 tbs = 3 tsp	1 pt = 437 ml = 0.437 l
1 fl oz = 2 tbs = 6 tsp	1 qt = 945 ml = 0.945 l
1 cup = 8 fl oz = 16 tbs	1 gal = 3,785 ml = 3.785 l
1 pt = 2 cups = 16 fl oz	1 mL, ml = 0.033 fl oz
1 qt = 2 pt = 32 fl oz	1 L, l = 33.8 fl oz = 2.112 pt = 1.057 qt = 0.264 gal
1 gal = 4 qt = 8 pt = 128 fl oz = 231 cu in	
WEIGHT:	
1 oz = 0.0625 lb	1 oz = 28.35 g
1 lb = 16 oz	1 lb = 454 g = 0.04536 kg
1 ton = 2,000 lb	1 ton = 907 kg
1 gallon of water = 8.34 lb	1 gallon of water = 3.786 kg
	1 g = 0.035 oz
	1 kg = 35.27 oz = 2.205 lb

ABBREVIATIONS

ac	=	acre	oz	=	ounce	cm	=	centimeter
fl oz	=	fluid ounce	pt	=	pint	cm^2	=	square centimeter
ft	=	foot	qt	=	quart	cm^3	=	cubic centimeter
gal	=	gallon	sq	=	square	g	=	gram
h	=	hectare	tbs	=	tablespoon	kg	=	kilogram
1 h	=	10,000 m^2	tsp	=	teaspoon	km	=	kilometer
in	=	inch	yd	=	yard	L, l	=	liter
lb	=	pound				m	=	meter
mi	=	mile				m^2	=	square meter
						mL, ml	=	milliliter
						mm	=	millimeter

II. Why Calibration is Essential

Calibration precisely determines the output of the application equipment under controlled conditions. The main reason for calibrating application equipment is to determine how much pesticide to put into the spray tank to ensure that the correct amount of chemical is applied. This is necessary for:

(1) effectively controlling pests
(2) protecting human health, the environment, and treated surfaces
(3) preventing waste of resources
(4) complying with the law. It is also important to have control over the volume of water being applied

Effective Pest Control

Manufacturers of pesticides spend millions of dollars researching ways to use their products, including determining the correct amount of pesticide to apply for effective control of pests. Using less than label recommendations may result in inadequate control and could be a waste of time and money. Using too little pesticide can lead to problems such as pest resistance and resurgences, while using too much pesticide may have adverse effects on natural predators, target surfaces, and the environment; excessive use also wastes materials and is illegal.

Human Health Concerns

Pesticides that are applied at rates higher than label recommendations may endanger human health. Illegal residues may occur on produce when a pesticide is over applied; the entire crop may be confiscated to protect consumers if residues are above allowable tolerances. Field workers and application equipment operators can also be exposed if the equipment applies too much pesticide.

Environmental Concerns

Pesticides may cause environmental problems when they are not used properly. Harm to beneficial insects, such as honey bees, and to wildlife must be avoided by carefully calibrating equipment to maintain application rates within label recommendations.

Protection of Treated Surfaces

Certain pesticides are phytotoxic and can be damaging to sprayed surfaces when used at higher than recommended rates. Manufacturers evaluate these potential problems during testing. Applying **more** than the labeled amount of pesticide may increase risks of damage. Chances of building up excessive residues in the soil or potentially polluting the groundwater are also increased when too much pesticide is used; these problems could limit types of crops that can be grown in that soil.

Preventing Waste of Resources and Disposal Problems

Using the improper amount of pesticide costs time and costs more money. Not only are pesticides expensive, but the fuel, labor, and wear and tear on the equipment are costly, too. Another very important reason to calibrate equipment is to minimize the amount of pesticide remaining in the tank after an application is completed. It can be difficult and expensive to legally dispose of this extra material.

III. Deciding How Much Pesticide to Apply

Study the "Directions for Use" section of the pesticide label for rates you should apply. If the label lists a range of possible amounts, use the least amount of pesticide that will achieve the control of the pest.

Amounts of pesticide to be used are expressed in various ways. Application rates may be expressed in terms of how much pesticide formulation should be applied. The instructions may tell you how much pesticide formulation should be applied to each unit of area or volume in the target site—5 gallons of formulation per acre, or 1 pound of formulation per 100 cubic feet of space, for example. Application rates also may be expressed in terms of how much pesticide formulation should be used per volume of mixture. Labeling might call for 3 tablespoons of product per 5 gallons of water or 1 pint of product per 100 gallons of water.

Sometimes pesticide labeling and other sources express application rates in terms of how much active ingredient should be applied per unit of area or per volume of mixture—1 pint active ingredient per 1,000 square feet, or ½ pound active ingredient per 500 gallons of water, for example. When the application rate is expressed in this way, you can select different formulations and be able to figure how much to dilute each one. However, figuring the correct dilution for active ingredient recommendations is more complicated.

Occasionally the application rate is expressed in terms of a percentage of the final dilution — ½ percent by volume or 1% by weight, for example. Products that have adjuvants often express the application rate in this way. Expressing application rates as a percentage allows the user to calculate the dilution correctly for whatever dilution method is being used for the formulation.

Mixing, Loading, and Calibration Alternatives

Knowing what amount of the pesticide you must apply is only the first step. Next, you must determine how you will deliver the correct amount to the target site. Depending on the type of formulation you choose and the type of application equipment you will use, you may have to do some combination of three basic tasks—mixing the pesticide, loading it into your equipment, and calibrating the equipment so you will know exactly how much pesticide it is delivering.

1. **Mixing**. Unless the pesticide is a ready-to-use formulation or is designed to be applied full strength, you must carefully combine the right amounts of concentrated pesticide formulation and diluent to make the needed application-strength pesticide mixture.

2. **Loading**. You may need to transfer the pesticide into the equipment before it can be applied.

3. **Calibrating**. For many kinds of applications, you must measure and adjust the amount of pesticide your equipment will apply to the target site.

Each different combination of formulation and equipment type requires you to do a different combination of these tasks to prepare for applying a measured amount of pesticide.

No Calibration, Mixing, or Loading Needed

Some pesticide formulations are sold at application strength and are already in the equipment needed for application. These include aerosol cans; squeeze-trigger sprayers; delayed-trigger foggers; baits; shaker-can dusters; impregnated collars, bars, strips, and rollers; and wiper bags. The pesticide is applied to the point of runoff, is directed at a specific target, is placed so the target contacts it, or is released to fill an enclosed space. Most of these pesticides are available for use in specialized pest control situations.

Loading Needed, No Mixing or Calibration

Some ready-to-use pesticides are not sold loaded in the pesticide application equipment. The user must load them into the equipment. If the application equipment to be used is a squeeze-trigger sprayer, shaker can duster, a vat for dipping animals or plants, a spray dip vat, a wiper applicator, or some fumigant applicators, no calibration is necessary.

Calibration and Loading Needed, No Mixing

Ready-to-use formulations sometimes must be loaded into equipment that does require calibration. These include most granular and dust formulations, some liquid formulations (especially solutions), and some fumigant formulations. The pesticide is loaded directly into application equipment without any further dilution. The equipment must be calibrated so that the correct amount of pesticide will be released per unit area.

Mixing and Loading Needed, No Calibration

Some concentrated pesticides are diluted and then loaded into equipment that does not require calibration. Many plant and animal dips or spray dips, and tree canopy sprays, are applied by equipment that does not need calibration. The applicator is instructed to "cover the plant, animal, or surface thoroughly" or "apply to the point of runoff."

Calibration, Mixing, and Loading Needed

Many concentrated pesticides are applied with equipment that must be calibrated. For many certified applicators, this is the option most commonly encountered. The concentrate must be diluted correctly and the equipment must be calibrated correctly. Both steps are crucial to applying the correct amount of pesticide to a target site. If there is an error either in dilution or in calibration, the wrong amount of pesticide will be applied.

Calibrating Your Equipment

Most pesticide applications involve equipment that must be measured and adjusted to release the correct amount of pesticide to the target site. Proper calibration is an essential but often neglected task. To be sure your equipment is releasing the right amount of pesticide, take time to calibrate it carefully and correctly. Recheck it regularly to detect changes caused by wear, corrosion, and aging.

Calibration often requires some simple arithmetic. Usually the equipment manufacturer, the pesticide dealer, the Department of Agriculture, or USDA Cooperative Extension Service will provide some standard formulas to help you. The easiest and most accurate way to do the calculations is with a calculator.

Choose equipment that you know how to use and that is:

- designed for the type of chemical being applied
- appropriate for the size and type of application job

Equipment will not deliver the right amount of pesticide to the target site if it is not working correctly. Before you begin to calibrate the equipment, check it carefully to be sure that all components are clean and in good working order. Pay particular attention to the parts that regulate the amount of pesticide being released, such as nozzles and hopper openings. If they become clogged, not enough pesticide will be released. If they become worn, too much pesticide will be released.

Equipment that must be calibrated includes mechanical dusters; granule spreaders; hand, backpack, boom, hand gun, high-pressure, airblast, and most other sprayers; and fumigant applicators. The many types of application equipment differ in the details of

their operation, but if you understand the basic principles of calibration, you can apply them in any situation. Study the manufacturer's instructions carefully—they explain exactly how to adjust the equipment. They often contain suggestions on such things as the appropriate rate of travel, the range of most efficient pump pressures, approximate settings for achieving various delivery rates, and types of nozzles that can be used.

Speed

For some types of application equipment, the speed at which the equipment moves (or is carried) through the target site is one of the main factors in determining the rate of application. For some other types of equipment, you do not need to consider speed when calibrating.

Equipment with Gravity-Flow Dispersal

If the equipment you have chosen uses gravity to maintain the flow of pesticide, calibration may be fairly simple. Some equipment, such as some granule spreaders, needs to be calibrated only to adjust the rate of flow or delivery. This equipment releases pesticide only when the wheels are in motion. If the speed of the equipment is kept at an even, moderate pace, the amount of pesticide being released per unit area will be uniform.

Equipment with Powered Dispersal

If your equipment has a pump or other mechanism to disperse the pesticide, you will need to determine the rate of speed best suited for the type of equipment and for the particular requirements of your application job. Such equipment may be either hand-carried or mounted on a vehicle. In either case, the speed at which the equipment moves through the target site determines the amount of pesticide applied in a given area. Keep the speed as constant as possible during the calibration process and during the actual application. For the most accurate calibration, operate the equipment at the target site or on ground similar to that at the target site. Whether the equipment is hand-carried or mounted on a vehicle, the condition of the ground that must be crossed is important. A rough and uneven surface will require the equipment to be operated at a slower speed.

The equipment manufacturer's directions may offer a range of appropriate speeds. Your knowledge of conditions in the target site (including the drift hazard), plus your experience with the equipment, will help you determine an appropriate speed.

Uniform Release

If the application equipment you will be using has more than one nozzle (or more than one cluster of nozzles) or hopper, part of the calibration process is to measure the output from each to be sure that they all are releasing the correct amount of pesticide. Note whether the pesticide output from one or more nozzles (or cluster of nozzles) or hoppers is 5% more or less than the amount desired. Check for clogging or other obstruction in the openings that are distributing less. Check for leaks or worn parts in the openings that are distributing more. If you find no correctable problem, replace the nozzles or hoppers.

You can check for uniform output in two ways. Either method requires that you attach containers (jars) to collect the output from each nozzle, nozzle cluster, or hopper. *Fill the tank with water only*, then operate the equipment for a set period of time (1 to 5 minutes) and compare the amount of output in each jar to the amount desired. Or operate the equipment over a measured area while calibrating the equipment and, at the end of the calibration run, compare the amount of output in each jar to the amount desired. If all the nozzles or hoppers are intended to release an equal amount of pesticide, just check to see whether all the jars contain the same amount.

IV. Methods of Equipment Calibration

A few simple tools are needed to calibrate pesticide application equipment. Put these items into a small toolbox and use them **only** for calibration purposes. Keep your tools clean and in good working condition. Make equipment calibration a professional operation.

NOTE: ***Pesticide application equipment and the discharge from application equipment being calibrated may contain pesticide residue. Always wear rubber gloves and other protective equipment to prevent pesticide contamination of your eyes, hair, skin, clothing, and shoes.***

Tools Needed for Calibration

Stopwatch
A stopwatch is essential for timing travel speed and flow rates. Never rely on a wristwatch unless it has a stopwatch function.

Measuring Tape
A 100-foot moisture- and stretch-resistant measuring tape is used for marking off distance and for measuring spray swath width.

Calibrated Liquid Container
A marked, 1- or 2-quart container, calibrated for liquid ounces, is needed for measuring spray nozzle output.

Scale
A small scale that measures pounds and ounces is needed for weighing granules collected from a granule applicator. A scale that weighs between 5 and 10 pounds is usually adequate**.**

Pocket Calculator
A pocket calculator is needed for making calculations in the field.

Pressure Gauge
An accurate, calibrated pressure gauge, with fittings compatible with spray nozzle fittings, is helpful for checking boom pressure and for calibrating the sprayer pressure gauge.

Flow Meter
A flow meter, attached to a flexible hose or filling pipe, can be used for measuring the amount of water put into a tank. It can also be used for measuring tank capacity and for determining the amount of liquid used during a calibration run. Both mechanical and electronic flow meters are available. If these are not available, a calibrated five-gallon pail can be used instead.

Flagging Tape
Colored plastic flagging tape is useful for marking off measured distances to determine equipment speed.

Always calibrate with clean water. Different calibration techniques are used for liquid application equipment and dust or granular application equipment.

V. Calibrating Liquid Sprayers

Frequent calibration is necessary to monitor pump and nozzle wear on equipment that applies pesticides that are dissolved or suspended in water. Pump wear may decrease the amount and pressure of fluid output; nozzle wear increases the volume of output, may lower the output pressure,

and may produce a poor spray pattern. Abrasive pesticides, such as wettable powders, increase the rate of wear.

Before making any calibration measurements, be sure to service the sprayer; follow the servicing directions outlined below.

Servicing Spray Equipment (see italicized paragraph on page 7, under IV. Methods of Equipment Calibration.)

1. Flush the tank and pumping system with clean water to remove debris and dirt;
2. Clean and replace all filter screens;
3. Check nozzles for wear and replace them if there is any doubt about the wear — all nozzles must be clean;
4. Lubricate all bearings and appropriate moving parts;
5. Inspect hoses for cracks and leaks, and replace them if necessary; and
6. Make sure the pressure gauge is working properly by testing it against another gauge known to be accurate.

Once the sprayer is serviced, begin the calibration process. The final goal is to determine how much area will be covered by each tank of spray when the sprayer is moving at a specific speed and operating at a specific pressure. Four factors must be measured: (1) tank capacity; (2) flow rate; (3) speed of travel; and (4) width of spray swath.

Tank Capacity

The capacity of the spray tank or tanks needs to be measured only one time, but it *must* be measured. You must know exactly how much liquid a spray tank holds. Never rely on manufacturer's ratings, because these could be approximate volumes or may not take into account fittings installed inside the tank or the capacity of spray lines, pump, and filters.

Fill the tank either with a bucket or other container of known volume, or by using a flow meter attached to a hose. Always use clean water. A five-gallon bucket works well for smaller sprayers; the bucket must be filled each time to hold exactly five gallons and must be calibrated and marked accordingly before use.

The spray tank should be perfectly level. Close all valves to prevent water from leaking out. Add water, five gallons at a time, until the tank is nearly filled. Use smaller-volume calibrated containers to top off the tank.

Record the total volume of water required to fill the tank (paint or engrave this figure onto the outside of the tank for permanent reference). The tank's sight gauge should be calibrated while the tank is being filled by making marks on the tank or gauge as measured volumes of water are put in. If the unit is not equipped with a sight gauge, mark volume increments on a dipstick that can be kept with the tank. Use 1-gallon marks for tanks with a capacity of 10 gallons or less, and increments of 5 or 10 gallons for tanks having a total capacity of fifty gallons or less. Increments of 10 to 20 gallons are used on larger tanks.

Once the gauge or dipstick is calibrated and labeled, it will be possible to determine how much liquid is in the tank when the tank is not entirely full. Tanks must always be level when you read the gauge or dipstick.

A flow meter attached to a filling hose may be used for measuring the volume of larger tanks. Be sure to calibrate and label the gauge or dipstick as the tank is being filled.

Travel Speed

Always measure travel speed under actual working conditions. If you are calibrating an orchard sprayer, use a filled tank in an orchard; similarly, row crop and field sprayers should be calibrated under actual conditions. Tractors travel faster on paved or smooth surfaces than on soft dirt or clods. Never rely on tractor speedometers for mile-per-hour measurements because wheel slippage and variation in tire size due to wear may cause as much as a 30% difference in indicated speed. When calibrating a backpack or hand-held sprayer, walk on terrain similar to the area that will be sprayed.

Using a 100-foot tape, measure off any convenient distance. It can be more or less than 100 feet, but calibration is more accurate if longer distances (between 200 and 300 feet) are used, especially if equipment moves at several miles per hour. Sometimes multiples of 88 feet are chosen because 88 feet is the distance covered in one minute while traveling one mile per hour. In orchards or vineyards, a given number of tree or vine spaces of known length can serve as a convenient reference. Indicate the beginning and end of the measured distance with colored flagging tape.

Have someone drive (or walk, if calibrating a backpack sprayer) the sprayer along the measured distance at the speed of an actual application. Choose a speed within a range appropriate for the application equipment. When using a tractor, note the throttle setting, gear, and revolutions per minute (rpm) of the engine. The use of a positive throttle stop is helpful so the engine can always be returned to the same speed. Be sure actual application speed is reached before crossing the first marker. Use a stopwatch to determine the time, in minutes and seconds, required to traverse the measured distance. For best results, repeat this process two or three times and take an average (*See Table 6.2*).

Flow Rate

Measure the actual output of the sprayer when nozzles are new, then periodically thereafter to measure nozzle wear. Although manufacturers provide charts showing output of given nozzle sizes at specified sprayer pressures, you should check output under actual conditions of operation. Manufacturer's charts are most accurate when using new nozzles because used nozzles will be worn and may have different output rates; however, even new nozzles may have slight variations in actual output. Sprayer pressure gauges may not be accurate, adding further error to the output estimate determined from charts.

Liquid sprayer output is usually measured in gallons per minute. Two collection methods, listed below, can be used depending on the type of sprayer being calibrated. Collection method 1 is designed for low-pressure sprayers and small hand-held units; it involves collecting a volume of water emitted out of individual nozzles over a measured period of time. Collection method 2 for large air blast and high-pressure sprayers, measures the total output of the sprayer over a certain period of time.

Table 6.2 Calculating speed of application equipment

1. To convert minutes and seconds into minutes divide the seconds (and any fraction of a second) by 60 and then add this to the number of whole minutes.

   EXAMPLE: Your trip took 1 min and 47.5 sec.

$$\frac{47.5\ \text{sec}}{60\ \text{sec/min}} = .79\ \text{min}$$

$$1\ \text{min} + 0.79\ \text{min} = 1.79\ \text{min}$$

2. Add the converted minutes from each run and divide by the number of runs.

   EXAMPLE: The following three runs were made:

Run 1 = 1 min, 47.5 sec = 1.79 min
Run 2 = 1 min, 39.8 sec = 1.66 min
Run 3 = 1 min, 52.0 sec = 1.87 min

Total = 5.32 min

$$\frac{5.32\ \text{min}}{3\ \text{runs}} = 1.77\ \text{min/run average time}$$

3. Divide the measured distance in feet by the average time in minutes to get how many feet were traveled in one minute.

   EXAMPLE: The measured distance for this example is 227 feet.

$$\frac{227\ \text{ft}}{1.77\ \text{min}} = 128.25\ \text{ft/min}$$

4. Divide the feet-per-minute figure by 88 (the number of feet traveled in 1 minute at 1 mile per hour) to get the speed in miles per hour.

   EXAMPLE:

$$\frac{128.25\ \text{ft/min}}{88\ \text{ft/min/mil/hr}} = 1.46\ \text{mil/hr}$$

Collection Method I

Low-pressure sprayers, including low-pressure boom sprayers, backpack sprayers, and controlled droplet applicators, can be calibrated by measuring the amount of spray emitted from nozzles. If the sprayer is equipped with more than one nozzle, collect liquid from each to compare their output; this comparison will point out any malfunction or wear. A stopwatch and calibrated container are required for taking measurements. Wear rubber gloves to avoid skin contact with the liquid, and stand upwind from the nozzles to prevent fine mist or spray from contacting your face and clothing. Eye protection prevents spray droplets from contacting your eyes.

For low-pressure power sprayers used in agricultural, right-of-way, and landscape application, fill the tank at least half full with water, start the sprayer, and bring the system up to normal operating pressure. Operate hydraulic agitators if they are to be used during the application, because hydraulic agitators divert some liquid from the nozzles and often lower the pressure in the system. Most power sprayers have a limited operating pressure range depending on the type of pump and type of power unit; never attempt to operate equipment beyond its normal working range because this may cause premature failure of the pump. If the sprayer is powered by a tractor (PTO) be sure that the tractor engine rpm is the same as that determined in the speed calibration; otherwise the pump output pressure will be different. Adjust the pressure to the spray situation and nozzle manufacturer's recommendations. Be sure appropriate nozzles are installed on the equipment. Check the pressure by attaching a calibrated pressure gauge at either end of the boom, replacing one of the nozzles. Open the valves to all nozzles and note the pressure, make adjustments as necessary, then remove the gauge.

While all nozzles are operating at the proper pressure, collect about fifteen to thirty fluid ounces from each. Use a stopwatch to determine the time in seconds it takes to collect each amount (*See Table 6.3*).

When calibrating backpack sprayers, pump the unit as you would during an actual application. Collect spray in a calibrated container for a measured period of time. Compressed air sprayers lose pressure during operation, so they must be pumped frequently. To calibrate, fill the tank about half full with water to provide sufficient air to keep the pressure uniform. For some types of controlled droplet applicators, it is possible to disconnect the hose and orifice from above the spinning disc or cup and collect liquid in a calibrated container over a measured period of time; the liquid must flow through the orifice.

Record the volume of liquid collected from each nozzle or orifice and the time in seconds required to collect each amount. Determine the fluid-ounces-per-second output for each nozzle by dividing the volume by the seconds required to collect it. Convert ounces per second into gallons per minute by multiplying the result by the constant 0.4688 (sixty seconds per minute divided by 128 fluid ounces per gallon equals 0.4688) *(See Table 6.3)*.

Output among nozzles will usually vary. The variation between nozzles should not be greater than 5%, and the output of any nozzle should not exceed the manufacturer's rated output by more than 10%. The percentage of variation can be computed by dividing the actual output by the rated output. Subtract 1.00 from this figure, then multiply by 100 to obtain the variation in percent (*See Table 6.3*). In the example given in Table 6.3, nozzle numbers 3 and 5 should be replaced. *However, whenever any nozzles are replaced, the flow rate of all the nozzles must be rechecked because changing one nozzle may affect the*

pressure in the whole system; after changing nozzles, readjust the pressure regulator to maintain the desired pressure.

Spray check devices are calibration aids that provide a visual representation of the spray pattern produced by nozzles on spray booms. This portable device is placed under a boom and the output from several nozzles is collected into a series of evenly spaced cells.

After collection, the device is rotated from a horizontal to a vertical position; collected liquid drains into glass vials corresponding to the individual cells. Floats inside these vials rise to the top of the liquid level. Variations in levels are easily seen, pinpointing nozzle problems and or poor nozzle height adjustment.

Table 6.3 Calculating gallons-per-minute for low-pressure sprayers

1. Determine the gallons-per-minute output of each nozzle by dividing the fluid ounces collected by the time (in seconds) and multiplying the result by 0.4688.

EXAMPLE:

Nozzle	fl oz	sec	= fl oz/sec	x 0.4688	= gpm
1	12.5	23.2	= 0.539	x 0.4688	= 0.253
2	12.0	22.5	= 0.533	x 0.4688	= 0.250
3	15.5	24.8	= 0.625	x 0.4688	= 0.293
4	14.5	26.1	= 0.556	x 0.4688	= 0.261
5	19.0	27.2	= 0.699	x 0.4688	= 0.328
6	13.0	23.9	= 0.544	x 0.4688	= 0.255

Total output = 1.640 gpm

2. Now compute the percent variation from the rated nozzle output. Divide the actual gallons-per-minute output by the rated output. Subtract 1 from this number and multiply by 100.

EXAMPLE:

Nozzle	Actual gpm / rated gpm		Subtract 1.00		Multiply by 100	=Percent variation (%)
1	0.253/0.250	= 1.012	- 1.00	= 0.012	x 100	= 1.2
2	0.250/0.250	= 1.000	- 1.00	= 0.000	x 100	= 0.0
3	0.293/0.250	= 1.172	- 1.00	= 0.172	x 100	= 17.2*
4	0.261/0.250	= 1.044	- 1.00	= 0.044	x 100	= 4.4
5	0.328/0.250	= 1.312	- 1.00	= 0.312	x 100	= 31.2*
6	0.255/0.250	= 1.020	- 1.00	= 0.020	x 100	= 2.0

*Greater than 5% variation needs to be changed.

Collection Method II

Due to the air blast or high pressures of larger sprayers, it is not possible to collect ejected liquid in a container. You must measure the output of the sprayer over a period of time by determining how much water was used.

Start by moving the sprayer to a level surface. Fill the tank full with clean water; the water must be at a level that can be duplicated when refilling. A convenient technique is to fill the tank with clean water to the point where it just begins to overflow. Use low-volume, low-pressure water, such as from a garden hose, for topping off the tank. Check for leaks around tank seals and in hoses. All nozzles must be clean and operating properly or the results will be inaccurate.

Stand upwind and operate the sprayer at its normal operating speed and pressure. Open the valves to all nozzles, starting a stopwatch at the same time. Continue to run the sprayer for several minutes, then close the valves to all nozzles and record the elapsed time.

If the tank has been calibrated and marked, the amount of liquid used will be apparent or can be determined with a calibrated dipstick. Otherwise, use a flow meter attached to a low-pressure hose or a calibrated five-gallon bucket and refill the sprayer to the original level. Record the gallons of water used; this volume is the amount of liquid sprayed during the timed run. Repeat this process two more times to get an average of sprayer output (*See Table 6.4*).

Width of Spray Swath

The final measurement needed to complete calibrations is the width of the spray swath. For multiple nozzle boom sprayers, the swath width is the width of the boom plus the distance between one pair of nozzles; swath width also can be calculated by multiplying the number of nozzles by the nozzle spacing. When making a pesticide application, position the end nozzle of each subsequent pass to leave a space equal to the nozzle spacing on the boom. Spray boom height must be adjusted so that there is approximately a 30% overlap of spray from adjacent nozzles on the boom. Position nozzles at the exact height they would be during an actual application. Check the spray boom to make sure it is level; an unlevel boom will cause uneven distribution of spray.

When spray is emitted as separate bands or strips, the swath width is equal to the combined width of each individual band, but does not include the unsprayed spaces between bands.

Swath width for herbicide strip sprays in orchards and vineyards should be measured only to the center of the tree or vine row and should not include overlap. Unless the herbicide is applied to the entire orchard or vineyard floor, the actual sprayed area will be less than the total planted area.

Sometimes nozzles are attached to an inverted U-shaped boom so that pesticides can be applied to the top and both sides of vines or plants in a row. Swath width for this type of equipment is equal to the distance between opposing nozzles.

Pesticides are often injected into the soil through special subsoil chisels spaced along a tractor-mounted tool bar. It is assumed that pesticides are being applied to the entire subsurface area in most soil injection applications; therefore swath width is equal to the number of chisels multiplied by the space between the chisels on the tool bar.

Occasionally pesticides are injected as a band, so swath width is the sum of all the band widths, similar to surface band applications. Measure the swath width of a backpack sprayer used for

ground application from the spray pattern produced on the ground in a test run. Keep the nozzle at the height held during an actual application; maintain this height at all times to prevent variation in swath width. Nozzles of these types of sprayers usually provide a uniform spray pattern, so swaths need to be overlapped only enough to ensure a uniform application pattern. Use the same method to measure the swath width of controlled droplet applicators.

Table 6.4 Calculating gallons per minute for high pressure sprayers

1. Record the elapsed time in minutes during each trial run and the amount of liquid sprayed in gallons.
   EXAMPLE:

Run	Time	Volume
1	1 min 45 sec	37.5 gal
2	1 min 30 sec	33.5 gal
3	1 min 50 sec	38.0 gal

2. Convert the time from minutes and seconds to minutes by dividing the seconds by 60 and adding this decimal to the minutes.

   EXAMPLE:

Run	min	sec	sec/60	= min
1	1	45	0.75	1.75
2	1	30	0.50	1.50
3	1	50	0.83	1.83

3. Divide the collected gallons for each run by the minutes to find gallons per minute.
   EXAMPLE:

Run	gal/min	= gpm
1	37.5/1.75	21.4
2	33.5/1.50	22.3
3	38.0/1.83	20.8

4. Add all the gallons-per-minute figures and divide this total by the number of runs (3 in this example) to get the average gallons-per-minute output.
   EXAMPLE:

Run	gpm
1	21.4
2	22.3
3	20.8

Total = 64.5 gpm

64.5/3 = 21.5 gpm average output

Determining the Amount of Pesticide to Use

Use the tank volume, the speed of the applicator, the flow rate of the sprayer, and the spray swath width to calculate the total area that can be covered with each tank of material. Knowing this value allows you to determine how much pesticide to put into the tank. Two calculation methods may be used, one for pesticides applied by the acre and the other for applications, such as landscape treatments or sprays in confined areas, made by the square foot. Table 6.5 gives an example of pesticides applied by the acre.

Changing Sprayer Output

Once a sprayer has been calibrated, its output rate is determined for a specific speed. There may be times when this output rate needs to be changed to accommodate variations in foliage, plant spacing, other aspects of the treatment area, or requirements to travel at a faster or slower speed. Also, the spray output will change as nozzles or pumps begin to wear. Several adjustments can be made, either alone or in combination, to effectively increase or decrease sprayer output within a limited range.

Table 6.5 How much pesticide to put into the spray tank
(Pesticides applied on a **per-acre** basis)

1. Divide the spray swath width (in feet) by 43,560 (the number of square feet in one acre) and multiply the result by the travel speed in feet per minute. To find the area in acres that can be treated in one minute, assume the swath width is 12 feet, the travel speed 128.25 feet per minute, and the delivery rate 1.525 gallons per minute.
   EXAMPLE:

$$\frac{12\text{ ft}}{43{,}560\text{ sq ft/ac}} \times 128.25\text{ ft/min} = 0.0353\text{ ac/min}$$

In this example, when a swath 12 feet wide is being sprayed, 0.0353 acres are covered in one minute.

2. Divide the gallons-per-minute figure by the acres-per-minute figure to find the gallons of liquid being applied per acre.
   EXAMPLE:

$$\frac{1.525\text{ gal/min}}{0.0353\text{ ac/min}} = 43.2\text{ gal/ac}$$

3. Divide the actual measured volume of the spray tank by the gallons-per-acre figure. To find how much pesticide to put in the tank, assume the tank holds 252.5 gallons when filled:
   EXAMPLE:

$$\frac{252.5\text{ gal/tank}}{43.2\text{ gal/ac}} = 5.84\text{ ac/tank}$$

4. Multiply the acres-per-tank figure by the recommended rate per acre of pesticide (check the pesticide label for this information) to find how much pesticide to put in the tank.

EXAMPLE:

Pesticide label says	Acres per tank	Amount of pesticide to put in tank
1.5 lb/ac	x 5.84	= 8.76 lb
3 qt/ac	x 5.84	=17.52 qt
2 gal/ac	x 5.84	=11.68 gal
1 pt/ac	x 5.84	= 5.84 pt

Changing Speed

The simplest way to alter the volume of spray being applied to an area is by changing the travel speed of the sprayer (Figure 6.1). A slower speed results in more liquid being applied, while a faster speed reduces the application rate. Such adjustments may be needed when swath width changes slightly, such as in orchards or vineyards where plant spacing may differ from block to block.

Changing the travel speed eliminates the need for altering the concentration of chemical in the spray tank, although there are limits to the amount of speed change that can be made. Operating application equipment too fast is a common error and will result in poor coverage. Operating it too slow results in runoff, waste, and an increase in application time and cost.

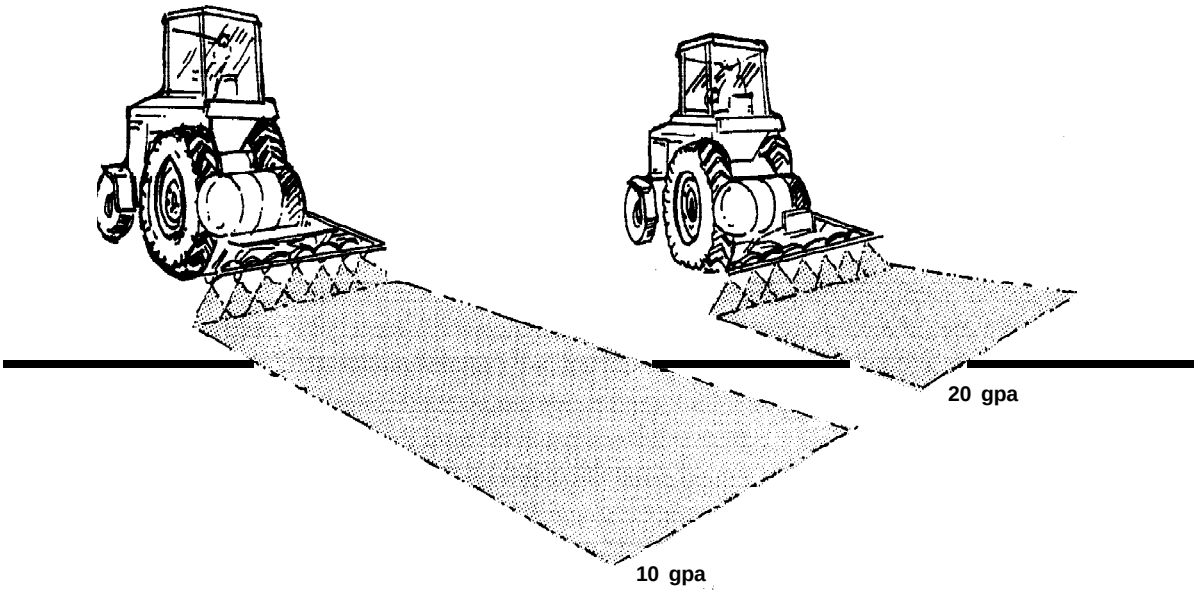

Figure 6.1 Altering the volume applied by changing travel speed.

Changing Output Pressure

As nozzles begin to wear, the spray volume will increase. When a pump becomes worn it becomes less efficient and the nozzle output drops off. Adjusting the pressure regulator to increase or decrease output pressure will change the spray volume slightly. Increasing pressure increases the output, while decreasing pressure lowers it. However, in order to double the output volume it is necessary to increase the pressure by a factor of four; this is usually beyond the capabilities of the spraying system because the amount of adjustment that can be made is limited by the working pressure range of the sprayer pump. Whenever pressure in the system is changed, the nozzle output must be remeasured and the calibration calculations reworked. Increasing pressure breaks spray up into finer droplets, while lowering pressure too much may reduce the effectiveness of nozzles by altering the spray pattern.

Changing Nozzle Size

The most effective way to change the output of a sprayer is to install different sized nozzles. Larger nozzles increase volume, while smaller ones reduce spray output. Changing nozzles usually alters the pressure of the system and requires an adjustment of the pressure regulator. The volume output of disc core nozzles may be adjusted by changing either the disc or the core, or by replacing both. Be aware that changes in either the core or disc will also change the droplet size and spray pattern. Use tables included in nozzle manufacturers' catalogs as a guide for estimating output of different combinations. Whenever any nozzles are changed, recalibrate the sprayer and refigure its new total output.

VI. Calibrating Dry Applicators

The techniques for calibrating dry applicators are similar in many ways to those used for liquids. However, granule applicators must be calibrated for each type of granular pesticide being applied and for each change in weather or field conditions. Granules vary in size and shape from one pesticide to the next, influencing their flow from the applicator hopper. Temperature and humidity, as well as field conditions, also influence granule flow.

Before beginning to calibrate a dry applicator, be sure that it is clean and all parts are working properly; most equipment requires periodic lubrication. Always wear rubber gloves to prevent contact with residues on the equipment. Calibration of granule applicators involves using actual pesticides, so special precautions must be taken. Some formulations are dusty, and you may need a respirator.

Three factors need to be measured when calibrating a dry applicator: (1) travel speed; (2) rate of output; and (3) swath width.

Travel Speed

Determine travel speed in feet per minute in the same way you would using liquid applicators *(See Table 6.2)*. Applicator hoppers should be filled so that speed can be measured under actual operating conditions.

Rate of Output

To determine the rate of output, fill the hopper or hoppers with the granular formulation to be used. Most granule applicator hoppers have ports with adjustable openings for granules to

pass through; refer to charts supplied by the manufacturer to determine the approximate opening for the rate and speed you will be using. Once the approximate opening is set, use one of the following methods to determine the actual output rate:

1. **Measure the quantity of granules applied to a known area.** Collecting and weighing the granules actually applied to a measured area is often the easiest way to calibrate a granule applicator and should be used when working with broadcast applicators. Spread out a plastic tarp of known size on the ground, then operate the broadcast applicator at a known speed across the tarp. Place the granules collected by the tarp into a container and weigh them (Table 6.6).

2. **Collect a measured amount of granules over a known period of time**. Collecting and weighing granules over a known period of time is similar to calibrating a liquid boom sprayer with multiple nozzles; this method is used for granule applicators with multiple ports. While operating the applicator at a normal speed, collect granules from each port in a container; record the time required to collect each sample. Weigh samples separately *(See Table 6.7)*.

3. **Refill the hopper after a measured period of time.** This method may be used with hand-operated equipment or when small quantities are being applied, but is most useful when multiple applicators are used together on a boom. Fill the hopper or hoppers to a known level and operate the equipment for a measured period of time. When finished, weigh the granules required to refill the hoppers to their original levels *(See Table 6.8*).

Table 6.6 Calculating granule output rate by measuring the quantity applied to a known area

1. Spread a plastic tarp that is at least 10 feet by 10 feet on the ground. Multiply the length by the width to determine the area of the tarp.
   EXAMPLE:
   Tarp size = 10 ft by 12 ft
   Tarp area: 10 ft × 12 ft = 120 sq ft

2. Fill the hopper or hoppers of the granule applicator, adjust the output ports to the recommended opening, and travel across the tarp at a known speed while granules are being broadcast.

3. Measure the swath width of the granules that were applied and compute the area of the swath. If the swath is wider than the tarp, the area figure to be used is equal to the area of the tarp. If the swath is narrower than the tarp, multiply the swath width by the length of the tarp.

4. Transfer all the granules on the tarp to a container and weigh them.

5. Multiply the weight of the granules collected (in pounds) by the area (acre, 1,000 square feet, or 100 square feet) given on the label. (An acre is 43,560 square feet.) Divide the result by the area of the swath.

   EXAMPLE:
   Assume the swath width of granules being applied equals 15 feet. Therefore use the tarp area of 120 square feet in the calculations. (If the swath width was less than the tarp width, for example 8 feet, the area would then be 8 feet x 12 feet = 96 square feet.) Multiply the weight (in pounds) by the labeled area and divide the result by the tarp or swath area:

Weight = 8 oz ÷ 16 oz/lb = 0.5 lb

$$\frac{0.5 \text{ lb} \times 43{,}560 \text{ sq ft/ac}}{120 \text{ sq ft}} = 181.5 \text{ lb/ac}$$

In this illustration, the granule applicator is broadcasting 181.5 pounds of material per acre. If the label calls for a greater amount, open the port more or slow the speed of travel of the applicator. If the label calls for a lesser amount, close the port some or speed up the rate of travel. Once an adjustment has been made, repeat the calibration.

Table 6.7 Calculating granule output rate by collecting a measured amount over a known period of time

1. Adjust the hopper opening according to manufacturer's instructions suggested for your required application rate. If no information is available, begin with an intermediate setting.

2. Operate the equipment at the speed of an actual application. Collect granules in a clean container, such as a pan or bag, before they drop to the ground. Use a stopwatch to determine the time required to collect each volume. If granules are dispersed through more than one opening, collect and time the output from each. Because some units drop granules onto a spinning disc for dispersal, it may be necessary to disable the disc by disconnecting the drive chain or belt to prevent granule loss during collection. For smaller units, collect the discharge in a bag placed over the outlet. Be sure granules move away from the port quickly enough to prevent clogging.

3. Weigh the output from each port separately to detect any variability; if necessary, adjust ports to equalize flow rates. Collections should be weighed in ounces.

4. Divide each weight in ounces by the collection time in minutes and multiply by 0.0625 to get the output in pounds per hour for each port.

EXAMPLE:
The following is an example of an output collected from a granule applicator with six ports, although the same calculations would apply if only one port were used. Hopper openings were adjusted following manufacturer's recommendations for an application of 200 pounds per acre:

Port		oz		min
1		29.5		0.25
2		33.0		0.28
3		31.5		0.26
4		29.0		0.25
5		33.0		0.27
6		30.0		0.26
Port	oz ÷ min	oz/min	x 0.0625	= lb/min
1	29.5/0.25	= 118.0	x 0.0625	= 7.375
2	33.0/0.28	= 117.9	x 0.0625	= 7.369
3	31.5/0.26	= 121.2	x 0.0625	= 7.575
4	29.0/0.25	= 116.0	x 0.0625	= 7.250
5	33.0/0.27	= 122.2	x 0.0625	= 7.638
6	30.0/0.26	= 115.4	x 0.0625	= 7.213
			Total output (lbs/min)	**44.42**

5. Add the individual outputs of each port in pounds per minute to get total pounds-per-minute output. In this example, the total output is 44.42 pounds per minute.

6. Use the technique shown in Table 6.8 to calculate the rate per acre or other unit of area.

6.8 Calculate the rate of output by refilling the hopper after a measured period of time

1. Fill the hopper or hoppers to a known level with granules.

2. Operate the equipment for a measured period of time at a known speed.

3. Weigh the amount of granules required to refill the hopper or hoppers to their original level. If multiple hoppers are being used, be sure each is applying approximately the same amount of granules. If a significant variation exists, adjust the ports and repeat steps 1 through 3.

EXAMPLE:
In this example, six applicators were used together on a boom. They have been adjusted so that they all apply approximately the same amount of granules:

Hopper	Operating time (min)	Weight of granules (lbs)
1	2.5	6.2
2	2.5	6.1
3	2.5	6.1
4	2.5	6.3
5	2.5	6.1
6	2.5	5.9
		Total output (lbs) 36.7

4. Divide the total weight from all hoppers by the time they were operated to convert the output to pounds per minute.

EXAMPLE:

$$\frac{36.7 \text{ lbs}}{2.5 \text{ min}} = 14.68 \text{ lbs/min}$$

5. Use the technique shown in Table 6.9 to calculate the rate per acre or other unit of area.

Swath Width

To measure the swath width of granules dispersed by the applicator, operate the equipment under actual field conditions. Whenever possible, place cans, trays, or other containers at even intervals across the width of the application swath to collect granules. Weigh the granules collected in each container separately to determine the distribution pattern. Some spreaders can be operated over a strip of black cloth or plastic to provide a rapid visual assessment of granule distribution and swath width.

Granule applicators that apply bands or inject granules into the soil do not have devices to disperse granules from side to side. Swath width is determined by adding the widths of individual bands.

Application Rate

Motorized and hand-operated applicators apply granules at a fixed output, independent of ground speed. If ground speed *increases*, the effect will be to *reduce the amount of granules* applied per unit of area; conversely, when ground speed *decreases, more material* is applied. Application rate with this type of equipment can, therefore, be adjusted not only by the size of the port opening, but also by the speed of travel. The output of ground – wheel-driven granule applicators, however, varies according to the ground speed. If ground speed increases, the applicator runs faster and the output rate is greater. When the ground speed slows, output decreases. The result of this automatic change in output is that the equipment will apply the same amount of material per acre or other unit of area, no matter what speed it is driven (the equipment will have minimum and maximum operating speeds determined by the manufacturer). Use Table 6.9 to calculate the actual rate of granules applied per acre or other unit of area. The application rate also can be adjusted by increasing or decreasing the size the port openings or by changing drive gears or sprockets to change the speed ratio of the metering mechanism to the ground wheel.

VII. Calculations for Active Ingredients, Percent Solutions, and Parts-per-Million Solutions

Not all pesticide recommendations call for dry or liquid formulated amounts of pesticide per unit of area. Sometimes recommendations require the pesticide to be applied in pounds of active ingredient (A.I.) per unit of area, to be mixed as a percent solution, or to be diluted to parts per million (ppm) solution. Before adding pesticide to the spray tank, read and understand the dilution instructions on the label.

are seldom available in their pure state; they are normally formulated into a ready-to-use product by combining them with adjuvants and inert ingredients such as carriers and solvents. Therefore, only a percentage of any formulated product, whether dry or liquid, is pure pesticide, known as **active ingredient** (A.I.). Some University of Arizona and other pesticide use guidelines call for A.I. when there are several formulations available, often from different manufacturers. Using A.I. calculations rather than formulation calculations enables the same amount of actual pesticide to be applied to a unit of area, no matter what formulation is used *(See Table 6.10)*.

Active Ingredient Calculations

Table 6.9 Calculating rate-per-acre or other unit of area

1. Divide the swath width by 43,560 (the number of square feet in an acre) and multiplying the result by the speed of travel. In this example, the swath width is 30 feet and the application speed is 352 feet per minute (4 miles per hour).

   EXAMPLE:

$$\frac{30 \text{ ft (swath)}}{43{,}560 \text{ sq ft/ac}} \text{ X } 352 \text{ ft/min} = 0.2242 \text{ ac/min}$$

2. Divide the output rate of the granule applicator in pounds per minute by the acres-per-minute calculated in step 1 to get the pounds of formulated pesticide being applied per acre. This example uses 44.42 pounds per minute as the output rate.

   EXAMPLE:

$$\frac{44.42 \text{ lb/min}}{0.242 \text{ ac/min}} = 183.6 \text{ lb/ac}$$

Table 6.10 Calculating active ingredient with liquid formulations

Assume that a sprayer has been calibrated and sprays 7.5 acres per tank. You have a recommendation to apply 1.5 pounds A.I. of chlorothalonil per acre to control rust on snap beans, and have been supplied with a liquid formulation containing 4.17 pounds (a.i.) of chlorothalonil per gallon.

1. Divide the pounds of A.I. per gallon by the recommended pounds of A.I. per acre to get the number of acres that can be treated with 1 gallon of formuation.

   EXAMPLE:

$$\frac{\text{4.17 lb A.I. per gal}}{\text{1.5 lb A.I. per ac}} = \text{2.78 ac/gal}$$

2. Divide the known acre capacity of your tank by the acres per gallon to get the number of gallons of formulation to put into the tank.

EXAMPLE:

$$\frac{\text{7.5 ac/tank}}{\text{2.78 ac/gal}} = \text{2.7 gal/tank}$$

Thus 2.7 gallons of formulated chlorothalonil should be put into the tank for spraying 7.5 acres of crop.

The A.I. of any pesticide will be listed on its label. Labels of liquid pesticides give the percentage by weight of active ingredient and also tell how many pounds of active ingredient are in 1 gallon of formulation; labels of dry formulations list the percentage by weight of active ingredient (Tables 6.11, 6.12).

Table 6.11 Calculating active ingredient with powder formulations

Assume that the calibrated sprayer you are using covers 7.5 acres per tank, and you have a recommendation to apply 1.5 pounds A.I. of chlorothalonil per acre for fungus control on melons. You are provided with a wettable powder formulation that, according to the label, contains 75% chlorothalonil.

1. Divide the percent A.I. (to convert it to a decimal) by 100 (or simply move the decimal point two places to the left).

   EXAMPLE:

$$\text{75\% = 0.75 A.I./lb formulation}$$

2. Divide the recommended amount of A.I. by the amount of A.I. in the formulation.

   EXAMPLE:

$$\frac{\text{1.5 lb A.I./ac}}{\text{0.75 lb A.I./lb formulation}} = \text{2 lb formulation/ac}$$

3. Multiply the pounds of formulation per acre by the number of acres per tank to find out how much formulation to put into the tank.

   EXAMPLE:

$$\text{2 lb formulation/ac} \times \text{7.5 ac/tank} = \text{15 lb/tank}$$

Table 6.12 Calculating active ingredient with granular formulations

Convert the percent A.I. into a decimal and divide this into the recommended application rate. Assume you are given a recommendation for application of 0.50 lb A.I. of ethoprop per 1,000 square feet for control of nematodes. You are provided with a granular formulation containing 10% active ingredient (0.1 pound of A.I. per pound of formulation).

EXAMPLE:

$$\frac{0.5 \text{ lb A.I./1,000 sq ft}}{0.1 \text{ lb A.I./lb formulation}} = 5 \text{ lb formulation/1,000 sq ft}$$

Calibrate the granule applicator so that it applies formulation at the calculated rate; here, 5 pounds of formulated ethoprop per 1,000 square feet.

Percent Solutions

Sometimes label recommendations require that the pesticide be mixed as a percent solution. The active ingredient is mixed to get a known concentration, regardless of the volume per unit area of spray put out by the sprayer. Percent solutions are mixed on a weight/weight basis (w/w), meaning pounds of A.I. per pound of water *(See Tables 6.13 and 6.14)*.

Table 6.13 Calculating a percent solution with a liquid formulation

Assume you have measured the volume of the spray tank and find that it holds 264.5 gallons of water. You are given a recommendation to apply a 1% solution of glyphosate for control of aquatic weeds, using a high-pressure sprayer with a hand-held spray nozzle. The formulation of glyphosate that you are to use contains 5.4 pounds of active ingredient per gallon. To prepare a percent solution using liquid formulations, you need to know the volume of the spray tank, the weight of active ingredient per gallon of formulation, and the weight of a gallon of water. The weight of a gallon of water is a constant, being approximately 8.34 pounds.

1. To find the total weight of the liquid in the filled tank by multiplying 264.5 gallons by 8.34 pounds per gallon:

   EXAMPLE:

   $$264.5 \text{ gal} \times 8.34 \text{ lb/gal} = 2{,}205.93 \text{ lb}$$

2. Multiply the total weight of liquid by the percent of solution, expressed as a decimal, to determine the weight of A.I. required to mix the desired solution:

   EXAMPLE:

   $$2{,}205.93 \text{ lb} \times 0.01 = 22.06 \text{ lb}$$

3. Divide the required weight of A.I. by the weight of A.I. in the formulation. The result is the number of gallons of liquid formulation that should be added to the tank to achieve the desired percent solution:

EXAMPLE:

$$\frac{22.06 \text{ lb A.I.}}{5.4 \text{ lb A.I./gal}} = 4.1 \text{ gal formulation}$$

In this example, one tank of liquid should contain 4.1 gallons of glyphosate formulation. The total volume of water combined with the glyphosate formulation should equal 264.5 gallons, the capacity of the tank. You would therefore use 260.4 gallons of water and 4.1 gallons of formulated glyphosate.

NOTE: These calculations give a close approximation of the amount of liquid formulation to add to the tank to achieve a known percent solution. The mathematics for a more exact figure are more complex and unnecessary for this example.

Table 6.14 Calculating a percent solution with a dry formulation

Assume your dry formulation is 75% A.I.; 1 pound of dry formulation would contain 0.75 pound of pesticide active ingredient. You need to mix a 1% spray solution of this formulation in 264.5 gallon tank.

1. Multiply the tank capacity in gallons by 8.34 pounds per gallon to find the total weight (in pounds) of the liquid in the filled tank.

   EXAMPLE:

   $$264.5 \text{ gal} \times 8.34 \text{ lb/gal} = 2{,}205.93 \text{ lb}$$

2. Multiply the total weight of liquid by the percent of the desired solution, expressed as a decimal to determine the weight of A.I. required to mix the desired solution.

   EXAMPLE:

   $$2{,}205.93 \text{ lb} \times 0.01 = 22.06 \text{ lb}$$

3. Divide the weight of A.I. (in pounds) by the decimal equivalent of the percent of A.I. in the formulation to get the number of pounds of formulation that should be added to the tank to achieve the desired percent solution.

   EXAMPLE:

   $$\frac{22.06 \text{ lb A.I.}}{0.75 \text{ A.I./formulation}} = 29.41 \text{ lb formulation}$$

Add 29.41 pounds of wettable powder to 264.5 gallons of water to achieve a 1 percent solution.

Parts-Per-Million Solutions

Certain pesticides need to be mixed in parts-per-million (ppm) concentrations, which are essentially the same as percent solutions. For example, a 100 ppm solution is equal to a 0.01 percent solution *(See Table 6.15)*. The ppm designation represents the parts of active ingredient of pesticide per million parts of water; ppm dilutions are a common way of measuring very diluted concentrations of pesticides *(See Tables 6.16 and 6.17)*.

Table 6.15 Parts Per Million (ppm)

ppm	Decimal	Percent Solution
1	0.000001	0.0001
10	0.00001	0.001
100	0.0001	0.01
1,000	0.001	0.1
10,000	0.01	1.0
100,000	0.1	10.0
1,000,000	1.0	100.0

Table 6.16 Calculating a parts-per-million dilution for dry formulations

Assume you are given a recommendation requiring a 100 ppm concentration of streptomycin to be mixed in a 500-gallon tank. Streptomycin is used for control of angular leaf blight on cotton. The formulation you have is a water soluble powder, containing 17% A.I.

1. Multiply (in pounds) the tank capacity in gallons by 8.34 pounder per gallon to find the total weight of the liquid in the filled tank.

   EXAMPLE:

   $$500 \text{ gal} \times 8.34 \text{ lb/gal} = 4{,}170 \text{ lb/tank}$$

2. Calculate how many pounds of A.I. are required for a pound of spray solution.

   EXAMPLE:

   $$100 \text{ ppm} = \frac{100 \text{ parts A.I.}}{1{,}000{,}000 \text{ lb solution}} = 0.0001 \text{ a.i./lb solution}$$

It will require 0.0001 pounds of A.I. for each pound of solution to achieve a 100 ppm mixture.

3. Calculate how many pounds of A.I. are required for a tank solution, using the weight of the liquid in the tank:

   EXAMPLE:

   $$4{,}170 \text{ lb/tank} \times 0.0001 \text{ lb A.I.} = 0.417 \text{ lb A.I../tank}$$

4. Divide the weight of A.I. by the decimal equivalent of the percent of A.I.. in the formulation. The result is the number of pounds of formulation that should be added to 500 gallons of water to achieve a 100 ppm solution.

   EXAMPLE:

   $$\frac{0.417 \text{ lb A.I.}}{0.17 \text{ lb A.I./lb formulation}} = 2.45 \text{ lb formulation}$$

Table 6.17 Calculating a parts-per-million dilution for liquid formulations

1. Multiply (in pounds) the tank's capacity in gallons by 8.34 pounds per gallon. Assume a pesticide contains 5.4 pounds of A.I. in one gallon of formulation. You are required to prepare a 100 ppm concentration in a 500 gallon tank.

   EXAMPLE:

   $$500 \text{ gal/tank} \times 8.34 \text{ lb/gal} = 4{,}170 \text{ lb/tank}$$

2. Calculate how many pounds of A.I. are required for a pound of spray solution.

   EXAMPLE:

   $$100 \text{ ppm} = \frac{100 \text{ parts A.I.}}{1{,}000{,}000 \text{ lb/soluton}} = 0.0001 \text{ a.i./lb solution}$$

   It will require 0.0001 pounds of A.I.. for each pound of solution to achieve a 100 ppm mixture.

3. Determine how many pounds of A.I.. are required for a tank of solution, using the weight of the liquid in the tank:

   EXAMPLE:

   $$4{,}170 \text{ lb/tank} \times 0.0001 \text{ lb A.I.} = 0.417 \text{ lb A.I../tank}$$

4. Divide the required weight of A.I. by the pounds of A.I. per gallon to get how many gallons of formulation should be added to the tank. Because this will probably be a small number, multiply the number of gallons by 128 ounces per gallon to convert to ounces.

EXAMPLE:

$$\frac{0.417 \text{ lb A.I../tank}}{5.4 \text{ lb A.I./gal}} = 0.0772 \text{ gal/tank}$$

$$0.0772 \text{ gal/tank} \times 128 \text{ fl oz/gal} = 9.88 \text{ fl oz/tank}$$

Adding 9.88 fluid ounces of this formulated pesticide to 500 gallons of water will result in a 100 ppm solution.

VIII. Summary

Calibration is essential for good pest control. By calibrating equipment we maintain effective pest control, protect our health and the environment, prevent waste of resources and maintain compliance with state and federal laws. **Calibration makes sense**.

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Chapter Six
Calibration & Mixing — Question and Answer Review

1. **Q. When you have the right mixture in your spray tank, can you still apply the wrong amount of pesticide?**

   A. Yes. Noncalibrated application equipment will apply the pesticide at an unknown rate. Unless calibrated, the equipment could be under- or overapplying the pesticide.

2. **Q. What is the delivery rate?**

   A. **Delivery rate** is the total amount of pesticide delivered on the target over a period of time.

3. **Q. Once your sprayer is calibrated, does it remain the same or should you recheck it often?**

   A. It must be rechecked often. For example, nozzles can wear or become plugged, thus changing the delivery rate.

4. **Q. If your sprayer is delivering less spray per acre than you want, how would you usually change the rate?**

   A. Change pump pressure, speed, or nozzles.

5. **Q. What must you measure to calibrate granular application equipment?**

   A. You must measure the amount of granules spread over a known area.

6. **Q. Must you calibrate granular application equipment each time you change granules? Applicators? Why?**

   A. Yes to both questions, because each granule flows differently, and, in hand models, each applicator may walk or crank at a different speed.

7. **Q. What facts must you know for the "gallons per acre — known area" method of sprayer calibration?**

   A. The number of square feet in an acre, the speed of your sprayer, the width of your spray boom, and the delivery rate of your sprayer.

8. **Q. Thirty-two ounces of water were collected from one spray nozzle in 30 seconds. What is the nozzle delivery rate in gallons per minute (GPM)? (ex. 6.4)**

A. Delivery rate = $\frac{32 \text{ ounces (wet)}}{30 \text{ seconds}} \times \frac{1 \text{ gallon}}{128 \text{ ounces}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 0.5 \text{ GPM}$

9. Q. Why is it so important to add the correct amount of pesticide to the mix?

A. Too little may result in poor results; too much may result in crop injury, illegal residues, or unnecessary expense.

10. Q. If your recommendations call for 3 pounds of wettable powder per 100 gallons of an emulsifiable concentrate, how much do you put in a 450 gallon tank? Show your calculations.

A. Answer: 13.5 pounds. There are 4.5 times as much water in the 450-gallon tank as in the 100-gallon tank, so 4.5 x 3 pounds = 13.5 pounds.

11. Q. How much do you put in an 80 gallon tank at 3 pounds per 100 gallons?

A. Answer: 2.4 pounds. 80 gallons is 80/100 of 100 gallons = 4/5. 4/5 x 3 pounds = 2.4 pounds.

12. Q. If the label says to mix 3 pints per 100 gallons of an emulsifiable concentrate, how much do you put in a 300 gallon tank? How much in a 50 gallon tank?

A. Answer: Nine (9) pints, or 1 gallon and 1 pint in 300 gallons. 3 x 3 pints = 9 pints.
Answer: 1 1/2 pints in 50 gallons. 1/2 x 3 pints = 1 1/2 pints.

13. Q. If two pints of EC are recommended per 100 gallons of water, how many teaspoons of EC would you add to one gallon? (1 pt. = 32 tsp.)

A. Answer: 2 teaspoons. 1/100 x 2 pints x 16 fluid ounces = 0.32 fluid ounces or a little less than 2 teaspoons.

14. Q. How much does 100 gallons of *water* weigh?

A. Answer: 100 x 8.34 lbs per gallon = 834 pounds.

15. Q. How many gallons of 25% emulsifiable concentrate would you add to a 50 gallon tank to get a 1% mixture? (ex. 6.13)

A. Answer: 2 gallons.
0.1 x 50 gallons x 8.34 pounds per gallon = 4.17 pounds active ingredient in 50 gallons of 1% solution.

0.25 x 1 gallon x 8.34 pounds per gallon = 2.085 pounds active ingredient per gallon of 25% EC

4.17 ÷ by 2.085 = 2 gallons 25% EC to make 50 gallons of 1% solution.

16. Q. How many pounds of 25% wettable powder must you add to 100 gallons of water to get a 1% active ingredients mixture? (ex. 6.14)

A. Answer: 33.36 pounds or almost 33 pounds 6 ounces.
0.01 x 100 gallons x 8.34 pounds per gallon = 8.34 pounds active ingredient in 100 gallons of 1% solution.

0.25 x 1 pound = 0.25 pounds active ingredient per pound of 25% WP

8.34 ÷ 0.25 = 33.36 pounds 25% WP to make 100 gallons of 1% solution.

17. Q. How much must the pressure increase to double the outflow?

A. Pressure must be increased four times to double the flow rate.

18. Q. What are *closed mixing* and *loading systems*?

A. *Closed mixing* and *loading systems* are systems designed to prevent pesticide from coming in contact with handlers or other persons during mixing and loading.

19. Q. What are *enclosed application systems*?

A. In *enclosed applicaiton systems*, a cab, cockpit, or other enclosure that surrounds the occupants and prevents them from coming in contact with pesticides outside of the enclosure.

20. Q. When should you consider installing a pesticide containment system?

A. If you often mix and load pesticides in one place, or if you often clean equipment at one location.

21. Q. What are the advantages of pesticide containment systems?

A. They can save time and money. They make spill cleanup easier, and they reduce pesticide waste by allowing reuse of rinse water and spill cleanup water. They also help prevent the harm that spills and runoff can cause to the environment or to people.

22. Q. What two precautions should you take to avoid getting pesticides into your water source at a mix-load site?

A. 1. Keep the water pipe or hose well *above* the level of the pesticide mixture, and use a device to prevent back-siphoning, if necessary.
2. Avoid mixing or loading pesticides in areas where a spill, leak, or overflow could allow pesticides to get into water systems.

[1]This chapter is a revised version of University of California Publication 3324.

CHAPTER 7:

PESTICIDE APPLICATION EQUIPMENT

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I. Introduction

Chapter Objectives

By the time you finish this chapter, you will

- learn the names and uses of the various types of application equipment;
- learn how to select the best application equipment for the job;
- understand the basic principles of operation for each type of equipment;
- know the advantages and disadvantages of each type of application.

Terms To Know

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

Agitation — Process of stirring or mixing.

High-pressure Sprayers — Sprayers using diluted sprays; pressure can be regulated up to several hundred pounds.

Low-pressure Boom Sprayers — Sprayers using low volumes and low pressures; can be adapted for many application situations.

Pressure Gauge — Indicates current pressure in a pressurized system.

Pressure Regulator —Maintains a required system pressure.

Pump — The "heart" of a sprayer, varied types are available for different application situations, each with advantages and disadvantages.

Every time you apply pesticides, you have a responsibility to make certain that the pesticide is applied correctly. Proper pesticide application is essential to the success of a pest control strategy. Pesticide equipment is one of the keys to proper application. Equipment ranges from the simplest garden hose attachment to complex fixed-wing aircraft or helicopters. Application equipment is designed to get the specific pesticide to the desired target. Most application equipment can be used for several different kinds of pests, and most application equipment can be placed into two groups: one that applies dry pesticide formulations and another that applies liquid pesticides. By choosing the type of equipment best suited for the type of work, applicators can save themselves time and money. In this chapter, different types of pesticide application equipment are described. Included in the description are the advantages and disadvantages of each type of equipment, along with information regarding component parts.

II. Application Equipment

Closed mixing and loading systems, enclosed application systems, and pesticide containment systems are excellent investments for applicators who handle large quantities of pesticides or who handle pesticides that are very hazardous to humans or to the environment. In some cases these systems may be required for handling certain pesticides or when pesticides are used in or near sensitive areas.

Closed Mixing and Loading Systems

A closed mixing and loading system is a system designed to prevent pesticide from coming in contact with handlers or other persons during mixing and loading. The labeling of some pesticides requires you to use a closed mixing and loading

system when handling the product. This requirement usually appears on products that have a high risk of causing acute effects or that may cause delayed effects. Typical statements on the labeling of such products include:

> **Must be transferred and mixed using closed system equipment. Do not use open mixing vats or tanks, or open pouring.**
>
> **Must be transferred into the spray tank through the use of a mechanical transferring device.**

There are two primary types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment; the other type uses soluble packaging.

Mechanical Systems

Mechanical systems are often a series of interconnected equipment that allows you to remove a pesticide from its original container, rinse the empty container, and transfer the pesticide and rinse solution to the application equipment without being exposed to the pesticide. The most common mechanical closed systems are for use only with liquid formulations.

Closed mixing and loading systems are often custom-made, using components from several commercial sources. Because pesticide container openings, shapes, and sizes vary, no single closed system can be used with all containers. The mechanical systems now available remove the pesticide concentrate from the original container in one of two ways: by gravity or by suction.

Gravity systems, sometimes called "punch and drain" systems, are available for use with both liquid and dry concentrates. The unopened pesticide container is inserted into a chamber, which is then sealed. A punch cuts a large opening in the container, allowing all the material to drain into the mixing tank. A water nozzle attached to the punch sprays the inside of the container to rinse it thoroughly. The rinse water then also drains into the mixing tank. The rinsed container is then removed for disposal and/or recycling.

A disadvantage is that only full container quantities can be used. It is not possible to use only part of the pesticide in a container and store the rest.

Suction systems use a pump to remove the pesticide through a probe inserted into the container. Some containers are equipped with built-in probes. The pesticide is transferred to the mixing tank by hose and pipe. When the container is empty, it and the transfer system are rinsed with water. The rinse water is added to the mixing tank for application to the labeled site..

To allow the use of only part of the pesticide in the container, the system must have a way to measure the amount of pesticide suctioned into the mixing tank and must allow the probe to remain in the container until all the pesticide is used and the container and probe can be rinsed. Some probes have a breakaway head that allows the head to stay and the probe to be withdrawn and reused.

Disadvantages are that some suction systems do not permit the resealing of partially emptied containers, and that highly viscous pesticides (those which pour like molasses) may be difficult to remove by suction.

Soluble Packaging

Soluble bags or containers are a much less complex type of closed system mixing and loading. The pesticide package, which is designed to be placed, unopened, into the mixing tank, dissolves in the solvent (usually water).

A disadvantage of soluble packaging is the risk of accidentally releasing the concentrate if the packaging is exposed to water or other solvents during shipping or storage. The bags are also easily punctured.

Enclosed Application Systems

You can reduce your exposure to pesticides by using enclosed systems to do some applications. An enclosed application system is an enclosure, such as a cab or cockpit, that surrounds the occupants and prevents them from coming in contact with pesticides outside of the enclosure.

Secondary Containment Systems

If you often mix and load pesticides in one place, or if you often clean equipment at one location, you may find a pesticide collection tray or pad a good investment. These trays and pads are designed to catch spills, leaks, overflows, and wash water and allow them to be recovered for reuse or disposal. Smaller trays and pads can be portable, but larger pads may be permanently installed.

These systems can save you time and money. They make spill cleanup easier, and they reduce pesticide waste by sometimes allowing you to reuse the rinse water and the spill cleanup water. They also help prevent the harm that spills and runoff can cause to the environment or to people.

Collection Trays

A collection tray can be used at mixing, loading, and equipment cleaning sites where only small amounts of pesticide are handled at a time and portable equipment is used. Such tasks often take place on a counter or bench. The tray can be made of sturdy chemical-resistant rubber or plastic, such as a boot or shoe mat. The tray must have a rim around it to collect spills and leaks and should have a spout where the contents can be poured off.

Collection Pads

A collection pad is suitable for mixing, loading, and equipment cleaning sites where large quantities of pesticides are handled and large equipment is cleaned. Such operations often take place outdoors or in a large, open space in a building such as a barn.

The collection pad should be made of a waterproof material, such as sealed, smooth concrete; glazed ceramic tile; or no-wax sheet flooring. Porous surfaces, such as wood, asphalt, soil, or carpeting, are not acceptable. The pad must be concave or must have curbs or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to be created at the site. It also must be equipped with a system for removing and recovering spilled, leaked, or released material — either an automatic sump system or a manually operated pump.

Locate the collection pad where rainwater, irrigation water, and flood water cannot flow over it. Wash the pad periodically to prevent possible harm to the environment and to animals and unprotected people.

Choosing Equipment

Take the time to choose your application equipment carefully. If you select the right equipment, you will not only be assured of satisfactory results, but you will also be able to use the same equipment for several types of pest problems. Even an applicator who specializes in one specific type of pest control will need to give careful consideration to equipment. Remember, too, that agricultural applications require very different equipment from structural applications.

Choose your equipment according to the following factors:

Time

How quickly do you have to apply a specific pesticide to achieve an acceptable level of control? Will the equipment be of sufficient size and capacity to treat the required area in an acceptable amount of time?

Suitability

Will ground equipment be restricted by the size of the crop or field conditions? If you move equipment through the field, will you damage the crop or spread the pest or disease? Can aerial application be safely used? Can the equipment be cleaned easily after use?

Frequency

How many times will the application need to be made in a season?

Treated and Surrounding Areas

What is called for – spot, band, or broadcast application? If the field is close to an urban area or school, what type of buffer zone does this treatment require? Will the application cause damage to the surrounding environment? Should you consider other methods of control that would reduce or eliminate the need for pesticide treatment?

Costs and Inputs

Which method is most economical? Can the equipment be used for other applications? Can changes in cultural practices reduce the need for treatment? Is sufficient manpower available for a timely application?

Different types of equipment offer certain advantages and disadvantages, which you need to evaluate in your choice.

Aerial Equipment

Fixed-Wing Aircraft

About 7,500 aircraft are used each year in the United States for aerial application. Most of the approximately 250 aircraft used in Arizona for agriculture are single-engine, high- or low-wing monoplanes. On large areas like forest or range land, multi-engine aircraft are used.

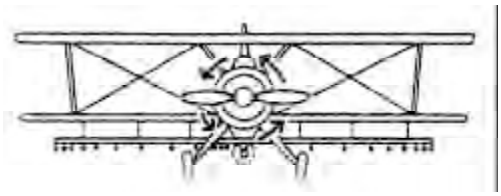

Figure 7.1 Fixed-Wing Aircraft

Advantages: Aerial application is fast and convenient, especially when you have to take quick action. Aerial methods also allow treatment when a field is at full cover or too wet for ground equipment to operate.

Disadvantages: Fixed-wing aircraft cannot generally treat small fields and are difficult to operate in areas that are close to urban areas or that have many hazards such as power lines and tall trees. Generally, application costs are higher with aircraft than with ground equipment (although the speed and timeliness may offset the cost difference). Drift may be a greater problem.

Helicopters

Helicopters have increased in use in recent years, but total flight time is quite small compared to other aircraft.

Advantages: Helicopters can be flown at slower speeds and make faster turns; they also apply a more uniform swath.

Disadvantages: Helicopters are more complex and require more maintenance; this increases the application cost per acre.

Ground Equipment

Low Pressure Boom Sprayers

Low-pressure boom sprayers are designed to handle most spraying needs on general farms and are probably used more than any other equipment (Fig 7.2). Usually mounted on tractors, trucks, or trailers, they can be driven over fields or large turf areas for broadcast or band pesticide applications. Low pressure sprayers generally use relatively low volumes (10-40 gal per acre) of dilute spray, applied at 30-60 lb of pressure (because roller type pumps are usually used, pressure cannot be more than 70 lb/sq in.). Handguns may be attached for remote spraying or spot treatments on weed patches and limited pest infestations.

Advantages: Low-pressure sprayers are relatively inexpensive and lightweight. They can be adapted to many uses and cover large areas rapidly. Since they are usually low volume sprayers, one tank load will cover a large area.

Disadvantages: Low pressure sprayers cannot adequately cover or penetrate dense foliage because of the low pressure and volume. Because most rely on bypass systems and return-flow agitations, wettable powder or flowable formulations often settle out; this problem can usually be overcome with mechanical agitators.

Figure 7.2 Low pressure boom sprayer

High Pressure Sprayers

High pressure sprayers are often called "hydraulic sprayers"; they operate with diluted sprays but the pressure can be regulated up to several hundred pounds. They are used for spraying shade trees, ornamentals, livestock, orchards, and farm buildings, as well as unwanted vegetation where dense foliage requires good penetration.

Advantages: High-pressure sprayers are used for many different pest control jobs because they can penetrate heavy vegetation or thick animal hair and can reach the tops of tall shade trees. Because they are strongly built, they are relatively long-lasting and dependable.

Disadvantages: High-pressure sprayers are usually heavy and expensive and require large amounts of water and frequent filling. High pressure means fine spray droplets, which increase drift problems.

Air Blast Sprayers

Air blast sprayers are used for virtually all spraying in commercial orchards and are often used on shade trees(Fig 7.3). They are primarily designed to carry pesticide and water mixtures under pressure from a pump through a series of nozzles. Operating at low, medium, or high pressure, the nozzles deliver the spray droplets into a stream of air. High-volume fans supply the air, which is directed to one or both sides as the sprayer moves between the rows of the trees. The blast of air aids in breaking up larger drops and transporting the droplets to provide thorough coverage. These sprayers usually have a mechanical agitator.

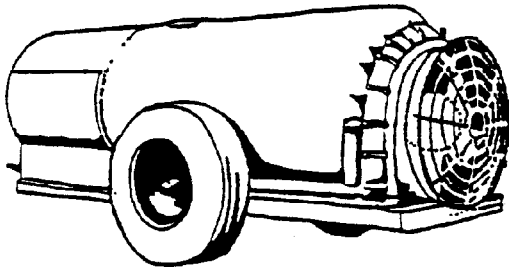

Figure 7.3 Air blast sprayer

Advantages: Air blast sprayers use only a small amount of water to cover large areas; very little operating time is lost in refilling.

Disadvantages: Air blast sprayers can be used only in calm weather. The air blast causes drift, and windy conditions interfere with the normal pattern of the blower. Larger models cannot be used to treat hard-to-reach areas.

Mist Sprayers

Mist sprayers are characterized by high air speeds and somewhat lower water volumes than conventional air blast sprayers. They have a metering device (possibly a conventional nozzle) that operates at low pressure and breaks up liquids through high-speed air.

Advantages: Mist sprayers save time and labor, primarily because less water is handled than with conventional air blast sprayers.

Disadvantages: Calibration on mist sprayers is more difficult, and favorable weather is more essential for spraying. On certain crops, coverage may be less satisfactory than with the normal volumes delivered by conventional air blast sprayers. Drift from target crop will limit its use.

Ultra-Low Volume (ULV) Sprayers

ULV sprayers apply the chemical concentrate directly to the target with a minimum of water or other liquid carrier. Some ULV ground sprayers have a fan that delivers high-speed air to help break up and transport spray particles.

Advantages: ULV sprayers save time and labor because water is not needed. They are commonly used for mosquito abatement programs.

Disadvantages: ULV sprayers increase applicator's risk from handling and spraying concentrated pesticide. Also, only a limited number of pesticides are cleared for ULV application. Calibration and the angle at which the ULV device is set are critical. ULV sprayers are not well suited for herbicide applications.

Aerosol Generators and Foggers

Aerosol generators and foggers break certain pesticide formulations into very small droplets or aerosols, so fine that a single droplet cannot be seen. When a large number of droplets are formed, however, the droplets appear as a fog or smoke. Foggers are usually used to fill an area with a pesticide fog (e.g., a greenhouse, warehouse, or open recreational area). Insects and other pests in the treated area will be controlled when they come in contact with the aerosol fog.

Advantages: Droplets produced by foggers are so fine that they do not stick to surfaces within the area. Foggers usually apply fairly safe formulations that can be used in populated areas for mosquito or other insect control without the problem of unsightly residues. The droplets float in the area and penetrate into tiny cracks and crevices or through heavy vegetation to control pests in hard-to-reach places.

Disadvantages: Foggers allow little, if any, residual control because the droplets do not stick. As soon as the aerosol dissipates from an area, new pests can move in. Foggers must be used under the correct weather conditions; for example, rising air currents could carry the fog above the pests and out of the treated area, without any contact.

Granular Spreaders

Granular equipment is designed to apply coarse, uniformly sized dry particles to soil, water, and in some cases, foliage(Fig 7.4). Spreaders may work with several types, including air blast, whirling disks, multigravity feed outlets, and soil injectors. Granular spreaders may also be used in broadcast and band applications.

Advantages: Granular spreaders, like dusters, are light and relatively simple; no water or dilution is needed. Because granular formulations are uniform in size, they flow easily and are relatively heavy.

Disadvantages: Granular materials do not stick to foliage and must be applied to the soil. Therefore, the applicator will need additional machinery for foliar applications.

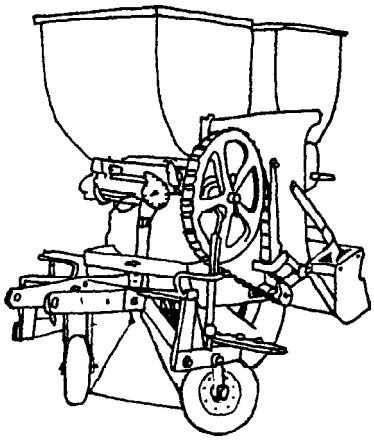

Figure 7.4 Granular spreader

Soil Injectors

Soil injectors are frequently used to apply fumigation materials to the soil to control nematodes and other soilborne pathogens, weed seeds, or insects. The most common method of soil application involves the use of chisel cultivators or shanks with a liquid or granular tube down the back, permitting material to be placed in the soil to a depth of a foot or more. With volatile materials, the shanks should be spaced one foot apart for a continuous band in order to achieve good coverage. Sweep-type elevator shovels, with a series of nozzles on the trailing edge, may be used to apply a single band of continuous cover beneath the soil surface.

Advantages: Soil injection is not likely to cause as much phytotoxic damage as foliar applications. Soil injections can be more precise, and undiluted or minimally diluted materials can be used at very low rates.

Disadvantages: The pressure orifice for low application rates must be very small on soil injectors; because of their size, it is difficult to keep them from plugging. Use of granular feed materials or positive displacement pumps, usually driven from a ground wheel of the application machine, can overcome this difficulty.

Injector Sprayers

Injector sprayers continuously measure concentrated pesticide into the spray system as needed. They contain one or two tanks for concentrated pesticide and usually one large water tank as a carrier. These sprayers can be designed so the volume of pesticide is controlled by ground speed or set for a constant ground speed.

Advantages: Injector sprayers have no mixed chemical left over after spraying.

Disadvantages: Injector sprayers' lead time for metering the concentrated injection may vary according to application rate and size and length of hose. Precise metering equipment is essential to achieve accurate application rates.

Wiper Applicators

Several types of wiper applicators are commercially available for field applications. One consists of a long horizontal, 3- to 4-inch-diameter pipe filled with a translocatable herbicide. A series of short, overlapping ropes or a wet pad are in contact with the herbicide and become saturated through a wicking action. As the ropes or pad on the pipe touch the weeds, they wipe on the herbicide. Another type uses a rolling tube covered with carpet that is continuously wetted. These applicators are sometimes mounted to the three-point hitch on a tractor.

Advantages: Wiper applicators apply herbicide only to the weeds; less herbicide is required.

Disadvantages: Wiper applicators cannot treat weeds below the crop canopy, but hand-held applicators that use the same principle can be used. Wiper applicators can also drip and cause crop injury. Multiple applications are usually required.

Other Types

Other types of equipment include hand-operated sprayers or dusters, most commonly used by individuals for relatively small pest problems or jobs that need only small amounts of spray. They are especially useful in hard-to-reach places where spray equipment access is limited.

Another type is the aerosol bomb, which is a pressurized can or tank with a self contained discharge nozzle and valve. Backpack equipment includes crank operated and spin disk granular applicators and hand sprayers with a capacity of up to five gallons; pressure is supplied by a hand operated piston or diaphragm pump. Some backpacks are motorized to apply granules, dusts, or sprays.

III. Spray Equipment Parts

To apply pesticides properly, an operator must have the right equipment and use it correctly. Selection of a good quality sprayer requires careful attention to each of the following parts(Fig 7.5):

Tanks

Tanks should be made of stainless steel, fiberglass, or polyethylene to avoid problems of rust, sediment, plugging, and restriction. Aluminum, galvanized, or steel tanks should not be used. Tanks ranging from 55 to 150 gallons are available on mounted sprayers with 200 gallons or larger on pull-type sprayers. Tanks need to have a large covered opening in the top with a removable strainer to make filling, inspection, and cleaning easy. Capacity marks on the side or a site gauge is required for adding the correct amount of water. Tanks should be rinsed with water and a suitable cleaning agent after every use and should have a drain in the bottom for complete emptying during cleaning.

Tank Agitators

Agitators are used both for initial mixing of pesticides and to keep insoluble mixtures from settling inside the tank. Equipment with agitators is recommended whenever wettable powders, water dispersible granules or emulsions are used. Agitation can be mechanical or hydraulic. Hydraulic agitation circulates materials back through jets at the bottom of the tank at least one foot from the tank walls. Mechanical agitators are propellers or paddles mounted on a shaft that is positioned near the bottom of the tank.

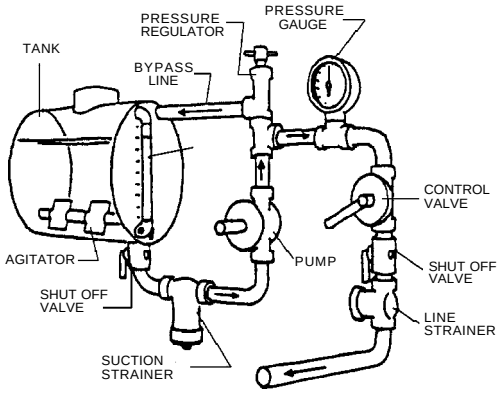

Figure 7.5 Basic spray equipment

Pumps

The pump is the heart of the sprayer. Many types are on the market and each has specific advantages and disadvantages. The following are the most important factors to consider in selecting a pump:

Capacity

Pumps should have sufficient capacity to supply the boom output and provide for bypass agitation if needed. The pump's capacity should be at least 20% greater than the largest volume required by the nozzles and agitation.

Pressure

The pump must be able to produce a desired operating pressure at the capacity required for the spraying job.

Resistance to Corrosion and Wear

The pump must be able to handle the chemical spray materials without excessive corrosion or wear. Some pumps handle abrasive materials such as wettable powders with much less wear than others. Chemical reaction and corrosion affect certain materials more than others.

Repairs

Pumps should be designed so repairs can be made economically and quickly.

Type of Drive

The pump should be readily adaptable to the available power source.

Types of Pumps

Piston pumps. These are positive displacement pumps that can provide high pressures (Fig 7.6). Piston pumps can apply both corrosive and abrasive materials. The piston pump is relatively expensive but has a long life. Large piston pumps have a capacity up to 60 gallons per minute and are used at pressures up to 1000 pounds per square inch. A piston pump requires a surge tank at the pump outlet to reduce line pulsation.

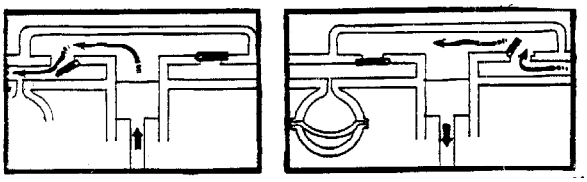

Figure 7.6 Piston pump

Diaphragm pumps. These positive displacement pumps have the same system hookup requirements as piston pumps. They are capable of producing pressures up to 850 pounds per square inch and volumes up to 60 gallons per minute.

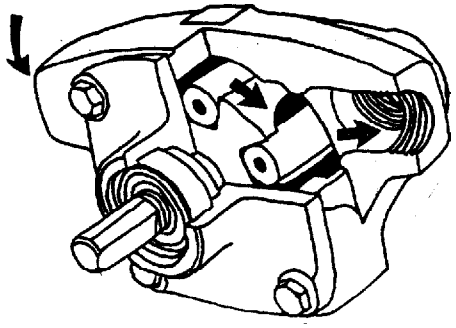

Figure 7.7 Roller impeller pump

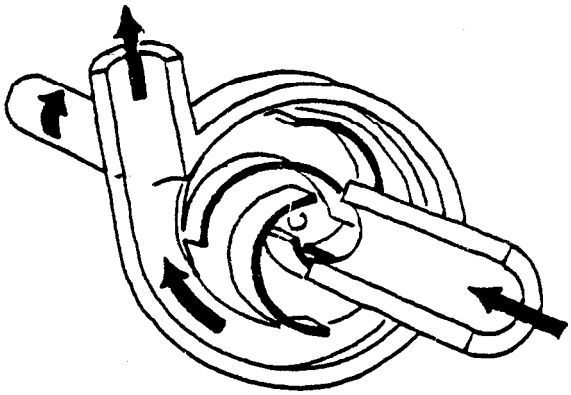

Figure 7.8 Centrifugal pump

Roller impeller pumps. These are widely used pumps in agriculture. They are relatively inexpensive and adaptable to a wide range of pressures, volumes, materials, and situations (Fig 7.7). The pumping action is created by the roller following the eccentric housing, forcing the material out of the slots and expelling it. Roller pumps are positive displacement and self-priming. They can produce low to moderate pressures up to 300 pounds per square inch and have capacities to 50 gallons per minutes. Abrasive materials will cause extreme wear on and failure of roller pumps (especially wettable powders). Roller pumps should have factory lubricated, sealed ball bearings, stainless steel shafts, and replaceable shaft seals.

Centrifugal pumps. These popular pumps can handle coarse or abrasive materials effectively (Fig 7.8). Pumping action is created by a high-speed impeller that literally throws the materials out of the pump. These pumps are most frequently used for low pressure sprayers. They can operate at pressures up to 200 pounds per square inch and volumes up to 200 gallons per minute, but volume drops off rapidly at pressures above 30 to 40 pounds per square inch. These pumps should be located below the supply tank to aid in priming.

Filters

Filters are used in sprayers to prevent foreign materials from entering and wearing precision parts of the sprayer and plugging nozzles. Suction line strainers (forty to fifty mesh) should be used between the tank and pump. Because the inlet of centrifugal pumps must not be restricted, suction line filters on most sprayers should be no smaller than 20 mesh or should be installed on the outlet side. These strainers help give uniform flow and prevent nozzle tips from clogging. The screens in nozzle tips should be sized according to the opening; the nozzle manufacturer catalogs list the recommended strainer for each tip. Filters should be checked and cleaned often to prevent poor coverage and pressure loss. The largest screens should be close to the pump, and smaller screens close to the nozzles.

Pressure Regulators

The pressure regulator or relief valve maintains the required pressure in the system. It is spring-loaded and opens to prevent excess pressure in the line while providing for some solution to return to the tank. Pressure-relief valves are generally not needed with centrifugal pumps, which can be controlled by a gate valve. For operating pressures over

200 pounds per square inch, the relief valve should be replaced with an unloader valve that reduces the pump pressure when the boom is shut off.

Pressure Gauges

Accurate pressure measurement is important. A pressure gauge should have a range twice the maximum expected reading. Spray nozzles are designed to operate within certain pressure limits, which should not be exceeded. High pressure can cause dangerous fogging and drift, while low pressure may increase droplet size so much that proper coverage is not obtained. Regularly check pressure gauges to determine their accuracy. Recognize that faulty pressure gauges may provide incorrect readings. Malfunctions will be indicated by fluctuations in pressure. The pressure gauge should be located near the delivery point to determine pressure drop from the regulator to the nozzles.

Control Valves

On boom sprayers, fast-acting control valves should be installed between the pressure regulator and boom to control the flow of materials. Special selector valves, of either manual or electric solenoid, are available to control the flow of spray materials to any section of the boom. Electric types offer the advantage of remote control from the operator's seat with no need to bring pressurized hoses near the operator. However, if there is a malfunction, the operator may not realize it.

Hoses and Filters

Hoses should be resistant to sunlight, oil, and chemicals. They should be made of neoprene or other soil-resistant materials and be strong enough to withstand peak pressures. Test hoses at twice the operating pressure. Suction hoses should be as short as possible, noncollapsible, and as large as the pump intake. Hoses and lines should be sized for velocity flow rates of approximately 5 feet per second. High velocities will result in high-pressure loss; low velocities will allow wettable powders to precipitate out.

Nozzles

Nozzles for sprayers are very important to proper pesticide application. Even experienced applicators overlook the proper selection and maintenance of nozzles, which are perhaps the most important component of liquid pesticide application equipment.

Nozzles serve three functions:

- They meter or regulate the flow of the liquid
- They atomize the liquid stream into droplets
- They spread droplets in a specific pattern

Nozzles have four major parts (Fig 7.9):

- Body
- Cap
- Strainer (screen)
- Tip or orifice plate

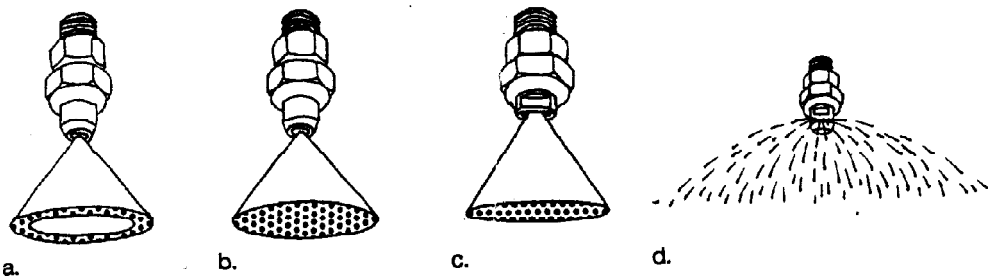

Figure 7.10 Nozzle types (a. hollow cone, b. solid cone, c. flat fan, d. flooding flat fan)

They may also include a separate spinner plate. Successful spraying depends on the correct selection, assembly, and maintenance of the nozzles.

Special screens fitted with a check valve help prevent nozzle dripping. Check valves should be used in situations where a sprayer must be stopped and started frequently, such as in small target areas, near sensitive crops or areas, indoors, or for right-of-way treatments.

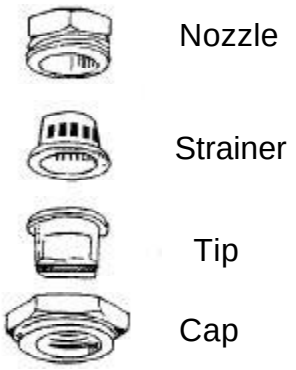

Figure 7.9 Parts of a nozzle

Nozzle tips break the liquid pesticide into droplets. They also distribute the spray in a predetermined pattern and are the principal elements that control the rate of application. To prevent clogging, place the largest screens closest to the tank. Screens should become progressively smaller toward the nozzle. Clean them often.

Nozzle types (Fig 7.10)

Solid-stream nozzles are used in handgun sprayers for a distant or specific target, such as livestock or nursery and tree pests, and for crack and crevice treatment in and around buildings.

Fan-pattern nozzles include at least three types–regular flat, even flat, and flooding.

Flat fan nozzle tips produce a nearly flat fan in several selected angles and deposit a flat, elliptical pattern on the ground. The outer edges of the deposit are of reduced volume, so this method requires an overlapping spray pattern. The overlap must be approximately 50% for even distribution. Flat fan nozzles can be used for herbicide, fungicide, and insecticide application.

- *Even flat fan nozzles* are available in 40, 65, 80, 95 and 110 degree fan angles, which provide a uniform distribution of spray throughout the pattern. Spray patterns do not overlap and thus are applied as separate bands.

- *Flooding (flat fan) nozzles* deliver a wide-angle flat spray pattern, fairly uniform across the width, but not as even as the regular flat fan nozzles. They operate at very low pressure and produce large spray droplets. The advantage of this nozzle is its even coverage on extremely rough terrain.

Cone-pattern nozzles have hollow and solid cone patterns and are produced by several types of nozzles. These patterns are used when penetration by herbicides, insecticides and fungicides and coverage of plant foliage or other irregular targets is desired.

- *Hollow cone nozzles* are designed for moderate to high pressures (40 - 60 PSI) under very uniform distribution conditions.

- *Solid cone nozzles* are used for hand spraying and spot spraying under moderate pressure (40 - 80 PSI) where larger, heavier droplets are required to reduce drift. The cone nozzle increases coverage of the foliage.

Table 7.1 Wear comparison of common nozzles to brass

Nozzle material	Durability compared to brass
Polymer	0.7 to 1.0 times greater
Stainless steel	3.5 times greater
Hardened stainless (HSS)	10 to 15 times greater
Ceramic	90 to 100 times greater

Nozzle material

Brass wears quickly from abrasion but is probably the most commonly used material for general use.

Polymer will not corrode but may swell when exposed to organic solvents. It is also subject to chipping and breakage.

Stainless steel resists abrasion, especially if hardened; it is suited for high pressures, particularly with wettable powders.

Hardened stainless steel has a very good wear life; good durrability and chemical resistance.

Carbide and **ceramic** are highly resistant to abrasion and corrosion. They are recommended for high pressure and abrasive sprays. They can be expensive.

The durability of various nozzle materials compared to brass is shown in Table 7.1

Nozzle Tip Numbers

Nozzle tip numbers are fairly uniform among the various manufacturers. The first two or three numbers refer to the angle of spray discharge and the last four to the gallons per minute of the tip at 40 pounds per square inch. For example, nozzle tip number 650067 means a nozzle tip with a 65 degree angle of fan discharge that delivers 0.067 gallons per minute at forty pounds per square inch. The decimal point is placed by counting three figures from the left side (i.e., a Tee Jet 8004 nozzle tip delivers 0.4 gallons per minute.) For spraying heights where the boom is 17 to 19 inches from the surface to be sprayed, 80 degree tips are recommended; for 19 to 21 inches, 73 degree nozzle tips, and for 21 to 23 inch, 65 degree tips are recommended. Risk of drift is generally greater with the wider nozzle tip angle.

Things to Remember

- Select a nozzle that will provide the desired droplet size, volume, and pattern.
- Supply the nozzle with a pesticide mixture free of foreign particles and at a properly regulated pressure.
- Mount nozzles so their location relative to the target remains constant and proper.
- After installation, calibrate the system to ensure that in all respects it is applying uniform coverage at the desired rates.
- Maintain the system in peak condition by periodic inspections and calibrations, paying detailed attention to the performance of each nozzle.

Sprayer Equipment Maintenance

Effective pesticide application depends on properly maintained and adjusted application equipment. Spraying equipment problems can be reduced or eliminated by regularly inspecting, servicing, and maintaining the equipment. Prevent the problems before they occur.

Preventive tips

- Check all gauges, hoses, pumps, and nozzles for leaks or malfunctions.
- Keep screens in place. Filter screens are designed to remove foreign particles from the spray liquid.
- Use clean water. Always use water not contaminated with sand or silt, which can damage pumps, screens, and nozzles.
- Clean nozzles regularly.
- Before use, flush stored or new sprayers to remove dirt, leaves, or rust.
- Inspect at regular intervals.
- Before storage, decontaminate and clean thoroughly.

Equipment Cleanup

Every time you have finished applying a pesticide, follow these basic equipment cleanup procedures;

1. Always clean mixing, loading, and application equipment as soon as you finish using it—do not leave equipment with pesticides on or in it at the mixing and loading site or at the application site. When the job is completed and the tank is empty, return the equipment to the designated equipment cleanup area. Avoid washing equipment repeatedly in the same location unless you use a containment pad or tray. Over time, the flooring or soil in a frequently used area can become contaminated with large amounts of pesticides. Also avoid keeping pesticide-contaminated equipment in one location all the time. Pesticides may move off the outside of the equipment and onto the floor or soil.

2. Do not assign a worker to clean pesticide-contaminated equipment unless that person has been instructed in the basic rules of pesticide safety. Remember that equipment cleaning presents as great a risk of exposure to pesticides as do many other pesticide handling tasks, and that all parts of the equipment are likely to have pesticide residues on them. When you clean pesticide-contaminated equipment, wear the personal protective equipment that the labeling requires for handling jobs, plus a chemical-resistant apron.

3. After the equipment is empty, clean both the inside and outside properly and thoroughly, including nozzles or hopper openings. Sometimes you may need to use the diluent used in the pesticide mixture (kerosene or high-grade oil), special cleaning agents, or water under pressure. In other cases, ordinary water may be enough.

   Sloppy cleanup practices are one of the main causes of equipment failure or malfunction. Never keep excess pesticides in your equipment for more than a short time. Even small amounts of pesticide residues that are left in equipment can damage it.

   Liquid pesticides that are left in the equipment may quickly corrode the equipment and clog or corrode the nozzle openings. They may cause the equipment to leak or cause the nozzles to release too little or too much pesticide when the equipment is operated. Some liquid pesticides change or degrade if they are stored after being diluted and will not be suitable for application at a later time. Some will settle out and form a solid clump at the bottom of the tank that even mechanical agitation cannot remix. Others will separate into two or more separate liquids that cannot easily be

remixed. Liquid pesticides that are allowed to stay in the equipment until they are totally dry may be impossible to remove completely at a later time.

Dry pesticides that become wet through humidity, rain, dew, or other moisture tend to clump and stick to the sides and hopper openings. They cannot be applied at a later time, and they cannot be easily removed from the equipment.

4. Wash with special care any vehicles that may be used for transporting unprotected workers or for family use. People have been poisoned by riding in vehicles that were used to apply pesticides or to perform flagging for aerial applications.

Spray Monitors and Controllers

Spray monitors are available in nozzle or system types. Nozzle monitors sense the flow through individual nozzles and provide a signal (flashing light or buzzer) if flow stops. This is particularly useful with nozzles that the operator cannot see. System monitors sense travel speed, pressure, and/or flow. This information, along with manually entered inputs such as swath width and gallons of spray in the tank, is used to continuously compute and display the application rate. Some monitors also display field capacity (acres/hour), gallons applied, acres covered, and other measurements.

Spray controllers are basically spray monitors with the added feature of automatically controlling application rate through adjustments to pressure or flow. The controller calculates the actual application rate from the sensors and compares it to the desired rate. If there is a difference, it adjusts the application rate automatically. If the correction becomes too large to be corrected by pressure adjustments, the controller warns the opera.

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Chapter Seven

Pesticide Applicator Equipment — Question and Answer Review

1. **Q. When you choose the pesticide application equipment for a job, what do you have to consider?**

   A. Working conditions, pesticide formulations, type of area treated, possible problems.

2. **Q. Would a fogger producing a fine mist be a good choice if there is a sensitive area nearby and the wind is blowing?**

   A. No. Drift is too likely.

3. **Q. If your job was to treat a few acres of forage crop, and water was not easily available, what type of sprayer would you probably choose? Why?**

   A. A low-pressure boom sprayer. Use a low volume of dilute spray so that one tankful will cover a larger area.

4. **Q. Would you use the same sprayer if the pesticide was only formulated as a wettable powder and the crop had dense foliage? Why?**

   A. No. Low-pressure boom sprayers will not adequately penetrate or cover dense foliage because of their low capacity (pressure and gallonage). Wettable powder formulations often settle out.

5. **Q. Is a hydraulic sprayer a low-pressure or a high-pressure sprayer?**

   A. A high-pressure sprayer.

6. **Q. If you were an inexperienced applicator, which type of sprayer might easily lead you to injure crops or wildlife by overdosing with concentrated pesticides?**

   A. Air blast sprayer.

7. **Q. Identify four nozzle materials and describe their wear resistance.**

   A. Brass — least resistant to wear
   Plastic and nylon — not recommended for high pressure, but resists corrosion.
   Stainless steel — excellent wear resistance.
   Hardened stainless steel — useful for highly abrasive formulations.

8. Q. List the three functions of a spray nozzle.

A. (1.) Regulate the flow of the liquid;
(2.) atomize the liquid stream into droplets;
(3.) spread droplets in a specific pattern.

9. Q. Which nozzle delivers a wide flat spray patter consisting of large droplets?

A. Flooding (flat fan) nozzle.

11. Q. When should a sprayer be cleaned?

A. After each pesticide application.

CHAPTER 8:

FEDERAL & ARIZONA AGRICULTURAL LAWS

This is a part of publication az1149: "Arizona Agricultural Pesticide Applicator Training Manual," 2000, College of Agriculture and Life Sciences, The University of Arizona, Tucson, Arizona, 85721. Full publication located at http://ag.arizona.edu/pubs/insects/az1149/

I. Introduction

Chapter Objectives

By the time you finish this chapter, you will

- have a general understanding of the types of laws and regulations that affect pesticide applicators;
- be aware of the importance of having up-to-date knowledge about how to comply with all laws and regulations that affect your operation.

Terms To Know

EPA (Environmental Protection Agency) — Federal agency that administers laws outlined in FIFRA.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) — Primary federal law that regulates pesticide use in United States.

Hazard Communication Standard — Standard under jurisdiction of Industrial Commission of Arizona (ICA) that guarantees worker's right to know about any hazard found in workplace, including pesticides.

OSHA (Occupational Safety and Hazard Administration) — Federal agency that enforces rules regarding worker safety on job sites.

Restricted-use pesticide — Pesticide that can be applied only by certified applicators.

Pesticide regulation can be complex, merging science, public policy, and law. The pesticide regulatory process is never at a standstill, and the Environmental Protection Agency (EPA) continuously updates pesticide decisions as scientific knowledge increases.

If you use pesticides in Arizona, you should be aware of federal and state laws and regulations governing their use, and how these laws apply to your particular situation. This chapter will help you become familiar with U.S. and Arizona legislation, regulatory agencies, and requirements for licenses, permits, and certification.

II. Defining the Terms

The first step in understanding licenses, permits, and certification is to learn what each one enables you to do and to identify those that specifically concern you. The information in this manual is intended primarily for individuals involved in agricultural pest control.

Licenses can be issued in either agricultural or structural categories. Licenses are issued for business purposes. Four different types of agricultural licenses are available: custom applicator, agricultural aircraft pilot, agricultural pest control advisor, and application equipment.

A *custom applicator*'s license, which includes all aerial application, allows an individual or company to make aerial or ground applications, for pay, on agricultural land that belongs to someone else. An *agricultural aircraft pilot*'s license is necessary for anyone who flies aircraft for aerial pesticide applications.

An *agricultural pest control advisor*'s license allows an individual to make written recommendations for agricultural pest control. An *equipment* license is necessary for each piece of equipment used for custom ground or aerial agricultural application.

The three licenses issued for structural purposes (business, qualifying party, and structural pest control advisor) relate to pest control operations in and around urban structures, ornamental shrubs and trees, railroad cars, boats, docks, trucks, airplanes, golf courses, lawns, and cemeteries. More detailed information is in the *Arizona Structural Core Manual* or in the booklet, *Structural Pesticide Applicator Information: Licenses, Permits and Certification*, which is available from Agricultural Communication Systems, Publications Distribution Center, at the University of Arizona.

Permits are required to buy or sell pesticides and are issued in two categories: grower and seller. Someone who commercially grows or produces an agricultural commodity needs a *grower*'s permit to apply or have pesticides applied to his agricultural land. A *seller*'s permit enables an individual or a firm to sell or deliver pesticides in containers greater than one gallon liquid, fifteen pounds dry, 50 pounds for pesticide and fertilizer combinations, or **restricted-use pesticides** (RUPs) in any size amounts.

Certification is required to use or supervise the use of pesticides classified as restricted use. These substances have been restricted to limit their availability because their use by inexperienced or untrained people can result in adverse human health or environmental effects, even when the label directions are followed. To be certified, demonstrate competency to handle pesticides without endangering yourself, the public, or the environment. An agricultural applicator is certified by the Department of Agriculture.

An individual in agricultural pest control may be certified as a private or commercial applicator. A *private* applicator uses or supervises the use of restricted-use pesticides (RUPs) to produce agricultural commodities on land owned by the applicator or him or his employer. A **private applicator** may also apply or supervise application on someone else's land, as long as no compensation other than trading of personal services is involved. A *commercial* applicator is paid to use or supervise the use of restricted use pesticides for any purpose on property he does not own.

The following points are important to remember:

1. In agricultural pest control, certification is needed only for restricted-use products; people who apply only non-restricted pesticides need not be certified. Arizona law requires the holder of a *custom applicator*'s license (agricultural) to be certified as a commercial applicator or to employ someone who is certified (R3-13-204.C.1).

2. Certification credentials do not replace or substitute for any other permit or license required.

3. Licenses, permits, and certification credentials must be renewed annually.

4. Since specific regulations for obtaining agricultural or structural pest control credentials differ, appropriate requirements must be followed.

Professional registration programs

The *Certified Crop Advisor (CCA)* endorsement is a part of a voluntary program designed to establish base standards of knowledge for individuals who advise growers on crop management and production inputs. The program is coordinated by the American Registry of Certified Professionals in Agronomy, Crops and Soils (ARCPACS); it is not a regulatory designation nor is it affiliated with the Arizona Department of

Agriculture. Requirements for professional endorsement are two years of crop production experience and a B.S. degree in agronomy OR four years of post high school experience. An applicant must also pass CCA state and national certification exams and sign a code of ethics. A CCA certification does **NOT** exempt an applicator from obtaining and maintaining Arizona Department of Agriculture credentials.

III. State and Federal Laws and Regulatory Agencies

Federal

Pesticides in Arizona are governed by federal and state laws and regulations. The Environmental Protection Agency (EPA), established in 1970, issues pesticide-related rules to administer the primary federal pesticide law, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and The Food Quality Protection Act (FQPA) of 1996. FIFRA has been amended several times with the last two amendments, in 1978, and 1988, making the most significant changes. In 1978, under Section 2(ee) three major changes were made. Unless prohibited by the label, (1) a pesticide can be used at less than label rate or prohibited by the label; (2) pesticides can be used to control a target pest not named on the label; and (3) pesticides can be applied using any method of application provided the label does not prohibit it. In 1988, FIFRA was amended to require re-registration of older pesticides within nine years and to restructure the fees for re-registration. FQPA amends FIFRA by defining EPA procedures for determination, issuance, and cancellation of pesticide residue tolerances, and exemptions from tolerance requirements. It develops screening processes for other effects. The current FIFRA amendments continue to have the following requirements:

1. All pesticide products must be registered and classified as *restricted* (applied by or under the supervision of a certified applicator) or *general* (use that is not under the supervision of a certified applicator).

2. An uncertified individual can buy and/or apply restricted products under the supervision of a certified applicator, provided the supervisor has authorized and instructed the individual and is readily available during applications.

3. Pesticides may not be used in a manner inconsistent with the label.

4. Pesticide uses that are valid only within a given state are also subject to EPA authority [i.e., Special Local Need registration (24c) and Emergency Exemptions (Section 18)].

Other federal agencies that regulate pesticides include the Department of Transportation (DOT) and the Food and Drug Administration (FDA). DOT regulates interstate pesticide shipments, sets standards for warning signs, and sets standards for simultaneous shipments of pesticides and food. The 1958 Food, Drug and Cosmetic Act (FFDCA) gives the FDA authority to ensure safety of chemicals used in food, drugs, and cosmetics; it authorizes the EPA to establish pesticide tolerances and to establish the concept of health guidelines. The Food Quality Protection Act of 1996 (FQPA) amends the 1958 FFDCA and repeals the Delaney Clause regarding pesticides in processed and livestock food. The 1972 Federal Environmental Pesticide Control Act (FEPCA) gives EPA its pesticide-related responsibilities.

Other Federal Laws

The laws and regulations governing pesticides are more comprehensive than those governing other chemicals. Several are listed below:

1. The Clean Water Act (CWA) gives the EPA jurisdiction over the nations's waterways, making it suitable for agricultural and recreational use. It regulates both point and nonpoint sources of contamination, which may include pesticides.

2. The Resource Conservation and Recovery Act (RCRA) regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes; it sets national standards for management of hazardous wastes.

3. The Toxic Substance Control Act (TSCA) ensures chemicals will be evaluated for risk and regulates the manufacture and processing of chemicals; it requires that manufacturers and distributors keep inventories of certain chemicals.

4. The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) establishes a trust fund (Superfund) for financing government clean-up of hazardous waste sites.

5. The Occupational Safety and Health Act (OSHA) consolidated many existing federal worker safety laws to cover all employees who may potentially be exposed to hazardous chemicals in the workplace. The Hazard Communication Standard was expanded in 1989 to cover and protect all employees who may be exposed to hazardous chemicals in the workplace. Requirements for material data safety sheets (MSDS) for hazardous chemicals are included in its provisions.

6. The Federal Endangered Species Act makes it unlawful to harm any plant or animal listed by the Fish and Wildlife Service (FWS) as *endangered* or *threatened.* Under the program, pesticide use is restricted in areas where endangered species are likely to be exposed. The EPA, in cooperation with the USDA and the FWS, developed the Endangered Species Protection Program to protect listed species from pesticide effects.

7. The Safe Drinking Water Act establishes minimum contaminate levels (MCLs), primarily for water treatment plants. Only a limited number of pesticides have MCLs.

8. The Emergency Planning and Community Right-To-Know Act (EPCRA) may require an emergency plan and contact for the storage of some pesticides that exceed certain amounts.

State of Arizona

There are several state agencies responsible for pesticide-related regulations. The Arizona Department of Agriculture (ADA) is the primary state regulatory agency for agricultural pesticide use. *State pesticide regulations can be stricter than federal laws but never less strict.* Currently, ADA has the authority to issue grower and seller permits and license custom applicators and pest control advisors. ADA licenses equipment, certifies agricultural applicators, and agricultural aircraft pilots. ADA also administers emergency exemptions (Section 18s), and approves Special Local Needs (SLN) registrations.

Other state agencies have the following responsibilities:

1. The Structural Pest Control Commission (SPCC) regulates the commercial application of pesticides in structural and urban situations, licenses companies engaging in the business of structural pest control, and administers certification for all structural applicators.

2. The Arizona Department of Environmental Quality (ADEQ) is responsible for preventing pesticide contamination of the environment. State statutes mandate that the Department conduct monitoring, testing, and evaluations to determine whether a pesticide belongs on the Groundwater Protection List. Additional responsibilities include ensuring proper disposal of hazardous wastes.
3. The Arizona Department of Health Services (ADHS) is responsible for obtaining and compiling pesticide exposure information.

Federal and State Civil and Criminal Violations

There are federal and state fines for **civil** violations by private and commercial applicators. **Criminal** violations may carry larger fines and the possibility of time in jail. State penalties for agricultural applicators, pilots, and PCAs include the loss or suspension of license and/or certification.

IV. Arizona Pesticide License Requirements

Custom Applicator's License

An agricultural applicator who operates a pest control business, must obtain a custom applicator's license from ADA. The applicant must return a completed application form with a license fee and proof of liability insurance coverage.

The applicant must score at least 75 percent correct on a written core examination, prepared and administered by ADA, to show familiarity with pesticides, statutes, and rules relating to the application and safe use of pesticides, calibration, application techniques, and other areas of pest control operation. The license is valid for one calendar year, but renewal applications must be submitted to ADA no later than December 1, accompanied by the renewal fee. Expiration is December 31.

Custom Applicator Equipment License

ADA licenses air and/or ground equipment used for custom application, such as aircraft, application systems, and certain tractor-powered field sprayers. The license is for each piece of equipment, and expires on December 31 of each year.

The equipment license is considered a permanent fixture and should be clearly visible. It may not be transferred unless the original piece of equipment is leased, sold, traded, destroyed, or is not usable for that year. Equipment licenses must be removed or obliterated if a custom license is suspended or revoked.

Note: You must get permission from ADA to transfer an equipment license.

Agricultural Aircraft Pilot License

Individuals who pilot an aircraft for pesticide applications must be licensed by ADA and hold a valid Federal Aviation Administration Commercial Aircraft Pilot's license. Applicants must pass, with at least 75 percent correct, a test given by ADA demonstrating knowledge of (1) agricultural pesticides; and (2) safe flight and application procedures, including those pertaining to applications in the vicinity of schools, day care centers, health care institutions, and residences. Applicants must also file an annual renewal application by December 1 and pay a renewal fee. The license is valid for the calendar year issued and expires on December 31 of each year.

Agricultural Pest Control Advisor's License

The agricultural pest control advisor (PCA) license is issued by ADA. Applicants must pass an exam and a fee is required. PCAs need a license covering all specific categories in which they intend to make written recommendations for agricultural pest control. Annual renewal fee is payable by December 1. PCA licenses will not be renewed unless advisors complete six hours of continuing education units (CEUs) approved by ADA in the previous licensing year or retake the exam.

The ADA prepares and administers the test. Everyone must take the CORE test, covering Arizona pesticide laws, rules and regulations, and general pesticide safety principles and practices. Separate tests are available in the following categories:

- control of insects, mites, and other invertebrates
- control of plant pathogens
- control of nematodes
- control of weed pests
- defoliation
- plant growth regulators
- vertebrate pest control

PCA applicants must score a minimum of 75 percent on each section taken. The license is issued for those areas in which competence is established. The applicant must pass the CORE section before a license is granted. In the event an applicant passes all category tests, but fails to pass the CORE test, the applicant will not be granted a license until the CORE is passed.

Continuing Education Units (CEUs)

ADA requires continuing education units (CEUs) for both private (3 hours), commercial (6 hours), and PCA license (6 hours) recertification. One hour of credit will be given for each fifty (50) minutes of actual instruction on subject matter related to the license or certification. Continuing education instruction must be approved by ADA. Documentation of completion of the CEU credits is provided to ADA. For verification purposes, ADA provides forms for the sponsor of the CEU instruction.

Recordkeeping and Reporting

ADA requires all holders of seller permits to maintain records showing the receipt, sale, delivery, or disposition of all pesticides or pesticide devices for a period of two years.

Private Applicators and Regulated Growers must record pesticide application data on an ADA-approved form after completing an application of a restricted-use pesticide. The record will contain the following:

- name and certification number of applicator
- name and permit number of the seller
- crop and number of acres
- name of the pesticide and EPA registration number
- rate/acre of active ingredient or formulation
- total volume of mix/acre
- date and time of application
- location of field (by county, range, township, and section)
- name of regulated grower and method of application.

This record must be retained for two years after the date of application.

Sensitive Areas and Buffer Zones

As a pesticide applicator you must be aware that there are areas throughout the state that fall under special jurisdiction. The following table lists the guidelines that must be observed for aerial and ground applications of highly toxic or odoriferous pesticides.

Table 8.1 Buffer Zones in Arizona

AERIAL APPLICATIONS	**School, Day Care**	**Health Care**	**Residential**
Highly Toxic (Liquid)	1/4 mile	400 feet	100 feet
Highly Toxic (Dust)	1/4 mile	400 feet	300 feet
Odoriferous	1/4 mile	1/4 mile	1/4 mile

GROUND APPLICATION	**School, Day Care**	**Health Care**	**Residential**
Highly Toxic (Liquid)	1/4 mile	400 feet	50 feet
Highly Toxic (Dust)	1/4 mile	400 feet	300 feet
Odoriferous	1/4 mile	1/4 mile	1/4 mile

Sensitive areas have buffer zones around them created to keep highly toxic pesticides at a safe distance. They are often designated because of past complaints or proximity of schools, day care centers, health care facilities, and residential areas. Applicators are requested to notify the ADA at least 24 hours prior to any application. When you are applying around a school or other areas that might be sensitive, it is good practice to telephone and notify people that there is going to be an application in the area. Speak to someone in a responsible position and keep a record of their name for future reference. Pesticide management areas (PMAs) are designated by the ADA. Applicators must try to notify ADA at least 24 hours prior to any application in these areas.

V. Arizona Pesticide Permit Requirements

Grower's Permit

A grower's permit allows the holder to purchase, or contract for the application of, pesticides to lands he owns, rents, or leases for growing or producing an agricultural commodity. Only one permit is necessary for all parcels under the person's control, unless they buy or apply pesticides under different business names; in this case a permit is needed for each enterprise. The grower completes an ADA application. This permit is paid annually, renewable by March 1 of each year.

Seller's Permit

A seller's permit is required for an individual or company to engage in the business of selling or delivering liquid pesticides in containers larger than one gallon, dry/granular formulations in quantities greater than fifteen pounds, fertilizer/

pounds, or RUPs in any container size. The applicant completes a form which is sent to the ADA with a fee. A permit is issued and permit number assigned. Seller and grower permit numbers must appear on each delivery ticket and container delivered. Permits are valid for one year, renewable by March 1.pesticide combinations in containers over fifty

VI. Arizona Certification for Applying Restricted-Use Pesticides (RUPs)

The ADA certifies applicators who wish to buy, apply, or supervise the use of restricted-use pesticides. Certification training is provided by The University of Arizona's Cooperative Extension.

Agricultural Applicators

Applicators who use restricted pesticides in the production of an agricultural commodity are certified by the ADA in two categories: private (on land owned or rented by an individual or employer) or commercial (on other people's property for pay). This does not replace a custom license.

Private Agricultural Applicators

Farmers, orchardists, and others who apply pesticides to their own or their employer's land to grow or produce an agricultural commodity have a choice of two ways to prepare for the required examination:

1. **The University of Arizona's Cooperative Extension offers classes to prepare for the pesticide Initial Certification Test given by the ADA.**

   - or -

2. **Self study and written examination: The applicant may obtain study guides from the Publications Distribution Center, Cooperative Extension, (520) 621-1713, then take a written exam at the ADA office or any local ADA district office by appointment.** The private applicator is required to pass a CORE examination with a score of 75 percent or higher.

The CORE requires knowledge and understanding in the following areas:

- Statutes and rules relating to the application and use of restricted use pesticides
- Pesticide labels and labeling
- Principles of pest control and pesticide terminology
- Pesticide safety and toxicity
- Pesticide application equipment and calibration
- Common causes of accidents
- Need of protective equipment and clothing
- Poisoning symptoms
- Practicable first aid

After passing the exam, the applicant receives an application to be returned with the certification fee to ADA. Private applicators pay an initial certification fee, which is good for one year. A renewal fee is due September 1, with expiration September 30 of the following year. Three ADA-approved continuing education units (CEUs) are also required for recertification.

Commercial Agricultural Applicators

An applicant for commercial agricultural certification must take and pass, with a grade of 75 percent or higher, two tests prepared and administered by the ADA. The first, or CORE test, covers the following:

- Label/labeling comprehension
- Safety
- Environment
- Agricultural pests
- Agricultural use pesticides
- Application techniques/equipment
- Laws and regulations

A category examination follows the core exam for commercial certification. The applicant must demonstrate practical knowledge in one or more of the following categories:

- agricultural pest control
- forest pest control
- seed treatment
- aquatic pest control
- regulatory (rodent) pest control
- regulatory (M-44) pest control

Anyone failing the CORE and/or category exams may apply for reexamination after seven days. After passing the CORE and category tests, the applicator completes a certification application. Certification credentials will cover only the categories tested and passed. Applicants may test in as many categories as they desire.

Government employees are exempt from the initial commercial applicator certification fee. Certification is valid for one year; the annual renewal (government employees exempt from fee, **not** renewal) is due by September 1, expiring September 30, the following year.
Proof of six continuing education units (CEUs) is required at the time of renewal. Additional information is available at the following addresses:

Arizona Department of Agriculture
1688 West Adams
Phoenix, Arizona 85007
(602) 542-3578

The Structural Pest Control Commission
9535 E. Doubletree Ranch Road
Scottsdale, Arizona 85258-5514
(602) 255-3664

Presentation of Continuing Education Units (CEUs)

In order to present continuing education units (CEUs) for certification credit, the requirements in the following table must be met, and the hours must be approved by the ADA, Environmental Services Division. (See Table 8.2)

Table 8.2. Requirements for approval of CEUs

Department of Agriculture, Environmental Services Division	
Submitted by:	Anyone with an agricultural program dealing with pesticide use
Required:	
Form	No
Outline showing class title and times	Yes
Hours requested	Yes
Sponsor Identification	Yes: Name and addresses (Speaker/presenter biographies may be required)
Number of presentations approved	One at a time
Submittal dates:	Two weeks prior to event [1]
Category specific:	Not required
Evaluated by:	In-house Committee
Deadline for submission of CEU credits for the year:	With renewal application (Renewal due by Sept. 1; expires on Sept. 30) [2]
Contact person:	Certification and Training Specialist, ADA
Contact telephone:	(602) 542-0901
[1] Late submissions may be accepted.	[2] PCA's have different dates.

Chapter Eight
Federal & Arizona Agricultural Laws — Question and Answer Review

1. **Q. What is the full name and acronym of the federal agency mandated to regulate pesticides?**

   A. Environmental Protection Agency, or EPA.

2. **Q. What is the full name and acronym for the law EPA uses to manage pesticides?**

   A. Federal Insecticide, Fungicide, and Rodenticide Act, or FIFRA.

3. **Q. What is the full meaning of FQPA?**
   A. The Food Quality Protection Act.

4. **Q. Discuss the two types of penalties defined by FIFRA for applicators who violate the law?**

   A. FIFRA provides civil penalties when the violation of a regulation was unintentional and criminal penalties when the law was knowingly violated.

5. **Q. Define restricted entry interval (REI).**

   A. The time immediately following application of a pesticide to a treated area when unprotected workers may not enter.

6. **Q. EPA regulations require warnings be given to workers. Discuss the warning requirements.**

   A. Warnings must be timely to the situation, and the label may require that they be given orally, by posting, or both, and should be given in the language that can be understood by the workers.

7. **Q. Which federal agency *sets* food tolerances for pesticides? Which federal agency *enforces* food tolerances for pesticides?**

   A. EPA sets food tolerances; FDA enforces food tolerances. USDA enforces tolerances in meat.

8. **Q. Can states set standards less stringent than Federal FIFRA requirements?**

   A. No. States may make standards stricter, but never less strict, than federal standards.

9. **Q. What state agency has the primary responsibility for regulating agricultural pesticide use in Arizona?**

A. The Arizona Department of Agriculture.

10. Q. Who needs to be *certified* in Arizona?

A. Anyone who uses or supervises the use of pesticides classified as restricted-use.

11. Q. What is the criteria for a private applicator?

A. A private applicator applies or supervises the application of restricted-use pesticides to produce agricultural commodities on land owned or rented by the applicator or his or her employer. A private applicator may also apply or supervise application on someone else's land, as long as no compensation other than trading of personal services is involved.

12. Q. What is the criteria for a commercial applicator?

A. A commercial applicator is paid to apply or supervise the application of restricted-use pesticides for any purpose on property he does not own.

13. Q. How often must licenses, permits, and certification credentials be renewed?

A. Licenses, permits, and certification credentials must be renewed annually.

GLOSSARY OF TERMS

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2-PAM Medical antidote used for emergency treatment of acute organophosphate poisonings only.

abrasive Tending to rub or wear away.

acaricide Pesticide used to control mites, spiders, and ticks.

accumulative pesticide Pesticide that tends to "build up" in animals or the environment.

active ingredient Ingredient that "does the work" in a pesticide formulation.

acute toxicity Toxicity producing sudden and dramatic symptoms from a single dose of pesticide.

adhesive Substance that will cause spray material to stick to sprayed surface, often referred to as "sticking agent."

adjuvant Chemical or agent, such as wetting agent or spreader, added to a pesticide mixture to help the active ingredient do a better job.

agitate To keep pesticide chemical mixed; to prevent from settling.

agitator Device using a paddle, air, or hydraulic actions to keep a pesticide mixed in the sprayer.

antagonism When two or more pesticide chemicals are used in combination or mixed together (the opposite of **synergism**), resulting in decreased toxicity.

anticoagulant Chemical used in bait to kill rodents by preventing normal blood clotting.

antidote Practical, immediate treatment, including first aid, in case of poisoning; remedy used to counteract effects of poison.

atropine sulfate Medical antidote used for emergency treatment of acute organophosphate and carbamate poisonings.

backsiphoning Action in which fluid or spray material moves from the sprayer back to the original source.

band application Application to a continuous, defined area, such as in or along a crop row, rather than over the entire field.

biennial Plant that completes its life cycle in two years, producing leaves and storing food in the first year and producing fruit and seeds in the second.

bioaccumulation Exponential accumulation of chemicals through food chain. Also called "bioconcentration."

biological insecticide Biological control agent that kills insects.

biological magnification Process where pesticides move up the food chain.

botanical pesticide Pesticide derived from plants.

brand name The trademark name used by a chemical company for a pesticide product.

buffer zone Area set aside around a school, day care, health center, or residence where exposure to highly toxic or odoriferous pesticides is restricted. Buffer zones differ for aerial and ground applications. Check with state regulatory agencies for specific areas.

carbamates Group of chemicals which are salts or esters of carbonic acid. Carbamates include insecticides, herbicides, and fungicides.

carcinogen Substance or agent capable of producing cancer.

caution On pesticide **label**, the **signal word** for slightly toxic pesticides, as defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

certified applicator Any individual certified to apply or supervise application of any restricted-use pesticide covered by that individual's certification.

chemical name Scientific name of the active ingredient of a pesticide, derived from its physical structure.

cholinesterase Enzyme produced by the body to control transmission of nerve impulses. This enzyme is inhibited or "tied up" by organophosphate and carbamate chemicals.

chronic toxicity Toxicity producing less specific symptoms than **acute toxicity**, usually occurring with small, repeated exposures to chemicals on a regular basis over an extended period of time.

commercial applicator Person paid to apply or supervise application of pesticides for any purpose on property that person does not own.

common name A shortened name that EPA recognizes as a substitution for a product's chemical name.

compatibility Ability of two or more chemicals to be mixed together or used in combination without affecting each other's properties.

cultural control Control measures used to prevent pest damage rather than eliminating an existing infestation. Cultural practices reduce pest populations by altering the environment, the condition of a host plant, or the behavior of the pest.

commercial applicator Person paid to apply pesticides on agricultural land that belongs to someone else.

danger Signal word on pesticide labels, for highly toxic pesticides, often associated with a skull and crossbones.

decontaminate To safely remove any pesticide from equipment or other surface as directed on a pesticide label or by a regulatory authority.

direct supervision *See* ***under the direct supervision of.***

dosage Specific amount or rate of pesticide.

drift Uncontrolled airborne movement of spray droplets, dust particles, or vapor away from the target area of application.

dust Dry mixture consisting of pesticide and some inert carrier such as clay or talc.

economic threshold The pest density at which control measures should be applied to prevent an increasing population from causing economic damage.

emergence Action of a young plant breaking through soil surface or an insect emerging from an egg or pupa.

emulsifiable concentrate Produced by dissolving toxicant and emulsifying agent in organic solvent. Solvents substantially insoluble in water are usually selected because water-miscible solvents have not, in general, proved satisfactory.

endangered species Species of arthropod, animal, mammal or plant that is considered close to extinction and protected by law; habitat may also be protected.

environment Interrelationships existing between water, air, land, plants, people, and other living organisms.

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

FIFRA Federal Insecticide, Fungicide and Rodenticide Act (amended); the Federal pesticide law.

fumigant Substance or mixture of substances producing a gas, vapor, fume, or smoke, intended to control pests. Fumigants may be volatile solids, liquids, or gases.

gpa Gallons per acre. A measure of liquid moved by a pump.

gpm Gallons per minute. A measure of liquid moved by a pump.

granular pesticide Pesticide mixed with or coating small pellets or sand-like materials; often applied with seeders or spreaders to soil.

growers permit Permit required by state law for persons applying pesticides to their commercial agricultural land.

hazard Risk of a pesticide causing injury to the applicator, workers, the public, or the environment.

herbicide Pesticide used to kill plants or inhibit plant growth. Weed or grass killer.

illegal residue Pesticide residue in excess of a pre-established, legally-safe level.

inert ingredient Inert liquid or solid material added to **active ingredient** to prepare a pesticide formulation. These ingredients are usually carriers.

inhalation toxicity Poisoning through the respiratory system.

inorganic pesticides Naturally-occurring pesticide substance, usually in elemental form.

insect growth regulator (IGR) Synthetic pesticide that mimics insect hormonal actions preventing the exposed insect from completing its normal development cycle and becoming an adult.

label All written, printed, or graphic matter on or attached to the pesticide container, the outside container, or the wrapper of the pesticide retail package.

labelling Information and other written, printed, or graphic matter accompanying a pesticide; the containers, wrappers, or supplemental literature that come with the pesticide.

larva Wormlike or grublike immature stage of an insect. Stage between egg and pupa of moths, butterflies, and beetles.

LD_{50} Estimated dosage necessary to kill 50% of a test species population under stated conditions; expressed in milligrams per kilogram of body weight (mg/kg).

leach To move downward through soil with rain or irrigation water.

low-pressure boom sprayer A machine which can deliver low to moderate volumes of pesticide at pressures of 30-60 psi.

metamorphosis Series of changes through which an insect passes in its growth from egg through larvae and pupa to adult.

microencapsulation Method of encasing active ingredients in fine, granular material (often polyvinyl) to produce sustained, even release of pesticide.

mist blower Sprayer in which hydraulic atomization of liquid at the nozzle is aided by air blast past the source of the spray.

molluscide Pesticide used to control slugs and snails.

nematicide Pesticide, often soil fumigant, used to control nematodes infesting roots of plants.

nonaccumulative Not building up or accumulating in organisms or the environment.

nonpersistent pesticide Pesticide lasting a few weeks or less; usually broken down by light, microorganisms, or evaporation.

nonselective pesticide Pesticide generally toxic to plants or animals without regard to species. Usually refers to a **herbicide**.

nontarget organism Plant or animal other than the one targeted by the pesticide application.

nozzles Devices that control drop size, angle, rate uniformity, and thoroughness of a pesticide application.

oral toxicity Ability of a pesticide or chemical to sicken or kill an animal or human when eaten or swallowed.

orifice Opening or hole in a nozzle through which liquid material is forced out and broken up into a spray.

pathogen Any organism which can cause disease. Pathogens include fungi, bacteria, viruses, mycoplasmas, and nematodes.

perennial Plant normally living for more than two years (e.g., trees and shrubs).

persistent pesticide Pesticide remaining active in the environment more than one growing season. Pesticide with a long half-life.

pest By law, forms of plant, animal life, and viruses, when they exist under circumstances that make them injurious to plants, man, domestic animals, and other useful vertebrates and invertebrates.

pesticide tolerance See **tolerance.**

pheromones Chemicals produced by insects and other animals to communicate with and influence the behavior of others of the same species.

phytotoxic Injurious or toxic to plants.

plant growth regulator Substance that alters the growth of plants. The term does not include substances intended solely for use as plant nutrients or fertilizers.

postemergence Applied after the appearance of a specified weed or crop.

preemergence Applied to emergence of a specified weed or crop.

preharvest interval (PHI) Minimum number of days permitted by law between the final pesticide application and harvesting of crop.

private applicator Person who applies or supervises application of **restricted-use pesticides** to produce agricultural commodities on land owned or rented by that person or his/her employer.

personal protective equipment (PPE) Clothing or any other materials or devices that shield the applicator from unintended exposure to pesticides.

protective equipment See **personal protective equipment.**

pyrethroids Synthetic insecticides that mimic natural pyrethrins found in the flowers of plants belonging to the chrysanthemum family.

rate Amount of active ingredient of pesticide applied per unit area (e.g. lb/ac).

reentry interval Length of time that must elapse between pesticide application and reentry into application area.

registration Approved by Environmental Protection Agency for use of a pesticide as specified on the pesticide label.

residue Amount of chemical that remains on harvested crops.

resistance Ability of an organism to suppress or retard the injurious effects of a pesticide.

respiratory exposure Exposure to a pesticide through breathing.

restricted use pesticide (RUP) Pesticide classified for restricted use under provisions of the Federal Insecticide, Fungicide and Rodenticide Act (FIRFA), amended.

rodenticide Pesticide used to control rodents.

selective pesticide Pesticide more toxic to some species of plant, insect, animal, or organism than to others.

seller's permit Permit required by state law for an individual or firm to sell or deliver quantities of **restricted-use pesticides** greater than 1 gallon liquid or 15 pounds dry, or pesticides and fertilizers combinations over 50 pounds.

sex attractant See **pheromone.**

signal word Word that must appear on pesticide **labels** to denote the relative toxicity of the product. Signal words are **DANGER, WARNING,** and **CAUTION.**

soil application Application of chemical to soil rather than to the vegetation.

soil fumigant Pesticide that, when added to soil, forms a gas to kill pests in soil. Usually a tarpaulin, plastic sheet, or soil layer is used to tap the gas within the soil.

soluble powder Powder formulation that dissolves and forms a solution in water.

spillage Leaking, running over, or dripping of pesticide chemical. Spillage should be contained and cleaned up immediately for safety.

spray drift The movement of airborne dust or spray particles from the intended area of application.

stomach poison Pesticide that must be ingested in order to kill a target insect or animal.

summer annuals Plants that germinate in spring, make most of their growth in summer, and die in fall after flowering and seeding.

surface water Water located above ground in rivers, lakes, ponds, streams, irrigation canals, and ditches.

suspension Very finely divided solid particles evenly dispersed in liquid.

symptom Indication of disease or poisoning in a plant or animal.

systemic pesticide Pesticide applied in one area and translocated or moved to another part of the organism. For example, systemic insecticide is applied to soil and watered in, the insecticide is absorbed by the roots, then travels throughout the plant, killing organisms feeding on the plant.

tank agitator See **agitator.**

tolerance Maximum amount of pesticide chemical that can legally remain in or on raw agricultural commodity.

toxicant A poison.

toxicity Natural capacity of a substance to produce injury or death. Toxicity is measured by oral, dermal, and inhalation studies on test animals.

trade name See **brand name.**

translocated pesticide Pesticide that moves within a plant or animal from entry site. Systemic pesticides are translocated.

ULV Ultra Low Volume. ULV sprayers apply chemical concentrate with a minimum of liquid carrier.

under the direct supervision of Application of a pesticide is made by a person acting under the instruction and control of a certified applicator, responsible for the actions of that person. The certified applicator is available if and when needed, even though the certified applicator is not physically present at the time and place of the pesticide application.

vertebrate Animal with a bony spinal column. Vertebrates include fish, mammals, birds, and snakes.

virus Microscopic pathogen that requires living cells for growth and is capable of causing diseases in plants and animals. Plant viruses are often spread by insects.

warning The signal word on a label of a pesticide containing moderately toxic pesticides as defined by the FIRFA, amended.

water soluble Capable of being dissolved in water.

weed Plant that is undesirable due to certain characteristics or to its presence in certain areas. "A plant out of place".

weed control Process of inhibiting weed growth and limiting weed infestations so that crops can be grown profitably or other operations can be conducted efficiently.

wettable powder A powder formulation that, when added to water, forms a suspension.

winter annual Plants that germinate in the fall and complete their life cycle by early summer.

Worker Protection Standard (WPS) Federal regulations designed to protect agricultural workers and pesticide handlers.