How to Pass the Certification Exam

Four Virginia certification exams are based on this manual, **Applying Pesticides Correctly** (Virginia Core Manual): private applicator, registered technician, commercial core, and business license. (Commercial applicators must also pass an exam in another specific category of pest control.) Here are some tips on how to prepare for and pass these exams.

Read the Manual

The first thing you should do is carefully read the manual. In Virginia, certification exam questions are derived from – and supported by – the corresponding manual. Even if you have extensive on-the-job experience or have taken a certification exam prep course, you should still study the manual. Doing so will maximize your chances of passing the exam.

Study the Learning Objectives

Each unit begins with a section called "Learning Objectives." These objectives state what you should be able to do after studying that unit. For example, in Unit 1, one learning objective is to be able to understand the responsibilities of certified pesticide applicators in Virginia. You can assume that at least one exam question will test your understanding of this topic. As you read the unit, keep the learning objectives in mind. When you finish reading, try to respond to each objective. If you have trouble, reread the section of the unit that discusses that topic. Do this for all learning objectives.

Study the "Test Your Knowledge" Questions

Each unit ends with a section called "Test Your Knowledge." These review questions check your understanding of the learning objectives. For example, in Unit 1, one question asks you to name two ways in which a certified applicator can become recertified. Several other questions deal with recordkeeping responsibilities. These questions directly relate to the learning objective given above (understand the responsibilities of certified applicators in Virginia).

Most exam items are based on the "Test Your Knowledge" questions in each unit. When you have finished reading the unit, see if you can answer the review questions. If you can answer the "Test Your Knowledge" questions correctly, you should be able to pass the certification exam.

Remember that all certification exam questions are in multiple-choice format. "Test Your Knowledge" questions are short-answer or true/false.

Study Tips

1. Break the manual up into sections. Study a unit or two each day for several weeks before the exam. Review any unclear or confusing sections.

2. Using a highlighter, mark sections in the text that relate to the learning objectives. Or make flash cards, writing text-based questions on the front and the answers on the back. Review them yourself or with another person.

3. Look at the headings and subheadings in each unit. They will help you understand how sections in the text relate to each other. For example, in Unit 5, there is a main heading titled "Pesticide Movement." In the section that follows, you will find the subheading "Weather Factors." This tells you that the information about weather factors is part of a larger discussion of pesticide movement offsite.

Exam Tips

1. Decide whether to take the exam at a VDACS testing center, a DMV customer service center, or (for private applicators only) an Extension office. At Extension offices and VDACS testing centers, you will take a written exam. At the DMV, you will use a touch-screen automated system.

2. All applicants must show a photo ID to the exam proctor. If you test at a DMV or VDACS testing center, you must also present a Notice of Authorization letter from VDACS Office of Pesticide Services. Prospective private applicators should make an appointment at a local Extension office. For more information, visit the VDACS-Office of Pesticide Services website.

3. Read your Notice of Authorization letter (if needed) carefully. It lists each category in which you may test and the date by which you must take the exam(s).

4. Bring a calculator to VDACS testing centers and Extension offices. At the DMV, a calculator will be provided on the testing computer screen. You will not be able to use a pencil and paper at the DMV.

5. Read each question carefully. Make sure you read all the words and understand their meanings. Misreading questions is a common cause of exam errors.

6. Certification exams include two general types of questions. The first type tests your ability to recall facts. The second type assesses your ability to apply what you know. The second type of question, for example, might ask you to evaluate a set of conditions and make a decision.

7. Negative words (such as NOT and EXCEPT) will appear in capital letters. The same is true for other key terms (for example, MOST, LEAST, FIRST, BEST).

8. Choose the one **best** answer for each question. For example, you may have to choose the BEST tactic to control a pest.

9. Read all the responses before choosing your answer. Otherwise, you might pick the wrong response simply because you overlooked the right one.

Sample Exam Questions

Below are three sample test questions. They are similar in construction and content to actual certification exam questions. The correct answer is in bold type.

1. Which material is MOST chemical-resistant?

   A. Canvas. B. Cotton. C. Leather. **D. Nitrile.**

2. The label of a pesticide instructs you to mix 2 pints of product in 100 gallons of water. How many ounces of product should you use if you want to make only 10 gallons of an end-use mixture? (Given: 1 pint = 16 ounces)

   A. 0.16. B. 0.32. C. 1.6. **D. 3.2.**

3. The FIRST step in any effective pest management program is

   A. confirming that the pesticide you want to use is labeled for the site you plan to treat.

   B. identifying the pest.

   C. making a cost/benefit assessment.

   D. obtaining a research-based control recommendation.

Applying Pesticides Correctly

A Guide for Private Applicators, Commercial Applicators, and Registered Technicians in Virginia

Preface

The Core Manual series began with separate guides for private and commercial applicators published jointly by the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA) in 1974. Those manuals were a part of the first implementation of the applicator training requirements of the Federal Insecticide, Fungicide, and Rodenticide Act of 1972. They established a threshold level of information necessary for applicators seeking initial certification.

The first revision, the 1983 National Core Manual, recognized the need for private and commercial applicators to have a common basis of knowledge about pesticide use. It combined the two 1974 publications into an expanded and updated Core Manual for use by both groups of applicators. Produced by North Carolina State University and Information Impact, in cooperation with USDA and EPA, it included new information and represented a step toward more in-depth knowledge for certified applicators.

The second revision of the National Core Manual, in 1992, was adapted for Virginia-certified applicators in 1994. This version reflected the continuing evolution of the applicator certification program. Pesticide use has become increasingly complex. Safe, responsible pesticide use has become ever more important to human health and environmental quality. The revised manual included much new information about the effects of pesticides. It centered on this issue: how to ensure that pesticides will remain in use to benefit society without endangering either people or the environment.

Another major change was the focus of the manual. The previous versions, while giving much basic information, focused largely on agricultural pesticide use. Recognizing that many applicants for certification come from fields other than agriculture, this version took a broader approach. The "core" of information it contains, in general, applies to the entire range of certification categories.

The 1992 National Core Manual and the 1994 Virginia Core Manual marked a major change in format. The information is presented in separate units, or modules. Each unit has its own learning objectives as well as review questions and answers.

The 2012 revision retained the format of the first Virginia Core Manual. However, it contained both new and revised content. The previous Unit 9 (Mixing, Loading, and Application) was eliminated and some of its content moved to other units. In addition, the previous Unit 10 (Applying the Correct Amount) was expanded into two units (9 and 10).

Since 2012, the Virginia Core Manual has had two minor revisions. The 2016 revision included important updates to the Worker Protection Standard, pesticide certification regulation changes, and other topics. The 2020 revision updates certification and business license fees.

Thorough knowledge of the Core Manual is required of all certified pesticide applicators in Virginia. The Core Manual supports general, basic safety training. The purpose of this manual is to help you become a competent pesticide handler. A person preparing to become a commercial applicator will need to study one or more category manuals as well. There is a manual for each commercial category of pesticide use. Refer to Unit 1 to learn about certification requirements and procedures as well as the responsibilities of pesticide applicators.

The Extension Service (USDA) and the Office of Pesticide Programs (EPA) support this project. It represents the continuation of a long-standing effort to ensure that pesticide applicator training is relevant and useful to applicators seeking certification. Its purpose is to encourage the safe and proper use of pesticides.

With the support of Virginia Cooperative Extension and the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS), the Virginia editions include information about Virginia's pesticide laws and regulations, a primer on the general types of pests, a glossary of important terms, and an index.

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Sources for the 2012 Revision:

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"Choose Pesticides Packaged in Returnable/Refillable Containers" (Bulletin 819). The Ohio State University (Ohioline). http://ohioline.osu.edu/b819/b819_8.html

"National Pesticide Applicator Certification Core Manual." 2006. Edited by C. Randall, W. Hock, E. Crow, C. Hudak-Wise, and J. Kasai. National Association of State Departments of Agriculture Research Foundation. (Includes CD.) Unit 7 (Personal Protective Equipment) was largely drawn from Chapter 6 of this manual.

"Pesticide Applicator Core Training Manual" (Bulletin E-2195). 1997. Michigan State University Extension, East Lansing.

"Pesticide Usage and Insect Pest Management" course material (VT ENT/PPWS 4264 and VT ENT 4254). 2011. D. E. Mullins. Department of Entomology, Virginia Tech, Blacksburg. [Resource for Unit 4, Pesticide Formulations.]

"Pesticides and Formulation Technology (PPP-31)." 1994. A. Martin, F. Whitford, and T. Jordan. Purdue Pesticide Programs, Purdue University Cooperative Extension Service, West Lafayette, Ind. [Resource for Unit 4, Pesticide Formulations.]

"Pesticides: Regulating Pesticides/Label Review Manual." EPA website. www.epa.gov/oppfead1/labeling/lrm/ [Resource for Unit 3, Pesticide Labeling.]

"Recognition and Management of Pesticide Poisonings." 1999. J. R. Reigart and J. R. Roberts. Fifth edition. Publications 735-R-98-003 (English); 735-R-98-004 (Spanish). Certification and Worker Protection Branch, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. www.epa.gov/opp00001/safety/healthcare/handbook/handbook.htm.

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Disclaimer

This manual is not a step-by-step guide to pesticide use. The methods and chemical classes described are not a substitute for pesticide label directions. Reading this manual will prepare you to pass the state-mandated certification examinations for private applicators and registered technicians. The Virginia pesticide business license examination is based on information in this manual. The Virginia Core Manual is also the basis for the commercial applicator core examination. However, simply reading this manual does not qualify you to be a fully trained pesticide applicator. A competent applicator must also learn through on-the-job experience and continuing education.

Since new materials and technologies change constantly, certified applicators must stay up to date. Pesticide applicator recertification sessions and professional organizations provide good continuing education programs. Refer to Unit 1 for information on recertification requirements.

Any commercial products and/or equipment named in this publication are included for informational purposes only. Virginia Cooperative Extension and the Virginia Department of Agriculture and Consumer Services do not endorse these products and/or equipment and do not intend discrimination against other products or equipment that may also be suitable. Chemical registrations and use patterns may change. Know the status of any pesticide you choose.

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Unit 1. Pesticide Use in Virginia

Learning Objectives

After studying this unit, you should be able to:

- State the responsibilities of certified pesticide applicators in Virginia.
- Identify the required state certification for the type of pesticide use you intend to perform.
- Comply with state regulations governing certified applicators in the commonwealth.
- State Virginia's requirements for holding a pesticide business license.
- Explain how to maintain state certification.
- Properly report a pesticide accident or spill.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Certified Applicator – Any commercial applicator, registered technician, and/or private applicator who has met the certification requirements in Virginia.

Commercial Applicator – A certified applicator who uses pesticides on the job, other than for agricultural production on private property.

Commercial Applicator for Hire – Any commercial applicator who uses or supervises the use of any pesticide commercially, on the property of others. Commercial applicators for hire in the commonwealth must have a pesticide business license or work for someone who does.

Commercial Applicator Government Employee – Any local, state, or federal government worker who uses or supervises the use of any pesticide for any purpose, regardless of the site, while performing his or her official duties.

Commercial Applicator Inactive – Any commercial applicator who is not currently employed in a pesticide-related job and is thus not covered by the required insurance. Inactive applicators must still satisfy renewal and recertification requirements.

Commercial Applicator Not for Hire – Any commercial applicator who uses or supervises the use of any pesticide as part of his or her job duties only on property owned or leased by the applicator, or by his or her employer.

Terms to Know cont.

Direct Onsite Supervision – The act or process by which a competent person, acting under the instructions and control of a certified commercial applicator who is responsible for the actions of that person, applies a pesticide. The certified commercial applicator must be present at the application site and be able to see the person applying the pesticide at all times.

Direct Supervision – The act or process by which a competent person, acting under the instructions and control of a certified commercial applicator who is responsible for the actions of that person, applies a pesticide. The certified commercial applicator must be either near or in close telephone or radio contact with the person applying the pesticide.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) – A law that established the basis of U.S. pesticide regulation to protect applicators, consumers, and the environment.

Pesticide – Any substance used to control a pest, or to reduce the unwanted or harmful effects of a pest.

Pesticide Business License – A document required of persons in the business of selling, storing, distributing, mixing, recommending the use of, or applying pesticides. For a complete explanation of conditions and exemptions, see "Licensing of Pesticide Businesses" later in this unit.

Pesticide Use – Application or supervision of an application of a pesticide. "Use" includes all the routine activities that are part of a pesticide application, such as mixing, loading, cleanup, and disposal. Handling, transfer, or transport after the manufacturer's original seal is broken is considered use. (Pesticide handling typically managed by persons other than the mixer/loader/applicator such as long-distance transport, long-term storage, or ultimate disposal is not considered routine use.)

Private Applicator – A certified applicator who uses or supervises the use of any restricted-use pesticide (RUP) to produce an agricultural commodity. Applications must be made on property owned or rented by the user, or by his or her employer. A certified private applicator may also apply an RUP to the property of another agricultural producer. However, he or she must receive no compensation except for trading personal services between them. Uncertified applicators employed by agricultural producers may use RUPs only when under the direct supervision of a certified private applicator.

Recertification – The demonstration of continued competency to apply pesticides safely by participation in appropriate, approved education courses or by reexamination.

Registered Technician – A certified applicator who renders services similar to those of a certified commercial applicator. Such a person has completed training and demonstrated competency as required for registered technicians but has not met the requirements for commercial certification. Registered technicians may apply general-use pesticides on the job without supervision. They may apply RUPs only under the direct supervision of a certified commercial applicator. Like commercial applicators, registered technicians may be for hire, not for hire, government employees, or inactive.

Restricted-Use Pesticide (RUP) – Any pesticide classified for restricted use by the administrator of the Environmental Protection Agency (EPA). The "restricted-use" classification restricts a product, or its uses, to use by a certified pesticide applicator (commercial or private) or under the direct supervision of a certified applicator.

Introduction

Applying Pesticides Correctly: A Guide for Private Applicators, Commercial Applicators, and Registered Technicians is the basic or "core" manual for certified pesticide applicators in Virginia. It supports general safety training for all pesticide users. The purpose of this manual is to help you become a competent pesticide manager. Use this book to learn about pesticide safety, pesticide laws and regulations, and basic pesticide facts. Each unit includes objectives, definitions of important terms used in the text, and review questions. These features will help you master the important skills and ideas in each unit. At the end of the manual, you will find a glossary and an index. The glossary is a set of definitions for words commonly used by pest control professionals. Terms found in the glossary appear in boldface text throughout the manual. The index will help you find specific terms or passages in this manual. Competency examinations for registered technicians and for private applicators are based solely on the content of this book. This book also supports the core exam for commercial applicators, as well as the Virginia **pesticide business license** exam.

NOTE: Persons preparing for certification in Marine Antifoulant Paints, commercial Category 5B, are only required to study the manual for that subcategory. They are exempt from the core examination that is required of all other commercial applicators.

Persons preparing to become a commercial applicator will need to study one or more category manuals as well. Virginia Tech sells pesticide applicator training manuals for each commercial category of pesticide use. Descriptions of all the private and commercial certification categories appear in this unit.

Training manuals are available through an online order site. To order a manual, visit the Virginia Tech Pesticide Programs (VTPP) website, www.vtpp.org.

Pesticide Management Overview

Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Virginia Pesticide Control Act, and regulations drafted to support the act in Virginia is the responsibility of the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS). On behalf of the Commissioner of Agriculture and Consumer Services, the Office of Pesticide Services:

- Registers all pesticides sold or used in Virginia.
- Licenses all pesticide businesses operating in Virginia.
- Certifies all persons required to be certified as pesticide applicators in Virginia.

Pesticides are not for amateurs. To protect people and the environment, only knowledgeable persons should handle pesticides. Certain pesticides, known as **"restricted-use" pesticides (RUPs)**, are so hazardous that only trained people are legally allowed to purchase and use them. Virginia law requires certification of most commercial pesticide users and all users – commercial or private – of restricted-use products.

Handling restricted-use pesticides requires special training.

Certification Categories and Procedures

Before preparing for certification, you must first decide if you need to become a private applicator, commercial applicator, or

KNOW THE LAW

The Virginia Pesticide Control Act (VPCA) was first passed in 1989 to replace the Virginia Pesticide Law. It was amended in 1993, 1995, 2008, 2012, and 2016. This act regulates the registration, manufacture, sale, transportation, and use of pesticides. It also requires the certification of pesticide applicators and the licensing of pesticide businesses in Virginia.

Some key requirements of VPCA include:

- All pesticides manufactured, distributed, sold, or used in Virginia must first be registered with the Virginia Department of Agriculture and Consumer Services (VDACS).
- Persons who buy or use restricted-use pesticides and certain occupational users of any pesticides must be certified as private applicators, commercial applicators, or registered technicians.
- Pesticide businesses must be licensed through VDACS and must carry certain insurance.
- All pesticides must be used only as directed on the labeling. Persons who use pesticides in a way that is "inconsistent with the pesticide labeling" are subject to penalties.

Other acts that may result in a penalty include:

- Selling or using an unregistered or unlabeled pesticide.
- Acting as a pesticide business without first becoming licensed.
- Applying pesticides commercially without first becoming certified as a commercial applicator or registered technician.
- Failing to keep required records or making false records.
- Failing to properly maintain pesticide application equipment.
- Providing a restricted-use pesticide to a person not certified to use it.

Violations of VPCA or regulations issued under it will subject you to civil penalties. These can be as much as $1,000 for a first offense that has less-than-serious consequences, up to $20,000 for repeated violations of the law. An additional penalty of up to $100,000 may be assessed for any violation that causes serious damage to the environment, serious injury to property, or serious injury to, or death of, any person. Investigators with VDACS (Office of Pesticide Services) regularly inspect pesticide businesses and investigate all complaints involving the misuse of pesticides.

registered technician. Commercial applicators must also choose one or more categories for certification, based on the type of pesticide use planned.

Types of Pesticide Applicator

The Commonwealth of Virginia recognizes several types of pesticide applicator. Each is defined below. Persons who do several sorts of pesticide-related jobs may need to be certified as both a private and a commercial applicator.

Private Applicator – A certified applicator who uses or supervises the use of any restricted-use pesticide to produce an agricultural commodity. Applications must be made on property owned or rented by the user, or by his or her employer. A certified private applicator may also apply an RUP to

the property of another agricultural producer. However, he or she must receive no compensation except for trading personal services between them. Uncertified applicators employed by agricultural producers may use RUPs only when under the **direct supervision** of a certified private applicator.

There are two certification options for people who use pesticides on the job (other than as a private applicator):

Certified Commercial Applicator – A certified applicator using any pesticide for any purpose on the job other than as described for a private applicator (production of an agricultural commodity on private property).

Certified Registered Technician – An individual who performs services similar to those of a certified commercial applicator. Such a person has completed training and demonstrated competency as required for registered technicians but has not met the requirements for commercial applicator certification. (Registered technician trainees receive general pesticide safety training and job-specific instruction in pesticide use.) Registered technicians may use general-use pesticides on the job without supervision. They may use RUPs only under the direct supervision of a certified commercial applicator.

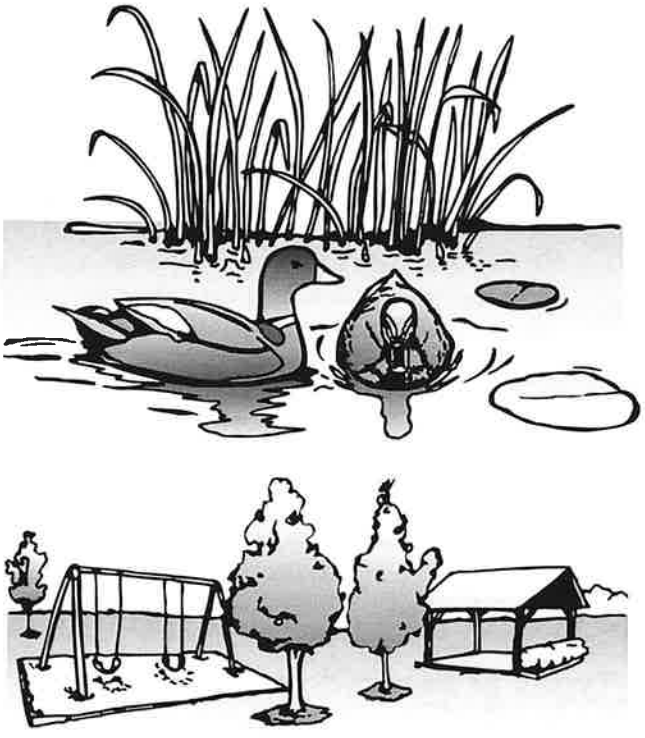
There are four classes of commercial applicator:

For Hire – Any commercial applicator who uses or supervises the use of any pesticide commercially, on the property of others. All pesticide handlers working for hire must be certified. Commercial applicators for hire in Virginia must have a pesticide business license or work for a properly licensed firm.

Not for Hire – Any commercial applicator who uses or supervises the use of any pesticide as part of his or her job duties only on property owned or leased by the applicator, or by his or her employer. Certification requirements depend on the nature of the pesticides used and the type of work performed. Applicators working not for hire must be certified if they are:

- Using restricted-use pesticides.
- Using pesticides on the sites listed below:
  - On any area open to the public at the following establishments:
    (a) Schools.
    (b) Healthcare facilities.
    (c) Daycare centers.
    (d) Convalescent centers.
  - Where open food is stored, processed, or sold.
  - On any recreational land more than 5 acres.

Government Employee – Any local, state, or federal government worker who uses or supervises the use of pesticides, regardless of the site, as part of his or her official



Applicators working not for hire must be certified when applying pesticides in sensitive areas.

duties. All such pesticide handlers must be certified, as either a commercial applicator or registered technician, to use any pesticide for any purpose.

Inactive – Any commercial applicator who is not currently employed in a pesticide-related job and is thus not covered by the required insurance. Holders of this type of certificate must still meet renewal and **recertification** requirements. However, they may not apply pesticides while in this status.

These same four classes (for hire, not for hire, government, and inactive) also apply to certified registered technicians in the same circumstances.

Exemptions

Some types of pesticide users do not have to be certified. Certification is not required of:

1. Persons conducting laboratory research involving pesticides.

2. Doctors of medicine and doctors of veterinary medicine applying pesticides as drugs or medications in the normal course of their practice or to control pests in corpses. Doctors of veterinary medicine applying pesticides for hire, advertising themselves as pesticide applicators, or engaging in large-scale pesticide use are not exempt.

3. Providers of janitorial, cleaning, or sanitizing services, if the only pesticides used are general-use sanitizers, disinfectants, and germicides.

4. Persons selling or applying paints containing pesticides not classified as restricted use.

5. Painters applying restricted-use marine antifoulant tributyltin (TBT) paints under the **direct onsite supervision** of a commercial applicator certified in Category 5B (Marine Antifoulant Paints). Under this exemption, one Category 5B-certified commercial applicator may supervise up to eight uncertified painters.

6. Forestry weed-control crews working on foot to apply general-use herbicides. Under this exemption, uncertified applicators must work under the direct onsite supervision of a certified commercial applicator. An applicator certified in Forest Pest Control may supervise up to eight uncertified applicators. The supervisor must remain in voice control of, and no more than 200 feet away from, his or her crew.

7. Governmental employees who use properly registered, ready-to-use pesticide products to prevent immediate personal harm from stinging and biting insects. This allows for the use of ready-to-use products ONLY on an occasional, isolated, site-specific basis to protect oneself from pests while doing a job other than pest management. This exemption does not include regular, routine, or maintenance applications of pesticides.

8. Prospective registered technicians, who use pesticides in training under the direct onsite supervision of a certified commercial applicator.

9. Persons who use or supervise the use of any pesticide not classified as restricted use to produce an agricultural commodity on private land. This includes pesticide applications made on property owned or rented by the grower. It may also include applications made on the property of another person. However, the applicator may not receive any compensation other than trading personal services between two growers.

10. Farm hands, who may use restricted-use pesticides only when working for and supervised by a grower who is a certified private applicator.

11. Private citizens using "homeowner" lawn, garden, or household pest control products on their property or in their home.

The regulations may also include additional exemptions for persons who can use pesticides with minimal risk to public health and safety because of:

- The nature of the pesticides used.
- The method of application.
- The experience and knowledge of the persons involved.

Categories of Pesticide User

Certification must be in the category or categories matching the type of pesticide use practiced or supervised.

Private Applicator Categories

There are four categories of private pesticide applicator. Private applicators of RUPs must be certified in one or more of the following categories:

***86* Single Product Certification:** For use of a single RUP or related restricted-use products with the same active ingredient having similar formulations and labeled uses. This certification is intended for emergencies or for special cases (such as state-level restricted-use designation for a product or active ingredient).

***87* Limited Certificate:** For use of a single RUP for one identified purpose. A nonreader may qualify for this type of certificate. He or she will need the recommendation of the regional pesticide investigator and the county Extension agent.

***90* Food, Fiber, Forestry Products, and Commodity Production:** For growers who use or supervise the use of RUPs to produce agricultural crops, livestock, or forest products. This includes the use of pesticides to control vertebrate pests of livestock. It also includes fumigation and chemigation applications.

***91* Ornamental Production:** For use of RUPs to control ornamental pests in nurseries and greenhouses. Certification in this category permits application via irrigation (chemigation) or by using fumigants.

Commercial Applicator Categories (for Hire, Not for Hire, and Inactive)

There are 12 commercial applicator categories. Several are divided into subcategories. Commercial applicators must be certified in the category or categories that match their type of work. In the category descriptions below, the word "use" means actual use or supervision of use.

***1A* Agricultural Plant Pest Control:** For use of pesticides to produce agricultural crops, on grasslands, and on noncrop agricultural land.

***1B* Agricultural Animal Pest Control:** For use of pesticides on agricultural animals, and to places on or in which such animals are confined, to control pests directly affecting such animals.

***1C* Fumigation of Soil and Agricultural Products:** For use of pesticides for soil fumigation to produce an agricultural commodity and/or for fumigation of agricultural products.

***1D* Chemigation:** For application of pesticides through an irrigation system.

***2* Forest Pest Control:** For use of pesticides in forests, forest nurseries, and seed orchards.

***3A* Ornamental Pest Control:** For use of pesticides to produce and/or maintain ornamental trees, shrubs, and flowers indoors and outdoors.

***3B* Turf Pest Control:** For use of pesticides to produce and/or maintain turf such as on golf courses, residential lawns, parks, and cemeteries.

***4* Seed Treatment:** For application of pesticides to seeds.

***5A* Aquatic Pest Control - General:** For use of pesticides in or on standing or running waters to control pests, excluding those applicators engaged in public health pest control.

***5B* Marine Antifoulant Paints:** For use of marine antifoulant paints containing tributyltin (TBT). Persons wishing to become certified in this subcategory are exempt from the core examination for commercial applicators.

***6* Right-of-Way Pest Control:** For use of pesticides to maintain public rights-of-way such as roads, electric power lines, telephone lines, pipelines, and railways; and to maintain fence lines, structural perimeters, and other similar areas.

***7A* General Pest Control:** For use of pesticides to control household pests, including pests that infest structures, stored products, and residential food-preparation areas, and pests that infest or contaminate food at any stage of production in food-processing facilities. This subcategory includes treatment of food-processing areas and control of vertebrate structural invaders. It does not include control of wood-destroying pests or the use of fumigants.

***7B* Wood-Destroying Pest Control:** For use of pesticides other than fumigants to control organisms that destroy structures made of or containing wood.

***7C* Fumigation (Non-Agricultural):** For use of fumigant pesticides to control pests in structures and items other than soils and raw agricultural commodities.

***7D* Vertebrate Pest Control (Excluding Structural Invaders):** For use of pesticides to control vertebrate pest animals outside of human dwellings or other structures.

***7E* Sewer Root Pest Control:** For use of pesticides to control roots in sewer lines.

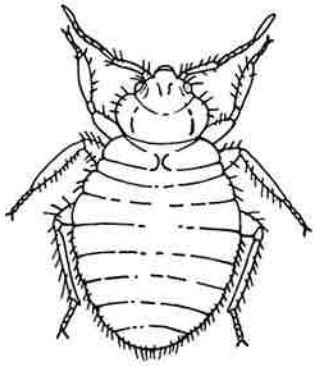
***8* Public Health Pest Control:** For use of pesticides to manage or control pests of medical significance that threaten public health. This category includes federal, state, and local employees involved in public health pest control.

***9* Regulatory Pest Control:** For use of pesticides by federal, state, and local government employees to control regulated pests. "Regulated pests" are those that are of special concern to the commonwealth. They are subject to government suppression, eradication, or quarantine programs.

***10* Demonstration and Research Pest Control:** For persons, including federal, state, and local government employees, who teach proper pesticide use, application techniques, and/or make pesticide recommendations; for research application of pesticides in greenhouses or field plots.

***11* Aerial Pesticide Application:** For commercial application of pesticides by fixed-wing or rotary-wing aircraft.

***12* Wood Preservation and Wood Products Treatment:** For commercial applicators using or supervising the use of pesticides at wood-treatment plants and sawmills for preservative treatment of wood and wood products. This category also includes remedial treatment of utility poles.



Bed bug control is covered in Categories 7A (General Pest Control) and 8 (Public Health Pest Control).

Registered Technician

"Registered technician" is a generic term and is not tied to any particular commercial category. There is one category for registered technicians: 60. Registered technicians in Virginia provide services similar to those provided by commercial applicators. Registered technicians may only apply pesticides in a category area in which they have received supervised training.

Certification Requirements and Procedures

All applicators must participate in approved training and demonstrate their competency by passing the required exam(s). Persons wishing to become certified as a commercial applicator or a registered technician must apply for examination. Only qualified applicants may sit for the certification exam(s). While the Virginia Pesticide Control Act does not set age limits for certified applicators, Virginia's labor laws limit who can work with certain chemicals in the workplace. The minimum age for private applicators is 16, and the minimum age for commercial applicators and registered technicians is 18. Commercial applicators working for hire must have a Virginia pesticide business license or work for someone who does. Registered technicians working for hire must work for a licensed pesticide business.

No one with a history of repeatedly violating any federal, state, or local pesticide law or who has had a Virginia applicator certificate or a pesticide business license revoked may apply for certification for two years. However, there is a provision in the Virginia Pesticide Control Act that provides persons in either of these circumstances the opportunity to show why they should be granted certification.

Certification procedures for a private applicator, commercial applicator, and registered technician differ. Please read the section that applies to you.

Private Applicator Certification

To become a private applicator, you must participate in approved training and pass a competency examination. Approved training, at a minimum, means study and review of required training materials, including this manual.

You may take the private applicator examination at Virginia Cooperative Extension (VCE) field offices. Please contact your local Extension office to make arrangements. Examinations given at Extension offices are paper-and-pencil format. These written, multiple-choice exams may not be read aloud to the applicant.

County Extension agents send completed tests to VDACS-OPS for scoring and processing. A completed exam is your application for private applicator certification. There is no application fee. The Office of Pesticide Services scores all examinations and notifies prospective private applicators of their results.

Private applicator exams are also available at Virginia Department of Motor Vehicles (DMV) Customer Service Centers. To take the private applicator exam at a DMV, you must first complete an application to test and submit it to the Office of Pesticide Services. Applications are available from OPS and your local Extension office. There is no fee. When your application is received by OPS, you will get a letter authorizing you to take the private applicator exam at DMV. Present this letter to the examiner at DMV, along with a form of photo identification. Exams at DMV are also multiple choice and are given on a touch-screen computer. You are informed of your score when you complete the test. If you pass, you will immediately receive a temporary certificate. The Office of Pesticide Services will mail your official certificate to you when your exam results arrive from DMV.

You need a score of 76% or higher to earn a private applicator certificate. This certificate will include both Categories 90 and 91. If your exam score is below 76%, you must retake the exam. To take the private applicator exam at the DMV, you must complete another application to test and submit it to OPS.

Most categories of private applicator require a written competency exam. However, nonreaders may qualify for a limited certificate (Category 87). This allows a grower to use a single restricted-use product for one identified purpose. A nonreader may earn this type of certificate with the recommendation of the regional pesticide investigator and a local VCE agent.

Maintaining Your Certification: Recertification

As noted above, a private applicator receives Categories 90 and 91 upon passing the private applicator exam. However, certification must be maintained through continuing education. To keep a private applicator certificate in force, you must earn at least one credit in each of three content areas per category every two years, before the expiration date on your certificate. The content areas are safety, legal aspects, and pest management. Contact your local Extension agent to learn when and where courses approved for full or partial recertification credit will meet. Be sure to note which category or categories they fulfill. Applicators may accumulate up to four years of recertification credit.

Private applicator certificates expire every other year on December 31. The Office of Pesticide Services will automatically issue a new certificate to those applicators who have met their recertification requirements in at least one category. If you allow your applicator's certificate to lapse by more than 60 days, you must retake the private applicator exam.

Starting in September 2017, OPS will mail Certification Retraining Status Reports only to applicators whose certificates expire on December 31 of that year and who need to attend a recertification course by December 31. You can check your status anytime on the VDACS-OPS website. This information is updated weekly.

NOTE: Because private applicator certificates expire on December 31, the first certificate issued may be good for less than – or more than – two years. If exams are passed October 1 to December 31 of a calendar year, the certificate will expire December 31 of the second year following. If exams are passed between January 1 and September 30, the certificate will expire December 31 of the next year.

For example, if you take and pass the private applicator exam in November, your certificate will be valid for two years and one month. However, if you test and pass the exam in September, your certificate will expire after only one year and three months.

Commercial Applicator Certification

To become a commercial applicator, you must have credentials showing that you are experienced and trained in pesticide use. Applicants holding a valid commercial applicator certificate from another state must submit a:

- Copy of that certificate, with category description(s).
- Virginia reciprocal certification application.
- Power of attorney form.
- Nonrefundable $100 application fee.

The necessary forms are available from VDACS-OPS/Certification, Licensing, Registration, and Training Section. Reciprocal certification is granted when categories, training, and testing requirements are similar.

Other prospective commercial applicators must take the Virginia exams. To take the tests leading to commercial certification, you must submit an application and a nonrefundable $100 fee. Federal, state, and local government employees do not need to pay the application fee. However, they must pay for certification manuals and any training they attend.

Only qualified applicants may test. Applicants must provide proof of preparation for the certification exam(s) in one of two ways:

- Be a registered technician in Virginia for at least one year.

- Provide VDACS with proof of formal education, training, or experience in pesticide use comparable to a year's experience as a registered technician to qualify for testing.

Two different application forms are used for commercial applicators. Application A is for initial certification. This is for people who are testing for the first time. Application B is for those who have already submitted the first application and want to take an exam again. Persons may be reexamined to add categories, to retake an examination, to reinstate a lapsed certificate, or to recertify by reexamination.

Application forms and instructions are available from VDACS-OPS, Extension offices, and Virginia Tech Pesticide Programs. You may request print copies by mail or access the forms and instructions online by visiting the VDACS-OPS website.

The Office of Pesticide Services will send each applicant a letter confirming the receipt of his or her application. It will also authorize qualified applicants to test in the categories listed on the application. Applicants should bring this authorization letter to the testing center, along with a form of photo identification. Qualified applicants have 90 days from the issue date of the letter to take the exam(s).

To become a commercial applicator, you must first pass a core examination. This test deals with general principles of pesticide safety, pest management, and knowledge of certain federal and state laws and regulations explained in this manual. Then, you must further demonstrate competency in a specific type of pest control by passing the proper category exam. The commercial core and category tests are written, multiple-choice exams.

You may take only the previously authorized exams at one sitting. Most tests have a one-hour time limit. Examinations are available on touch-screen computers at all DMV Customer Service Centers during normal business hours. You may also arrange to take paper exams, by appointment, at VDACS testing centers.

A score of 76% or higher is required to earn a commercial applicator certificate.

If you pass the core and one or more category examinations, you will receive a certificate. People who take and pass exams at DMVs will immediately get a temporary certificate. The Office of Pesticide Services will mail your official certificate to you when your exam results arrive from DMV.

Each time an applicant fails an exam, a new application and fee are required to receive another examination authorization letter.

Commercial applicators who work for hire will not be issued an active certificate unless they have, or work for someone who has, a valid Virginia pesticide business license.

Maintaining Your Certification: Renewal and Recertification

Renewal of Certificates: Commercial applicator certificates expire June 30 of the second year after issue. They must be renewed every two years. The Office of Pesticide Services will send each commercial applicator a renewal notice. Return the notice with the $100 renewal fee on or before June 30 to avoid a $14 penalty. No late renewals will be accepted after August 29.

Starting in September 2017, OPS will mail Certification Retraining Status Reports only to applicators whose certificates expire on June 30 of that year and who need to attend a recertification course by June 30. You can check your status anytime on the VDACS-OPS website. This information is updated weekly.

NOTE: Because commercial applicator certificates expire on June 30, the first certificate issued may be good for less than – or more than – two years. If exams are passed March 1 to December 31 of a calendar year, the certificate will expire June 30 of the second year following. If exams are passed between January 1 and February 28 or 29, the certificate will expire June 30 of the next year.

For example, if you take and pass the commercial applicator exam in March, your

certificate will be valid for two years and three months. However, if you test and pass the exam in January, your certificate will expire after only one year and five months.

Applications for renewal will not be processed unless the applicator has met the requirements for recertification credit in the proper category or categories (see below). If you allow your certificate(s) to lapse by more than 60 days, you must retest in both the core material and the specific category or categories to reinstate your certificate(s). Applicators must inform the VDACS-OPS/Certification, Licensing, Registration, and Training Section if their mailing addresses change.

Commercial applicators who work for hire will not be issued renewed certificates unless they have, or work for someone who has, a valid Virginia pesticide business license.

Government applicators do not have to pay application and renewal fees. Applicators who have met their recertification requirements (see below) will receive their renewed certificates automatically.

Recertification: To qualify for renewal, commercial applicators must participate in a continuing pesticide-education program suitable for their category or categories. Applicators earn two years of recertification credit per fully approved program. Persons may accumulate up to four years of recertification credit in each category. Those who fail to recertify in at least one category will not be able to renew their certificates.

Participating in a continuing-education program will allow you to earn recertification credit.

Virginia Cooperative Extension, pesticide-related trade and professional organizations, and other groups offer commercial applicator recertification courses. A current listing, by category, of all approved commercial applicator recertification courses is available online by visiting the VDACS-OPS website. Program availability varies by category and by season. Most courses are offered between September and March. Keep in touch with your local Extension agent as well as professional organizations to avoid missing recertification classes.

Certified applicators based out of state may recertify in Virginia by reciprocity. This requires the "home" state to grant reciprocal recertification to Virginia applicators in equivalent categories. Applicators must maintain certification in the home state. They must also provide proof of this to the Office of Pesticide Services before their Virginia certificate expires.

Failure to maintain a certificate, due to either failure to respond to the renewal notice or failure to recertify, will result in expiration. Persons who allow certificates to lapse by more than 60 days must take the Virginia certification exams to regain commercial applicator status.

Registered Technician Certification

To become a registered technician, you must complete an approved training program that includes at least 20 hours of instruction and self-study of this manual. It should also include at least 20 hours of on-the-job training in the proper application of pesticides under the direct onsite supervision of a certified commercial applicator. The on-the-job training must include practical experience in the pesticide-related job duties the trainee will be expected to perform.

The applicant should do three things within 90 days of starting a position that requires the commercial use of pesticides:

1. Complete all registered technician training.
2. Submit an application to OPS to take the registered technician exam.
3. Take the registered technician exam.

A nonrefundable $50 application fee is required. Federal, state, and local government employees do not have to pay the application fee. However, they must pay for certification manuals and any training they attend.

The Office of Pesticide Services will send the applicant a letter confirming the receipt of his or her application. It will also authorize the applicant to take the exam. The applicant should bring this authorization letter to the testing site, along with a form of photo identification. This written, multiple-choice examination addresses basic pesticide safety, pest management, and knowledge of relevant federal and state laws and regulations as found in this manual.

Registered technician exams are available at DMV Customer Service Centers during business hours, and by appointment at VDACS testing sites. Exams at DMV are given on a touch-screen computer. You are informed of your score when you complete the test. If you pass, you will receive a temporary certificate. The Office of Pesticide Services will mail your official certificate to you when your exam results arrive from DMV. Written exams taken at VDACS testing sites are sent to OPS in Richmond for scoring and processing. A score of 76% or higher is required to earn a registered technician certificate.

Registered technicians who work for hire will not be issued an active certificate unless they work for someone who has a valid Virginia pesticide business license.

Each time an applicant fails an exam, a new application and fee are required to receive another examination authorization letter. Individuals who fail to take and pass the registered technician exam within 90 days of the initial examination may not apply pesticides commercially, even under direct onsite supervision, until they pass the exam.

Individuals who have previously submitted a registered technician application form and either did not take the examination within 90 days of being hired or transferred into the position or did not pass a subsequent examination within 90 days of the initial examination cannot apply pesticides commercially, even under direct onsite supervision, until they reapply and pass the examination.

Maintaining Your Certification: Renewal and Recertification

Renewal of Certificates: Registered technician certificates expire June 30 of the second year after issue. They must be renewed every two years. The Office of Pesticide Services will send each technician a renewal notice. Return the notice with the $50 renewal fee on or before June 30 to avoid a $6 penalty. No late renewals will be accepted after August 29.

Starting in September 2017, OPS will mail Certification Retraining Status Reports only to applicators whose certificates expire on June 30 of that year and who need to attend a recertification course by June 30. You can check your status anytime on the VDACS-OPS website. This information is updated weekly.

NOTE: Because registered technician certificates expire on June 30, the first certificate issued may be good for less than – or more than – two years. If exams are passed March 1 to December 31 of a calendar year, the certificate will expire June 30 of the second year following. If exams are passed between January 1 and February 28 or 29, the certificate will expire June 30 of the next year.

For example, if you take and pass the registered technician exam in March, your certificate will be valid for two years and three months. However, if you test and pass the exam in January, your certificate will expire after only one year and five months.

Applications for renewal will not be processed unless the applicator has met the requirements for recertification credit (see below). Persons who allow their certificate to lapse by more than 60 days must retest. Technicians must inform the VDACS-OPS/Certification, Licensing, Registration, and Training Section if their mailing addresses change.

Government applicators do not have to pay application and renewal fees. Applicators who have met their recertification requirements (see below) will receive their renewed certificates automatically.

Recertification: To qualify for renewal, registered technicians must participate in an ongoing pesticide-education program. Registered technicians earn recertification credit by attending approved recertification courses in the category that matches their pesticide-related job duties.

Applicators earn two years of recertification credit per fully approved program. Persons may accumulate up to four years of recertification credit. Those who fail to recertify will not be able to renew their certificates.

Virginia Cooperative Extension, pesticide-related trade and professional organizations, and other groups offer registered technician recertification courses. A current listing of all approved recertification courses is available online by visiting the VDACS-OPS website. Program availability varies by category and by season. Most courses are offered between September and March. Keep in touch with your local Extension agent as well as professional organizations to avoid missing recertification classes.

Failure to maintain a certificate, due to either failure to respond to the renewal notice or failure to recertify, will result in expiration. Persons who allow certificates to lapse by more than 60 days must take the Virginia certification exam to regain registered technician status.

Responsibilities of Certified Pesticide Applicators

Like certification procedures, responsibilities vary for different types of pesticide applicators. The next section lists the responsibilities of each: private applicator, commercial applicator for hire, commercial applicator not for hire, government employee, inactive commercial applicator, and registered technician. Find and read the section that applies to you.

Private Applicator

A. Adherence to the Pesticide Label

The pesticide label is a legal agreement between the Environmental Protection Agency (EPA), the product manufacturer, and the user. Pesticide product labels provide instructions for all stages and phases of use. Applicators must read, understand, and follow label directions carefully. Do not apply pesticides to any site not listed on the product label. Do not apply materials at rates higher than the label directs. Pesticide applicators must follow label directions for transport, mixing, loading, application, storage, and disposal of pesticide products and containers. The Federal Environmental Pesticide Control Act (FEPCA), a 1972 amendment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), prohibited the use of any pesticide that is inconsistent with its label. Moreover, it set penalties for deliberate violations. Virginia law also makes it illegal to use a pesticide in a way that is inconsistent with its label.

B. Supervision of Uncertified Applicators

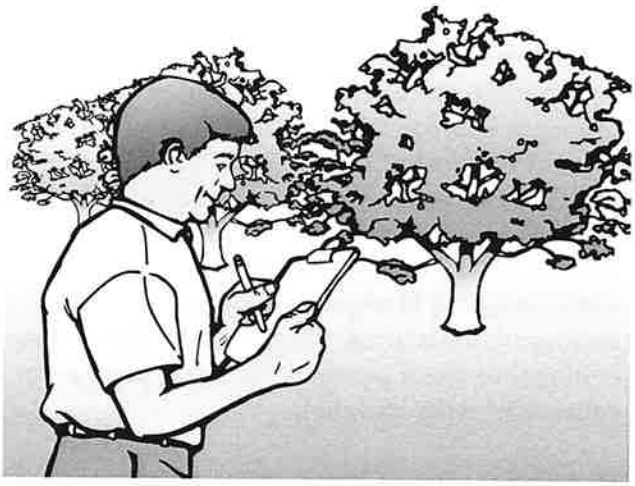
Uncertified but competent persons may apply restricted-use pesticides (RUPs) to produce agricultural commodities on private property when under the direct supervision of a certified private applicator. The private applicator is responsible for the actions of the uncertified person.

C. Recordkeeping

The Food, Agriculture, Conservation, and Trade (FACT) Act of 1990, also known as the Farm Bill, requires private pesticide users to keep records of applications of restricted-use pesticides. Applicators must maintain these records for two years.

A certified private applicator who applies an RUP has 14 days to make a record of that application. If a grower hires a commercial applicator to apply a restricted-use pesticide, he or she should get the necessary record-keeping information from the commercial applicator. Commercial applicators must provide a copy of an RUP application record to their client within 30 days of the application.

Certified private applicators must make their records of restricted-use pesticide applications available, upon request, to any federal or state agency that deals with pesticide use. In addition, certified private applicators must make their records, or record information, available to an attending licensed healthcare professional, or a person acting under the instructions of such a professional, if it is necessary to treat a person who may have been exposed to the RUP applied.



Recordkeeping is an important part of responsible pesticide application.

Private applicator records for RUP uses must contain the following information:

1. Restricted-use pesticide brand or product name and EPA registration number.
2. Total amount of RUP applied.
3. Size of the area treated (ex. number of units or acres).
4. Crop, commodity, stored product, or site to which the RUP was applied.
5. Location of the application.
6. Date (day, month, and year) of the RUP application.
7. Name and certification number of the certified applicator who applied or supervised the application of the RUP.

Application(s) of RUPs in a total area of less than 1/10 acre occurring on the same day may be recorded as a "spot treatment." A record for a spot treatment requires:

1. Brand or product name.
2. EPA registration number.
3. Total amount applied.
4. Designation of "spot application" with a brief description of the area or location.
5. Date of application.

NOTE: Recording applications as "spot treatments" as described above is NOT allowed for nursery and greenhouse applications.

The federal **Worker Protection Standard (WPS)** also involves some recordkeeping. WPS requires growers who hire agricultural workers or handlers to make, maintain, and post pesticide application information and hazard information (Safety Data Sheets) for all pesticides in a central area no later than 24 hours after an application is completed. Application and hazard information must be displayed continuously until 30 days after the last applicable restricted-entry interval or until workers or handlers are no longer on the establishment, whichever is earlier. WPS information must be retained for two years after expiration of the REI. The WPS pesticide application information list must record:

1. The location and description of the area treated.
2. The crop or site treated.
3. The name(s), EPA registration number(s), and active ingredient(s) of the pesticide product(s) used.
4. The date(s) the application is started and ended.
5. The time(s) the application started and ended.
6. The restricted-entry interval for the pesticide.

Worker Protection Standard application records are part of a broader requirement to

provide safety information for farm workers at a central location. This includes pesticide-use data (in the form of an up-to-date application list), emergency information, and an EPA-approved pesticide safety poster. You will find more information about WPS in the "Know the Law" section in Unit 6 of this manual. For detailed information about WPS, consult the EPA manual **How to Comply with the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Owners and Employers Need to Know.**

Please keep in touch with your local Extension agent for the latest information on recordkeeping. He or she will also know about WPS as well as other pesticide laws and regulations affecting agricultural producers.

There is a sample private applicator recordkeeping chart at the end of this unit (Table 1-1). It contains all the data elements required for both federal recordkeeping and WPS pesticide-use information. Note that this form differs from the commercial applicator recordkeeping form (Table 1-2).

D. Reporting Pesticide Accidents

Report all pesticide accidents or incidents that pose a threat to any person, to public health or safety, and/or to the environment to the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS). Telephone notification is required within 48 hours. A written report describing the accident or incident is also necessary. This report must include the following elements:

1. Name(s) of individual(s) involved in accident or incident.
2. Name(s) of pesticide(s) used.
3. Quantity of pesticide spilled and containment procedures.
4. Time, date, and location of accident or incident.
5. Cleanup or repair actions taken.
6. Name (or description if unnamed) and location of nearby water bodies that might be contaminated by a pesticide accident or spill.

Send this report to OPS within 10 days of the initial notification. Direct phone calls and written reports to:

Field Operations
Office of Pesticide Services
Virginia Department of Agriculture and Consumer Services
P. O. Box 1163
Richmond, VA 23218
(804) 371-6560

If the accident or incident involves a spill, contact OPS to determine whether to report the release to comply with other regulations. Such regulations include the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA Title III, also known as the Community Right-to-Know Law). The chemical's hazard level and the volume of discharged material determine whether to report the spill.

If a spill involves other persons or property, notify the Virginia Department of Emergency Management by calling (800) 468-8892. See Unit 11 of this manual for more information on reporting and dealing with spills.

E. Revocation or Suspension

Private applicator certificates may be suspended or revoked if the holder, in the eyes of the Commissioner of VDACS, presents a substantial danger or threat to public health and safety or to the environment. The commissioner may issue an emergency suspension and may revoke a certificate after a hearing has taken place. If a person's certificate is revoked, he or she must wait two years before reapplying for certification in Virginia.

A private applicator certificate can also be suspended if an uncontested civil penalty has not been paid within 60 days.

Commercial Applicator - for Hire

A. Adherence to the Pesticide Label

The pesticide label is a legal agreement between the Environmental Protection Agency (EPA), the product manufacturer, and the user. Pesticide product labels provide instructions for all stages and phases of use. Applicators must read, understand, and follow label directions carefully. Do not apply pesticides to any site not listed on the product label. Do not apply materials at rates higher than the label directs. Pesticide applicators must follow label directions for transport, mixing, loading, application, storage, and disposal of pesticide products and containers. The Federal Environmental Pesticide Control Act (FEPCA), a 1972 amendment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), prohibited the use of any pesticide that is inconsistent with its label. Moreover, it set penalties for deliberate violations. Virginia law also makes it illegal to use a pesticide in a way that is inconsistent with its label.

Read the label first.

B. Supervision of Registered Technicians (and Uncertified Persons in Training)

Commercial applicators must provide on-the-job training and instruction for uncertified employees or coworkers in training to become registered technicians. Uncertified trainees must have direct onsite supervision while using any pesticide. Registered technicians for hire must work with a commercial applicator and for a properly licensed pesticide business. Certified registered technicians may apply restricted-use pesticides only when under the direct supervision of a commercial applicator. They may use general-use pesticides without direct supervision. Commercial applicators are responsible for the work of the registered technicians they employ or supervise. They must provide registered technicians with clear, specific instructions on all aspects of pesticide use.

C. Recordkeeping

Commercial applicators who work for hire must keep records of ALL pesticide applications. See "Licensing of Pesticide Businesses" below for detailed information.

D. Licensing

Commercial applicators for hire must hold a Virginia pesticide business license or work for someone who does. (See "Licensing of Pesticide Businesses" below.) If the employer's Virginia pesticide business license is not valid, then the applicator's certificate becomes invalid.

E. Reporting Pesticide Accidents

Report all pesticide accidents or incidents that pose a threat to any person, to public health or safety, and/or to the environment to the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS). Telephone notification is required within 48 hours. A written report describing the accident or incident is also necessary. This report must include the following elements:

1. Name(s) of individual(s) involved in accident or incident.
2. Name(s) of pesticide(s) used.
3. Quantity of pesticide spilled and containment procedures.
4. Time, date, and location of accident or incident.
5. Cleanup or repair actions taken.
6. Name (or description if unnamed) and location of nearby water bodies that might be contaminated by a pesticide accident or spill.

Send this report to the Office of Pesticide Services within 10 days of the initial notification. Direct phone calls and written reports to:

Field Operations

Office of Pesticide Services

Virginia Department of Agriculture and Consumer Services

P. O. Box 1163

Richmond, VA 23218

(804) 371-6560

If the accident or incident involves a spill, contact OPS to determine whether to report the release to comply with other regulations. Such regulations include the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA Title III, also known as the Community Right-to-Know Law). The chemical's hazard level and the volume of discharged material determine whether to report the spill.

If a spill involves other persons or property, notify the Virginia Department of Emergency Management by calling (800) 468-8892. See Unit 11 of this manual for more information on reporting and dealing with spills.

F. Revocation or Suspension

Commercial applicator certificates may be suspended or revoked if the holder, in the eyes of the Commissioner of VDACS, presents a substantial danger or threat to public health and safety or to the environment. The commissioner may issue an emergency suspension and may revoke a certificate after a hearing has taken place. If a person's certificate is revoked, he or she must wait two years before reapplying for certification in Virginia.

A commercial applicator certificate can also be suspended if an uncontested civil penalty has not been paid within 60 days.

Commercial Applicator - Not for Hire and Government Employee

A. Adherence to the Pesticide Label

The pesticide label is a legal agreement between the Environmental Protection Agency (EPA), the product manufacturer, and the user. Pesticide product labels provide instructions for all stages and phases of use. Applicators must read, understand, and follow label directions carefully. Do not apply pesticides to any site not listed on the product label. Do not apply materials at rates higher than the label directs. Pesticide applicators must follow label directions for transport, mixing, loading, application, storage, and disposal of pesticide products and containers. The Federal Environmental Pesticide Control Act (FEPCA), a 1972 amendment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), prohibited the use of any pesticide that is inconsistent with its label. Moreover, it set penalties for deliberate violations. Virginia law also makes it illegal to use a pesticide in a way that is inconsistent with its label.

B. Supervision of Registered Technicians (and Uncertified Persons in Training)

Commercial applicators must provide on-the-job training and instruction for uncertified persons in training to become registered technicians. Uncertified trainees must have direct onsite supervision while using any pesticide. Certified registered technicians may apply restricted-use pesticides only when under the direct supervision of a commercial applicator. They may use general-use pesticides without direct supervision. Commercial applicators are responsible for the work of the registered technicians they employ or supervise. They must provide registered technicians with clear, specific instructions on all aspects of pesticide use.

C. Recordkeeping

Records of all pesticide applications must be made and maintained for two years following the pesticide use. Such records must contain the following information:

1. Name, address, and telephone number of the applicator's employer, and address or location of the application site, if different.
2. Name and certification number of the person making or supervising the application.
3. Date of application (day, month, and year).

4. Type of plants, crop, animals, or sites treated.

5. Principal pests to be controlled.

6. Acreage, area, number of plants or animals treated, or size of structure treated.

7. Identification of pesticide:

   - Brand name or common name of pesticide used.

   - EPA product registration number.

8. Amount of pesticide concentrate and amount of diluent (ex. water) used, by weight or volume; or the volume and concentration applied to a structure as defined in item 6.

9. Type of application equipment used.

There is a sample recordkeeping form for pesticide applications made by a certified commercial applicator at the end of this unit (Table 1-2). Note that this form differs from the WPS and USDA recordkeeping form for restricted-use pesticides (Table 1-1).

D. Reporting Pesticide Accidents

Report all pesticide accidents or incidents that pose a threat to any person, to public health or safety, and/or to the environment to the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS). Telephone notification is required within 48 hours. A written report describing the accident or incident is also necessary. This report must include the following elements:

1. Name(s) of individual(s) involved in accident or incident.

2. Name(s) of pesticide(s) used.

3. Quantity of pesticide spilled and containment procedures.

4. Time, date, and location of accident or incident.

5. Cleanup or repair actions taken.

6. Name (or description if unnamed) and location of nearby water bodies that might be contaminated by a pesticide accident or spill.

Send this report to the Office of Pesticide Services within 10 days of the initial notification. Direct phone calls and written reports to:

Field Operations
Office of Pesticide Services
Virginia Department of Agriculture and Consumer Services
P. O. Box 1163
Richmond, VA 23218
(804) 371-6560

If the accident or incident involves a spill, contact OPS to determine whether to report the release to comply with other regulations. Such regulations include the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA Title III, also known as the Community Right-to-Know Law). The chemical's hazard level and the volume of discharged material determine whether to report the spill.

If a spill involves other persons or property, notify the Virginia Department of Emergency Management by calling (800) 468-8892. See Unit 11 of this manual for more information on reporting and dealing with spills.

E. Revocation or Suspension

Commercial applicator certificates may be suspended or revoked if the holder, in the eyes of the Commissioner of VDACS, presents a substantial danger or threat to public health and safety or to the environment. The commissioner may issue an emergency suspension and may revoke a certificate after a hearing has taken place. If a person's certificate is revoked, he or she must wait two years before reapplying for certification in Virginia.

A commercial applicator certificate can also be suspended if an uncontested civil penalty has not been paid within 60 days.

Commercial Applicator - Inactive

A. Status

Inactive commercial applicators cannot legally use pesticides in their work and cannot supervise the work of others.

B. Revocation or Suspension

Commercial applicator certificates may be suspended or revoked if the holder, in the eyes of the Commissioner of VDACS, presents a substantial danger or threat to public health and safety or to the environment. The commissioner may issue an emergency suspension and may revoke a certificate after a hearing has taken place. If a person's certificate is revoked, he or she must wait two years before reapplying for certification in Virginia.

A commercial applicator certificate can also be suspended if an uncontested civil penalty has not been paid within 60 days.

Registered Technician

A. Adherence to the Pesticide Label

The pesticide label is a legal agreement between the Environmental Protection Agency (EPA), the product manufacturer, and the user. Pesticide product labels provide instructions for all stages and phases of use. Applicators must read, understand, and follow label directions carefully. Do not apply pesticides to any site not listed on the product label. Do not apply materials at rates higher than the label directs. Pesticide applicators must follow label directions for transport, mixing, loading, application, storage, and disposal of pesticide products and containers. The Federal Environmental Pesticide Control Act (FEPCA), a 1972 amendment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), prohibited the use of any pesticide that is inconsistent with its label. Moreover, it set penalties for deliberate violations. Virginia law also makes it illegal to use a pesticide in a way that is inconsistent with its label.

B. Reporting Pesticide Accidents

Report all pesticide accidents or incidents that pose a threat to any person, to public health or safety, and/or to the environment to the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS). Telephone notification is required within 48 hours. A written report describing the accident or incident is also necessary. This report must include the following elements:

1. Name(s) of individual(s) involved in accident or incident.
2. Name(s) of pesticide(s) used.
3. Quantity of pesticide spilled and containment procedures.
4. Time, date, and location of accident or incident.
5. Cleanup or repair actions taken.
6. Name (or description if unnamed) and location of nearby water bodies that might be contaminated by a pesticide accident or spill.

Send this report to the Office of Pesticide Services within 10 days of the initial notification. Direct phone calls and written reports to:

Field Operations
Office of Pesticide Services
Virginia Department of Agriculture and Consumer Services
P. O. Box 1163
Richmond, VA 23218
(804) 371-6560

If the accident or incident involves a spill, contact OPS to determine whether to report the release to comply with other regulations. Such regulations include the Resource Con-

servation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA Title III, also known as the Community Right-to-Know Law). The chemical's hazard level and the volume of discharged material determine whether to report the spill.

If a spill involves other persons or property, notify the Virginia Department of Emergency Management by calling (800) 468-8892. See Unit 11 of this manual for more information on reporting and dealing with spills.

Contact the proper authorities to report a pesticide spill.

C. Recordkeeping

Records of all pesticide applications must be made and maintained for two years following the pesticide use. Such records must contain the following information:

1. Name, address, and telephone number of the applicator's employer, and address or location of the application site, if different.
2. Name and certification number of the person making or supervising the application.
3. Date of application (day, month, and year).
4. Type of plants, crop, animals, or sites treated.
5. Principal pests to be controlled.
6. Acreage, area, number of plants or animals treated, or size of structure treated.
7. Identification of pesticide:
   - Brand name or common name of pesticide used.
   - EPA product registration number.
8. Amount of pesticide concentrate and amount of diluent (ex. water) used, by weight or volume; or the volume and concentration applied to a structure as defined in item 6.
9. Type of application equipment used.

There is a sample recordkeeping form for pesticide applications made by a certified commercial applicator or registered technician at the end of this unit (Table 1-2). Note that this form differs from the WPS and USDA recordkeeping form for restricted-use pesticides (Table 1-1).

D. Licensing of Registered Technicians for Hire

Registered technicians for hire must work for someone who holds a Virginia pesticide business license. (See "Licensing of Pesticide Businesses" below.) If the employer's Virginia pesticide business license is not valid, then the applicator's certificate becomes invalid.

E. Revocation or Suspension

Registered technician certificates may be suspended or revoked if the holder, in the eyes of the Commissioner of VDACS, presents a substantial danger or threat to public health and safety or to the environment. The commissioner may issue an emergency suspension and may revoke a certificate after a hearing has taken place. If a person's certificate is revoked, he or she must wait two years before reapplying for certification in Virginia.

A registered technician certificate can also be suspended if an uncontested civil penalty has not been paid within 60 days.

Licensing of Pesticide Businesses

A Virginia pesticide business license is required of:

- Persons engaged in the business of distributing, applying, or recommending the use of a pesticide product.
- Persons who store or sell pesticides.

If a business has several outlets or stores, a separate license is required for each location. The annual fee for a Virginia pesticide business license is $150. A Virginia pesticide business license does not replace a local or municipal business license.

Exemptions

Some businesses and persons using or selling pesticides do not need a Virginia pesticide business license. These include:

1. Businesses that sell pesticides wholesale only to other wholesalers or retailers and not to any end users.
2. Businesses, wholesale or retail, that sell less than $50,000 (wholesale cost per year) of general-use pesticides mainly or exclusively labeled for use by homeowners. (Businesses selling restricted-use pesticides, regardless of sales volume, do not qualify for this exemption.)
3. Federal, state, and local government agencies and employees. (Government employees are exempt from licensing for only those duties they perform in an official capacity as federal, state, or local government employees.)
4. Certified applicators not for hire who use or supervise the use of pesticides as part of their job duties but do so only on property that they or their employer owns, leases, or controls.
5. Janitorial, cleaning, and/or sanitizing services that use no pesticide other than disinfectants, germicides, and sanitizers.
6. Wood treaters not for hire.
7. Seed treaters not for hire.
8. Agricultural producers. (Growers who also sell, store, recommend, or apply pesticides for compensation do not need a pesticide business license for the farm operation. However, they do need one for any pesticide-related commercial activity.)

General Conditions and Terms

Each business outlet or location must submit a separate application for a Virginia pesticide business license. Each application must include a completed application form and the annual fee of $150. Application forms and instructions are available from VDACS-OPS, Virginia Cooperative Extension offices, and Virginia Tech Pesticide Programs. You may request print copies by mail or access the forms and instructions online by visiting the VDACS-OPS website.

To process the application, the business must provide evidence of financial responsibility, in the form of a liability insurance policy. This policy must protect persons who might be injured because of pesticide use associated with the applicant's business. Minimum coverage levels are $100,000 for property damage, $100,000 for personal injury (per person), and $300,000 per occurrence.

Each applicant (or an employee of the business) must demonstrate his or her knowledge of pesticide use and management by passing a written pesticide business license examination. If the applicant or an employee is a certified commercial applicator, the examination requirement is waived.

If a pesticide business applies pesticides for hire or makes pesticide recommendations for a fee, it must employ a commercial applicator of record. This commercial applicator is responsible for the safety of all pesticide applications as well as for making any pesticide-use recommendations. Pesticide businesses that sell RUPs also must employ a commercial applicator.

Pesticide business licenses expire March 31 of each year. To keep a license in force, the Virginia Department of Agriculture and Consumer Services must receive a completed renewal application and annual fee on or before the close of business March 31. Late renewals will incur a late fee of 20% of the annual fee. No pesticide business license renewals will be processed unless:

- The liability insurance policy on file is current.
- The commercial applicator of record has a valid commercial applicator certificate.

Responsibilities

1. If RUPs are sold or distributed, a certified commercial applicator must be present at each location during business hours. The name of the certified applicator in charge must be on file with VDACS. Businesses must notify the OPS/Certification, Licensing, Registration, and Training Section within three business days of any change in assignment.

2. Businesses that apply or recommend pesticides for a fee must employ a properly certified commercial applicator. The commercial applicator is responsible for the safe application and recommendation of pesticides.

3. Sales of RUPs and applications of any pesticides must be recorded and maintained for two years.

   a. Sales records must include:

      (1) Identification of buyer or receiver: name, address, applicator certificate number or pesticide business license number, and certificate or license expiration date.

      (2) Date of sale.

      (3) Identification of pesticide:

         - Brand name.
         - EPA product registration number.

      (4) Quantity of pesticide sold or delivered.

   b. Application records must contain the following information:

      (1) Name, address, and telephone number of the customer, and address or location of the application site, if different.

      (2) Name and certification number of the person making or supervising the application.

      (3) Date of application (day, month, and year).

      (4) Type of plants, crop, animals, or sites treated.

      (5) Principal pests to be controlled.

      (6) Acreage, area, number of plants or animals treated, or size of structure treated.

      (7) Identification of pesticide:

         - Brand name or common name of pesticide used.
         - EPA product registration number.

      (8) Amount of pesticide concentrate and amount of diluent (ex. water) used, by weight or volume; or the volume and concentration applied to a structure as defined in item 6.

      (9) Type of application equipment used.

   There is a sample recordkeeping form for pesticide applications made by a certified commercial applicator or registered technician at the end of this unit (Table 1-2). Note that this form differs from the WPS and USDA recordkeeping form for restricted-use pesticides (Table 1-1).

4. Pesticide businesses must comply with state regulations for storage and disposal of pesticides.

Terms for Revocation, Suspension, or Denial of a Pesticide Business License

Licenses may be revoked for failure to:

- Provide records.
- Have a commercial applicator on premises as required.
- Notify Virginia Department of Agriculture and Consumer Services of changes in evidence of financial responsibility.

Other reasons to revoke a license include:

- Harming public health, public safety, or the environment.
- Committing multiple violations of the Virginia Pesticide Control Act.
- Interfering with the Commissioner of Agriculture and Consumer Services, or his or her agents.

A license may be suspended without a hearing. This can happen if the failure to provide access to records or to have a commercial applicator on premises as required threatens public health, public safety, or the environment.

Applications for a pesticide business license will be denied if an applicant does not submit the information required or comply with all licensing requirements at the time of application. The commissioner may deny a license to an applicant who has violated pesticide laws or regulations, or who has had a license suspended or revoked.

Table 1-1. Private/Grower Pesticide Application Record for _____

USDA records of restricted-use pesticide applications must be kept for two years.
WPS requires pesticide application information and Safety Data Sheets for all pesticides to be posted in a central area no later than 24 hours after an application is completed. Application and hazard information must be displayed continuously until 30 days after the last applicable restricted-entry interval or until workers or handlers are no longer on the establishment, whichever is earlier. WPS information must be retained for two years after expiration of the REI.

Application ❸ Date(s) (day/month/year) and ❶ Time		❸ Crop/ Commodity or Site Treated	❸ Location and Description of Treated Area	❸ Brand or Product Name	❶ Active Ingredient Common Name	❸ EPA Registration Number	❷ # of Units or Acres Treated	❷ Total Amount of Product Used (oz, lb, pt, qt, gal)	❷ Applicator Information: (Name and Certificate #)	❶ Restricted Entry Interval (REI)	
❶ Start	❶ Finish									Duration (# of hours)	Expiration (Date/Time)

❶Required for Worker Protection Standard
❷Required for Federal Pesticide Recordkeeping Requirements, USDA
❸Required for Worker Protection Standard and Federal Pesticide Recordkeeping Requirements

Prepared by Virginia Cooperative Extension and VDACS (Virginia Department of Agriculture and Consumer Services) Office of Pesticide Services, 2016.

Table 1-2. Commercial Applicator Pesticide Application Record for _____

Note: The Commonwealth of Virginia requires records of pesticide applications to be kept for two years.

Name, address, and telephone number of property owner	Address and location of the application site (if different than recorded in left column)	Certified applicator's name and certificate number	Date (day/mo/yr)	Type of plants, crops, animals, or sites treated	Principal pest to be controlled	Acreage, area, or number of plants or animals treated	Brand or common name of pesticide	EPA product registration number	Total amount of product *and* of diluent (if used)	Type of application equipment

Prepared by Virginia Cooperative Extension and VDACS Office of Pesticide Services, 2006.

Table 1-2. Commercial applicator pesticide application record

Test Your Knowledge

Q. What is the main purpose of the Virginia Core Manual?

A. To support general safety training for all pesticide users. This will help you become a competent pesticide manager.

Q. What state law sets the rules for pesticide use in Virginia?

A. The Virginia Pesticide Control Act.

Q. Which state agency is responsible for ensuring the safe use of pesticides in Virginia?

A. The Virginia Department of Agriculture and Consumer Services.

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

A. A private applicator is a farmer who uses restricted-use pesticides while producing an agricultural commodity on private land. Agricultural commodities comprise a wide range of goods and raw materials. Examples include corn, soybeans, tobacco, food animals, nursery stock, and lumber. Commercial applicators control pests on the job for consumers, their employers, and/or the public.

Q. How long must Worker Protection Standard (WPS) application records be posted?

A. No later than 24 hours after an application is completed and continuously until 30 days after the last applicable restricted-entry interval or until workers or handlers are no longer on the establishment, whichever is earlier.

Q. What is the main difference between the four classes of commercial applicators?

A. Their employer:

1. A commercial applicator for hire works for a pesticide business. He or she makes a living controlling pests for consumers, who pay the applicator or the employer for services rendered. Examples include people in the termite control or lawn care business.
2. A commercial applicator not for hire uses pesticides as one of several job duties. Examples include golf course superintendents and in-house pesticide applicators in private schools or food plants.
3. A government employee works for a local, state, or federal government agency. Examples include an in-house pesticide applicator in a public school or a state park employee tending landscape plantings within the park.
4. An inactive applicator does not use pesticides on the job. However, these applicators must maintain their certificate by renewing every two years and attending recertification courses as required.

Q. How does a registered technician differ from a certified commercial applicator?

A. A registered technician does the same type of work as other commercial applicators. However, a registered technician may use only general-use pesticides unless directly supervised by a certified commercial applicator.

Like commercial applicators, registered technicians may be for hire, not for hire, government employees, or inactive.

Q. What sort of training is required of registered technicians?

A. At least 20 hours of instruction and self-study of this manual. In addition, prospective registered technicians must have at least 20 hours of on-the-job training in proper pesticide handling and application. Trainees must have the direct onsite supervision of a certified commercial applicator whenever they are handling pesticides.

Q. What sort of credentials do you need to apply to take a commercial applicator exam in Virginia?

A. One of the following:

1. A valid Virginia registered technician certificate that has been in force for at least one year.
2. Proof of formal education, training, and/or experience in pesticide use comparable to a year's experience as a registered technician to qualify for testing.

Q. What are the formats for the certification exams? Where are the exams given?

A. Paper and pencil, and touch-screen computer. Both types are multiple choice. Paper exams are given at VDACS testing centers and (for private applicators only) Extension offices. Touch-screen computer exams are available at DMV Customer Service Centers.

Q. In which commercial applicator category would you need certification if you controlled weeds along roadsides for the Virginia Department of Transportation?

A. Category 6, Right-of-Way Pest Control.

Q. In Virginia, who is required to have a pesticide business license?

A. Persons engaged in the business of distributing, applying, or recommending the use of a pesticide product and those who store or sell pesticides. Commercial applicators and registered technicians for hire must hold a Virginia pesticide business license or work for someone who does.

Q. What responsibilities are common to all certified applicators?

A. 1. Adhering to the pesticide label.

2. Supervising applicators in their charge.
3. Keeping records of pesticide applications.
4. Reporting accidents or incidents.
5. Attending approved continuing-education courses required to keep certificates in force.

Q. Name the required elements of a written report describing a pesticide accident.

A. 1. Name(s) of individual(s) involved in accident or incident.

2. Name(s) of pesticide(s) used.
3. Quantity of pesticide spilled and containment procedures.
4. Time, date, and location of accident or incident.
5. Cleanup or repair actions taken.
6. Name (or description if unnamed) and location of nearby water bodies that might be contaminated by a pesticide accident or spill.

Q. Name the two ways in which a certified applicator can become recertified.

A. 1. By maintaining certification through approved continuing-education courses.

2. By retaking the appropriate exam(s).

   Persons who allow their certificate(s) to lapse by more than 60 days must retest in the proper category or categories, as well as the core, to reinstate the certificates.

Q. A commercial applicator passed a certification exam on April 1, 2010. When does the certificate expire?

A. June 30, 2012.

Q. A registered technician passed a certification exam on January 15, 2010. When does the certificate expire?

A. June 30, 2011.

Q. Do records need to be kept for application of all pesticides or just those classified as restricted use?

A. Private applicators must keep records of restricted-use pesticide applications. They also may need to record all pesticide applications if they employ farm workers. Commercial applicators and registered technicians must keep records of all pesticide applications.

Q. What sort of records must sellers of RUPs keep?

A. Any licensed pesticide businesses selling restricted-use pesticides must keep sales records.

Q. How long must applicators or businesses keep records of RUP sales and of commercial applications of any pesticides?

A. Two years.

Q. An employee of a daycare center places ant baits in the lobby of the center and sprays for cockroaches. Does the employee need to be certified?

A. Yes. He or she is a commercial applicator not for hire. Certification is necessary **because a daycare center is a sensitive area and the lobby area is open to the public.**

Q. What is the difference between the limited certificate category (87) and the single product certification category (86) for private applicators?

A. A limited certificate allows use of a single RUP for one identified purpose. A nonreader may qualify for this type of certificate. Single product certification allows use of a single RUP or related product in emergencies or special cases.

Q. In Virginia, who needs to be certified to use pesticides? Who does not?

A. Most commercial pesticide users and all private applicators using restricted-use products. However, the following do not need certification:

1. Private applicators (growers) who use only general-use products.
2. Farm workers who act under the direct supervision of a certified private applicator.
3. Researchers who work in the laboratory.
4. Medical doctors and doctors of veterinary medicine.
5. People who provide janitorial or sanitizing services.
6. Persons who apply paints not classified as restricted-use pesticides.
7. Properly supervised TBT boat painters.
8. Properly supervised ground-based forest weed-control crews using general-use herbicides.
9. Homeowners using home, lawn, and garden products.
10. Employees of local, state, or federal governmental agencies who from time

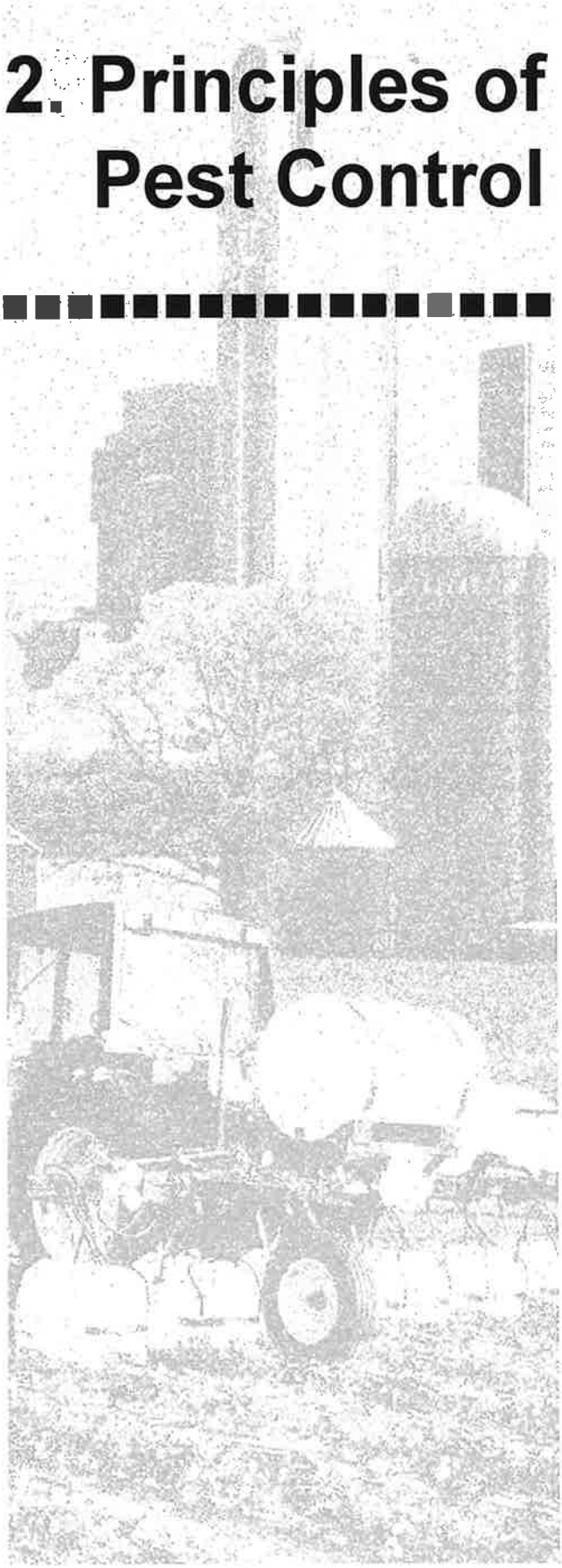
to time make incidental use of ready-to-use pesticides that are properly registered in Virginia ONLY to protect themselves from stinging and biting insects while doing a job other than pest management.

In addition, persons in training to become certified registered technicians may use pesticides under direct onsite supervision.

Q. What is a commercial applicator of record? What are his or her duties?

A. A commercial applicator who works for a pesticide business that applies pesticides for hire or makes pesticide recommendations for a fee. A commercial applicator of record is responsible for the safety of all pesticide applications as well as for making any pesticide-use recommendations.

Unit 2. Principles of Pest Control



Learning Objectives

After studying this unit, you should be able to:

- Explain the importance of pest identification.
- Name the five most common types of pests.
- Compare and contrast different pest management options.
- Explain the differences between key pests, occasional pests, and secondary pests.
- Distinguish between prevention, suppression, and eradication.
- Define thresholds and their importance in developing a pest management strategy.
- Describe monitoring as an element of a pest management strategy.
- Describe the basic principles of integrated pest management (IPM).
- Name and describe the different parts of an effective IPM program.
- List several factors that can cause a pesticide application to fail.
- Explain the problem of pesticide resistance and how to prevent it.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Annual – A plant that completes its life cycle in one year.

Appendage – An animal body part or organ that projects from the main part of the body.

Arthropod – An animal with jointed legs and a segmented, jointed outer skeleton.

Biennial – A plant that completes its life cycle in two years. The first year it germinates and grows. The second year it continues to grow, produces fruit and seeds, and then dies.

Control – To kill, to prevent or lessen the harmful effects of, to destroy, or to repel an undesirable organism.

Dicot – Plant with two seed leaves (cotyledons) and broad, net-veined leaves. As a rule, flower parts are in multiples of four or five (ex. four, five, or 10 petals).

Disease – An abnormal, unhealthy condition caused by an invading organism such as a bacterium or a virus.

Gall – Abnormal plant growth caused by stimuli from an insect or other organism.

Host – An organism infected by a parasite; a plant or animal on or in which a parasite lives.

Terms to Know cont.

Integrated Pest Management (IPM) – A system that uses all suitable pest control measures together in a way that keeps pest populations below the levels that cause economic injury.

Invertebrate – An animal without a backbone (ex. an insect or a slug).

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

Metamorphosis – Change in body form during the life cycle of an organism. There are two different types: complete and gradual.

Mode of Action – How a pesticide works; the way it controls a pest.

Mollusk – A soft-bodied, invertebrate animal, usually protected by a shell. Clams, snails, and slugs are mollusks.

Monitoring – Determining the size and distribution of a pest population in an area. See also Scouting.

Monocot – Plant with one seed leaf (cotyledon) and narrow, parallel-veined leaves. As a rule, flower parts are in threes or multiples of three (ex. three, six, or nine petals).

Nematode – A microscopic, eel-like roundworm.

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

Organism – Any living thing (ex. plants, animals, fungi, and bacteria).

Parasite – An organism that gets all or part of its food from another living organism. In so doing, it harms that organism (its host).

Pathogen – An organism that causes disease in other organisms.

Perennial – A plant that lives for more than two years.

Pest – Any living thing that is undesirable or harms people, property, or the environment.

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

Predator – An animal that attacks, kills, and feeds on other animals.

Resistance – The natural or genetic ability of an organism to tolerate toxic effects and/or pest attack.

Scouting – Regularly searching for, identifying, and assessing numbers of pests and the damage they are causing. See also Monitoring.

Threshold – A pest population level that requires action to prevent unacceptable injury or harm.

Vertebrate – An animal with a backbone (ex. a mammal, bird, or reptile).

Weed – Any plant growing where it is not wanted.

Pests

A pest is anything that:

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

Most organisms are not pests. A species may be a pest in some situations and not in others. For example, termites invading a house are pests. Those recycling dead trees in a forest are not. An organism should not be considered a pest until it is proven one. Make sure that the damage you observe is due to the pest and not some other cause. Categories of pests include:

- **Key pests** that are nearly always present, often cause major damage, and require regular control (ex. subterranean termites).
- **Occasional pests** that are migratory or cyclical and may require intermittent control (ex. fall webworm).
- **Secondary pests** that require control only under certain circumstances, such as the elimination of a key pest or the absence of a natural host. Some plant diseases are secondary pests because they infect plants only under certain conditions. Certain turf weeds are pests only when the turf stand is thin or poorly managed.

Pest Identification

Accurate identification is the first step in an effective pest management program. You cannot implement a pest control program until you know what the pest is. The more you know about the pest and the factors that influence its development and spread, the easier, more cost-effective, and more successful your control program will be. When you correctly identify a pest, you gain access to important information. This includes its life cycle and the time that it is most susceptible to control measures.

As a certified applicator, you must be familiar with the pests you are likely to encounter in the type of work in your certification category. To be able to identify and control pests, you need to know:

- Their physical features.
- The characteristics of the damage they cause.
- Their development and biology.
- Whether they are key, occasional, or secondary pests.

Accurate pest identification is the first step in pest control.

- Your control goal.

Some pests (such as nematodes) are so small that you cannot see them without using a hand lens. In other cases, you may need to identify the pest by signs of its damage. Rodents, for example, often dig distinctive burrows that are common only to that species.

If you need help in pest identification, contact your Virginia Cooperative Extension (VCE) agent. Extension offices have many publications on pest identification. Virginia Tech also provides diagnostic services through VCE for many types of pests.

These services include the:

- Weed ID Clinic.
- Plant Disease Clinic.
- Nematode Assay Laboratory.
- Insect Identification Laboratory.

Follow Extension guidelines when collecting samples and submitting them for identification. If you have questions about proper methods, contact your local Extension agent or one of the diagnostic labs listed above. Include the location and date you collected the sample.

Types of Pests

This section will help you recognize common types of pests. If you know what pest group a living thing belongs to, it is easier to identify. Common pest groups include:

- Weeds.
- Parasites and diseases.
- Mollusks.
- Arthropods: insects and their relatives.
- Vertebrates.

Weeds

Weeds are plants growing out of place. Most weeds on land are grasses, sedges, or broadleaf plants. Weeds that live in water (aquatic plants) are either vascular plants or algae. Most of the plants we call weeds are hardy and aggressive.

Weeds are successful for several reasons:

- Most produce a large number of seeds.
- Most have efficient ways to spread seeds.
- Many can spread by runners or underground stems.
- Seeds of many types of weeds can remain dormant for a long time.
- Most can grow in harsh conditions.
- Most can compete for soil moisture, nutrients, and sunlight better than cultivated plants.

Weeds can be classified by their anatomy (structure) and by their life cycle.

Plant Structure

Flowering plants fall into one of two major groups:

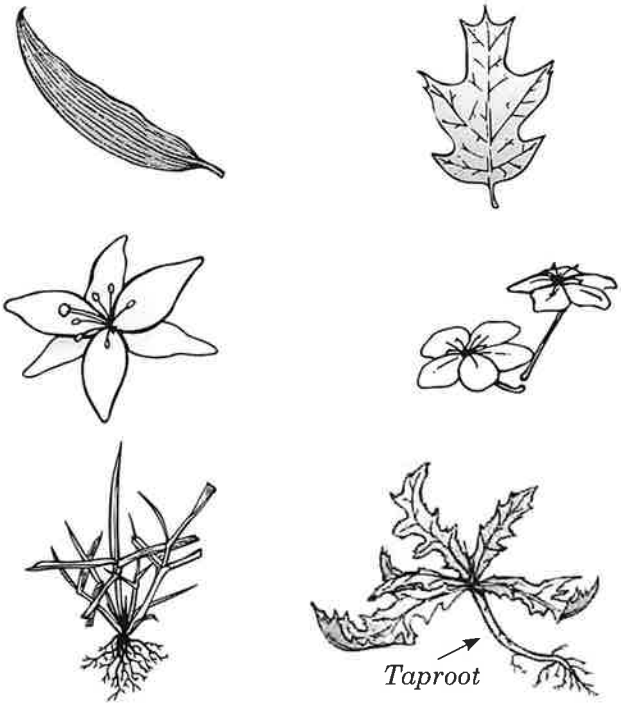
1. **Monocots** (grasses and sedges).

2. **Dicots** (broadleaves).

Monocots and dicots differ in anatomy, or structure. Some herbicides are selective and control either grasslike or broadleaf plants, but not both. Therefore, it is important to know whether your target weed is a monocot or a dicot.

Monocots have one seed leaf (cotyledon), parallel leaf veins, flower parts in multiples of three, and fibrous roots. Grasses and lilies are monocots. Common pest monocots include johnsongrass, crabgrass, and nutsedge.

Dicots have two seed leaves (cotyledons), broad or narrow leaves with netlike veins, and flower parts in multiples of four or five. They



Monocot *Dicot*

usually have taproots that penetrate deep into the soil. Some dicots, like trees and shrubs, have woody stems. Examples of dicot pests are pigweed, thistles, dandelions, and poison ivy.

Life Cycles of Weeds

Weeds are also classified by life cycle. To successfully control a weed, you must know whether it is a summer annual, a winter annual, a biennial, or a perennial.

Annuals live one year or less. They germinate from seed, grow, flower, set seed, and die in no more than 12 months. The seeds of summer annuals germinate in the spring or summer. These plants flower in late summer or early fall. Russian thistle, lambsquarters, wild oats, and crabgrass are summer annuals. Winter annuals germinate in the late summer, fall, or winter. They flower in the spring. Wild mustards and chickweed are winter annuals.

Biennials have a two-year life cycle. They germinate and grow foliage (leaves) during the first year. Often, the first year's growth is a wide, low-growing cluster of leaves called a "rosette." In the second year, biennials flower, set seed, and die. Bull thistle, musk thistle, Queen Anne's lace (wild carrot), mullein, and chicory are biennials. The thistles and mullein grow leaves in a rosette.

Perennials live more than two years. Some may live for many years. Perennial plants store food in underground parts. They use the energy from that storehouse to produce new growth early in each growing season. Because of this, they are usually much harder to control than annual weeds. They flower and set seed repeatedly, one or more times each year.

Perennial weeds can take root by germinating from seed. In addition, some perennials have special structures that allow them to spread in other ways. For example, johnsongrass has a rhizome, a specialized underground stem. Some have creeping stems or modified aboveground roots called "stolons." These grow along the soil surface, producing new roots and shoots. Other perennials have bulbs, tubers, or taproots that can divide and produce new growth. Common perennial weeds include Canada thistle, johnsongrass, field bindweed, wild onion, dandelion, and plantains. Plants with woody stems, such as locust trees and poison ivy, are perennials.

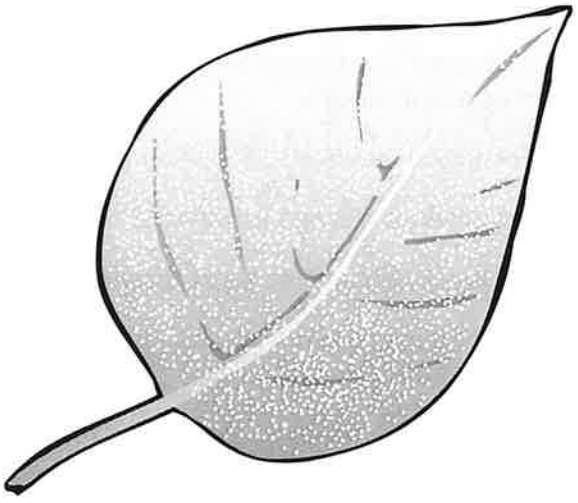
Parasites and Diseases

Parasites attack both plants and animals. The plant or animal that a parasite infects or feeds upon is its host. Many parasites cause diseases in the host. These, in turn, may cause health problems, such as abnormal appearance, growth, or function. Pathogens such as fungi, bacteria, mycoplasmas, and viruses cause many plant and animal diseases. Pesticides are often used to control diseases caused by these pathogens.

Plant Diseases

Many plant diseases are widespread and hard to control. A plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function.

Parasitic fungi thrive in moist, humid areas. They cause soft rot of fruits, leaf spots, root rots, and powdery mildew, among other diseases. Bacterial infections cause leaf spots, leaf blights, and wilts. Infected leaves often appear oily or greasy with water-soaked



Powdery Mildew

spots. Viral diseases may cause stunting, yellow rings on leaves, wilting, or mosaic patterns (yellow or bleached streaks).

Other Parasites

Other parasites such as flies, ticks, and lice may host and transmit diseases in animals. Some of these parasites cause blood loss and physical damage to livestock. Parasites can reduce the rate of weight gain, cause a decrease in milk or egg production, interfere with reproduction, and lower the infected animal's resistance to disease.

Some parasites such as fleas, bed bugs, and lice can harm people through their bites. Lice, ticks, and mosquitoes can transmit diseases such as typhus, Lyme disease, and West Nile virus. Certain parasites such as mites cause discomfort with itching. Blood-feeding flies attack people and livestock, often causing itching and swelling. Some of these flies also transmit diseases.

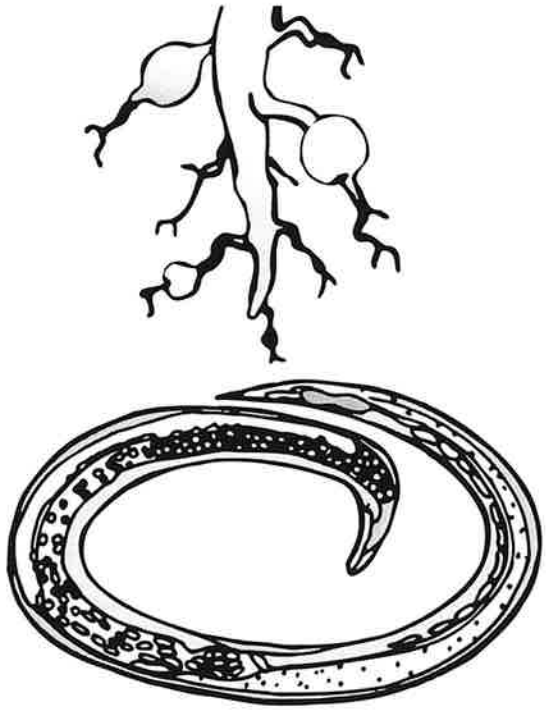
Parasitic plants are also a concern. Parasitic plants harm host plants by taking some of their nourishment from them. Examples include mistletoe, dodder, and yellow rattle.

Nematodes and Other Parasitic Worms

Nematodes are very small roundworms. Some nematodes invade the bodies of animals. Others can cause some plant diseases. They can be important pests of agricultural plants, ornamental plants, and turf.

Most nematodes are harmless. However, plant-parasitic nematodes attack the roots, stems, and leaves of plants. Nematode root feeding interferes with a plant's ability to take up water and nutrients. Infected plants wilt and seem to be suffering from a lack of water or nutrients. Some plant-parasitic nematodes important in Virginia are lesion nematodes, root-knot nematodes, and spiral nematodes.

Tapeworms are another type of parasite. These parasitic flatworms live in the intestinal tract of many vertebrates.



Nematode Damage and "Typical" Nematode

Mollusks

Mollusks are soft-bodied animals with no backbone. Most have shells for protection against predators. Snails and slugs are pest mollusks found on land. These mollusks damage plants by feeding on foliage and fruit. They also leave slime trails as they move from place to place. Mollusks reduce the value of commercial produce if they feed on harvested plants and fruit. Some snails are the intermediate hosts of parasites that infect humans or domestic animals.

Arthropods: Insects and Their Relatives

Arthropods are animals with segmented bodies and jointed **appendages**. They have an external skeleton made of a lightweight but strong material called "chitin." Their appendages include jointed legs for walking. Some arthropods have other specialized appendages, including:

- Sucking tubes.
- Chewing mouthparts.

- Egg depositors.
- Antennae.
- Pincers.

Examples of arthropods are lobsters and crayfish, barnacles, ticks and mites, spiders, scorpions, and insects. Some arthropods interfere with or annoy people. Pest arthropods damage desirable plants, food and feed, building materials, and fibers; bite or sting; parasitize plants or other animals; and/or spread diseases. Most pest arthropods are insects.

Plant pests include:

- Leaf eaters (ex. gypsy moth).
- Internal feeders (ex. codling moth).
- Stalk or stem borers (ex. European corn borer).
- Plant or sapsuckers (ex. hemlock woolly adelgid).
- Leaf and root clippers (ex. cutworms).
- Underground root feeders (ex. white grub).

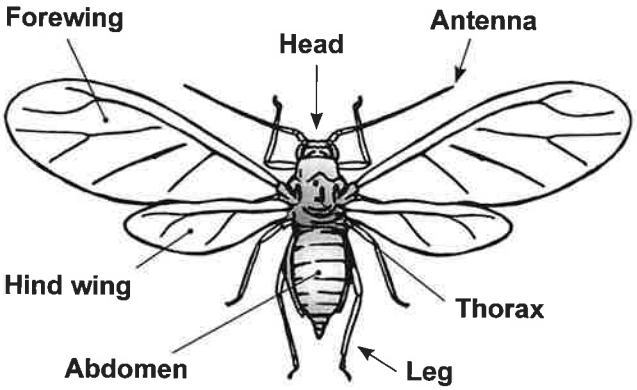
Animal pests include:

- Flies.
- Ticks.
- Mites.
- Lice.
- Other arthropods that suck blood and animal fluids.

Remember that most insects are not pests. In fact, some of them, called "beneficial insects," play an important role in agriculture. Some beneficial insects, such as ladybird beetles and lacewings, feed on harmful insects, mites, and weeds. Others, such as honeybees and butterflies, are pollinators. Without pollinators, many types of plants could not reproduce.

Insects

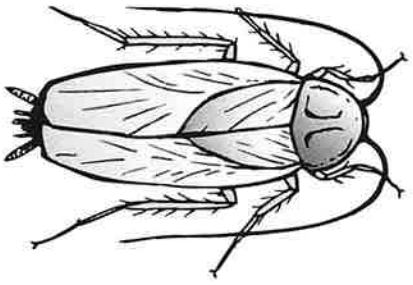
Insect bodies have three distinct parts: head, thorax (the middle part), and abdomen (the rear part). Most adult insects have one or two pairs of wings and three pairs of legs on the thorax. They have one pair of antennae. Many have complex mouthparts. Insects produce large numbers of offspring. Insects are sometimes difficult to identify because they change in body form as they grow and develop. This change in body form is called "**metamorphosis.**" Insect life cycles include either gradual or complete metamorphosis.



Parts of an Insect

Gradual Metamorphosis

In gradual metamorphosis, insects develop from eggs into wingless nymphs and then into mature adults. There is no pupa stage. The nymphs and adults look very much alike and often share the same habitat. Nymphs, however, are not sexually mature. As nymphs feed and grow, they molt (shed their skin) several times. As they molt, nymphs grow larger and acquire wings and functional reproductive organs. Grasshoppers, plant bugs, cockroaches, and leafhoppers develop by gradual metamorphosis.



Cockroaches undergo gradual metamorphosis.

Complete Metamorphosis

Complete metamorphosis is more complicated. In this type of development, insects pass through four life stages: egg, larva, pupa, and adult. Usually, both the larval and adult stages are active. Insect larvae often look very different from the adult stage of the same species (ex. butterflies and moths). They often live in different places and feed on different things.

Larvae are active feeders. Larvae, which often look like worms, have two antennae and six legs. Full-grown larvae molt to form pupae. Pupae are often covered by a cocoon or some other protective case. Insects in the pupa stage look inactive. However, inside the cocoon or case, the animal is changing into the adult form. The adult form is active. Some adult insects feed and some do not. The adult form produces the eggs for the next generation. Butterflies, moths, weevils, beetles, flies, ants, wasps, and fleas develop by complete metamorphosis.

Arachnids

Arachnids are wingless arthropods with four pairs of legs on the rear body section. They do not have antennae. Arachnids have two body parts: cephalothorax (head and thorax combined) and abdomen. Examples include spiders, ticks, mites, and scorpions. Several mite species are serious plant pests. They suck plant juices, eat the undersides of leaves, and disfigure the plants they feed on. Some tick species endanger the health of people and domestic animals.

Table 2-1. Insects vs. arachnids

	Body parts	Wings*	Legs	Antennae
Insects	3	2 or 4 (1 or 2 pairs)	6 (3 pairs)	2 (1 pair)
Arachnids	2	None	8 (4 pairs)	None

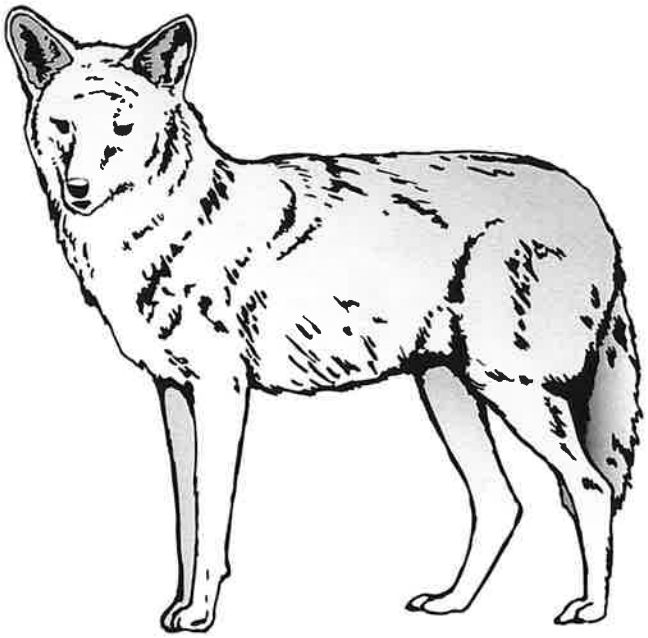
** Most (but not all) adult insects have wings.*

Vertebrates

Vertebrates are animals with a backbone or spinal column. Most vertebrates are large when compared to insects and arachnids. Mammals, birds, reptiles, and fish are all vertebrates. In Virginia, most vertebrate pest complaints concern birds and mammals. Vertebrates become pests when they damage property, agriculture, and/or natural resources. They may also threaten human health and safety.

Some vertebrates, such as bats and starlings, spread disease. Others, such as crows, rats, and raccoons, may destroy feed or eat the seeds or fruit of crops. Deer compete with livestock, cause traffic accidents, and destroy residential landscapes. Coyotes may feed on domestic animals. Snakes do little real damage, but many people fear them and consider them pests.

Indoor vertebrate control usually centers on eradication of rodent pests. Outdoor vertebrate control focuses on suppressing nuisance animals such as coyotes, raccoons, or beavers to an acceptable level.



Coyote

Pest Control

To decide whether pest control is necessary, remember these three pointers:

1. **Control a pest only when it is causing or is expected to cause unacceptable harm or damage.**

2. **Use a control strategy that will reduce the pest numbers to an acceptable level.**

3. **Cause as little harm as possible to everything except the pest.**

Even though a pest is present, it may not do much harm. You gain nothing if controlling the pest costs more than the damage it is causing – or if the treatment causes unacceptable collateral damage. Setting a treatment threshold will help you decide if and when to apply pesticides.

Thresholds

Thresholds are the levels of pest populations that trigger action to prevent the pests in an area from causing unacceptable injury or harm. Thresholds may be based on appearance, health, or economic concerns. Specific levels, known as "action thresholds," have been determined for many pests.

A threshold is often set at the level where the economic losses caused by pest damage, if the pest population continued to grow, would be greater than the cost of controlling the pests. These types of action thresholds are known as "economic thresholds."

Threshold levels vary. In some situations, the threshold level is zero: even a single pest may be unacceptable. For example, the presence of any rodents in a food-processing plant forces action. In homes, people often decide to control certain pests, such as rodents or roaches, even if only one or a few are evident. In other cases, a wait-and-see approach is better.

Threshold levels are constantly changing. If the control measures are expensive, the economic threshold is often high. High control costs mean it takes more commodity loss to justify the control action. **Monitoring** is an excellent way to determine whether a pest population has reached the treatment threshold.

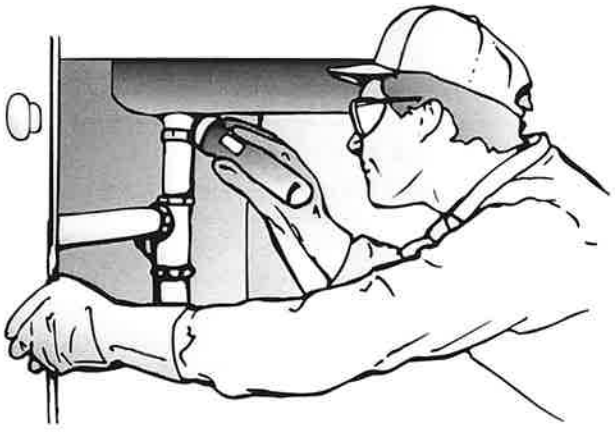
Monitoring

Pest monitoring (scouting or checking) helps assess the pest problem. In most pest control situations, you should monitor the designated area often. Regular monitoring can answer several important questions:

- What kinds of pests are present?
- Are their numbers and the damage they caused great enough to justify control?
- When is the right time to begin control?
- Have past control efforts successfully reduced the number of pests?

Monitor arthropod, mollusk, and vertebrate pests by trapping or scouting. Monitor weed pests by counting the number of pests per unit area. This will tell you their density. Monitor microbial pests by looking for the injury or damage they cause.

Check environmental conditions in the managed area. Temperature and moisture levels, especially humidity, are often important clues in predicting when a pest outbreak will occur or will hit threshold levels.



Monitor a pest population to determine whether treatment is necessary.

Monitoring is not necessary in situations where a pest is continually present and the threshold is zero. For example, there is zero tolerance for the presence of bacteria in operating rooms and other sterile areas of healthcare centers. In these settings, routine pest control measures are necessary to prevent pests from entering the area and to eradicate any pests that may be present.

Pest Control Goals

Whenever you try to control a pest, you will want to achieve one or more of these three goals:

1. **Prevention** – minimizing the chances that a pest will become a problem.

2. **Suppression** – reducing pest numbers or damage to an acceptable level.

3. **Eradication** – destroying an entire pest population.

Prevention may be a goal when you can predict the presence or abundance of the pest in advance. Key pests, by definition, are usually very predictable. Occasional and secondary pests may be predictable if you know the circumstances or conditions that will favor their presence. For example, some plant diseases occur only under certain environmental conditions. If such conditions exist, you can take steps to protect the desirable plants.

There are many ways to reduce or prevent pest damage. These include planting weed- and disease-free seed, choosing plants resistant to diseases and insects, and practicing good sanitation. Other preventive techniques include excluding pests from the target area and using preemergent herbicides to kill weed seeds. Prevention is an important part of integrated pest management.

Suppression is a common goal in many pest situations. The intent is to reduce the number of pests to a tolerable level. Once you detect a pest's presence and decide that control is necessary, suppression and prevention often are joint goals. The right combination of control measures can often suppress the pests already present and prevent them from again reaching the threshold level.

Eradication is a rare goal in outdoor pest control because it is difficult to achieve. The usual goal is prevention and/or suppression. In indoor areas, eradication is more feasible. Enclosed environments usually are smaller, less complex, and more easily controlled than outdoor areas. In many enclosed areas – such as healthcare centers, food-processing plants, food-preparation facilities, homes, schools, and office buildings – certain pests cannot or will not be tolerated. Eradication may be a goal in regulatory pest control (see below).

Regulatory Pest Control

Regulatory pest control (sometimes called "legal control") refers to the efforts of state and/or federal agencies to control pests that endanger public health or are likely to cause widespread damage to crops, livestock, forests, or ornamental plants. Such pests often cannot be successfully managed at the local level. Eradication may be possible when a foreign pest has been accidentally introduced but is not yet established in an area. State and federal government agencies often carry out these campaigns. Mediterranean fruit flies, gypsy moths, and fire ants are examples of pests managed by state or federal programs.

Quarantines are another option in regulatory pest control. A "quarantine" is a control process meant to keep pests out of pest-free regions. State and federal agencies monitor airports, seaports, and other major entry points to intercept pests. Officials closely examine food, animals, nursery stock, and plant cuttings to prevent the spread of noxious pests.

Avoiding Harmful Effects

Responsible pest control involves more than just identifying a pest and using a control tactic. The treatment site, whether it is outdoors or indoors, usually includes nontarget

organisms (such as people, animals, and plants) and environmental features (such as air, water, structures, objects, and surfaces). The pest control measures you choose could damage all of these. Unless you consider the possible effects on the entire treatment area, your pest control effort could cause harm or lead to new or continued pest problems. Rely on your training and good judgment. When pesticides are part of the strategy, read and follow all instructions on the pesticide labeling.

Pest control strategies disrupt most treatment sites to some degree. The actions of every type of organism or element sharing the site usually affect the actions and well-being of many others. When the balance is disrupted, certain organisms may disappear or drop in number, while others may become more plentiful.

Integrated Pest Management

Integrated pest management (IPM) is an ecological approach to pest control. It is based on the habitat and life cycle of the pest. IPM combines chemical and nonchemical methods in a single plan or strategy. The goal of an IPM program is to reduce pest populations to an acceptable level in a way that is practical, cost-effective, and safe for the environment as well as human health.

Why Use IPM?

There are many good reasons to use IPM instead of just using pesticides – or using only one kind of pesticide. Using several tactics to control a pest problem tends to ensure better success at the treatment site. It also promotes a balanced ecosystem where no one type of organism dominates. Relying solely on pesticides can be expensive and harmful to the environment, especially if you are using restricted-use pesticides. There may also be other problems, including pesticide resistance, poor pesticide performance, and secondary pest outbreaks. Reducing pesticide use can help protect nontarget organisms such as the ladybird beetle and other beneficial insects. Finally, IPM programs are often more acceptable to the public.

Effective IPM programs involve:

- Identifying the pest and understanding its biology.
- Monitoring the target pest.
- Deciding whether control is justified.
- Determining a pest control goal.
- Knowing what control tactics are available.
- Evaluating the benefits and risks of each tactic or combination of tactics.
- Choosing the most effective strategies that will cause the least harm to people and the environment.
- Using each tactic correctly.
- Observing all applicable local, state, and federal regulations.
- Recording and evaluating the results.

The strategies you choose will depend on the target pest and the kind and amount of control you need.

Natural Controls

Forces of nature act on all organisms, causing their populations to rise and fall. These natural forces (controls) act independently of humans and may either help or hinder pest control. You may not be able to alter the action of natural forces on a pest population. However, you should be aware of their influence and take advantage of them whenever possible. Natural forces that influence pest populations include:

- Climate.
- Natural enemies.
- Geographic barriers.
- Food and water supply.
- Availability of shelter.

Climate

Weather conditions, especially temperature, amount of daylight, and humidity, affect pests' activity level and their rate of reproduction. Rain, freezing temperatures, drought, or other bad weather may kill or suppress pests. Climate also affects pests indirectly by influencing the growth and development of their hosts. A population of plant-eating pests depends on the growth of its host plants. Unusual weather conditions can change normal patterns so that increased or decreased damage results. For example, during droughts, ants may search for water and food sources within people's homes.

Natural Enemies

Birds, reptiles, amphibians, fish, and mammals feed on pests and help keep their populations under control. Many predatory and parasitic arthropod species feed on pest species. In addition, pathogens often suppress pest populations. All these organisms are natural enemies of certain pests. Encouraging a natural balance may help produce an ecosystem where no one organism dominates and pest populations are manageable. Natural enemies play a big part in maintaining this balance.

Lack of natural enemies is evident when an exotic species is introduced from another area. With nothing to hold it back, an exotic pest population can get very large. The pest may cause damage if there are no predators or other enemies to keep its population in check. Red imported fire ants (RIFA) and Africanized bees ("killer" bees) are examples of how introduced pests with no natural enemies in their new surroundings can spread very quickly. See "Biological Control" below for more information on the use of natural enemies in pest management.

Geographic Barriers

In ancient times, geographic features such as mountains, deserts, and oceans restricted the spread of many pests. When people began exploring the world, however, they carried with them the diseases, animals, and plants of their native lands. These organisms traveled to other civilizations across oceans in ships and over land into forests, fields, and towns. Despite physical barriers, pests often travel to many parts of the world and have become very costly to control.

Food and Water Supply

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

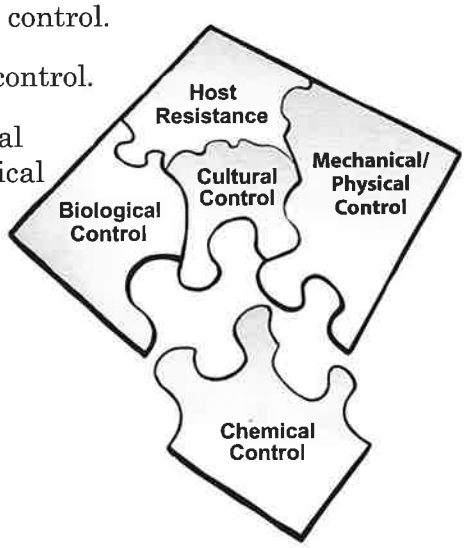
Availability of Shelter

The availability of shelter can affect some pest populations. Overwintering sites and places to hide from predators are important to the survival of many pests.

Applied Controls

Unfortunately, natural controls often do not control pests quickly or completely enough to prevent unacceptable injury or damage. Further, as a rule, you cannot apply them at will to solve a specific problem. At this point, you must implement an IPM program that includes both nonchemical and chemical measures or applied controls. Applied controls are the elements of an integrated pest management program. These may include:

- Host resistance.
- Biological control.
- Cultural control.
- Mechanical and physical control.
- Chemical control.



IPM Puzzle

Host Resistance

Some plants, animals, and structures withstand pests better than others do. Many varieties of plants, wood, and animals are resistant to certain pests. Using resistant types, when available, helps keep pest populations below harmful levels by making conditions less favorable for the pests.

Host resistance works in three main ways:

1. Chemicals in the host repel the pest or prevent the pest from completing its life cycle.
2. The host is more vigorous or tolerant than other varieties and therefore is less likely to be seriously damaged by pest attacks.
3. The host has physical characteristics that make it more difficult to attack.

Biological Control

The use of living organisms to control pests is called "biological control" ("biocontrol"). In some cases, these organisms, or biocontrol agents, are natural enemies of the pest. All living things have natural enemies. They may be predators, parasites (parasitoids), or pathogens. Natural enemies help to keep populations of nuisance plants, insects, and other organisms in balance. Biological control involves a number of different management tactics. All use some aspect of the pest's biology to combat it.

Biological control usually is not eradication. The degree of control fluctuates. Biological control systems using natural enemies work best when they have time to become established. Ideally, the number of beneficial organisms comes into balance with pest populations at a level below the treatment threshold. After establishing a biological control program, you may need to release more predators or parasites.

Biocontrol also includes methods to biologically alter the pest. One example is the production and release of large numbers of sterile males.

Cultural Control

"Cultural control" means changing the habitat where pests flourish. Cultural control methods can disrupt ideal pest conditions and decrease pest pressure. These methods are most effective when applied at the weakest stage of the pest's life cycle. Cultural controls make the pest less likely to survive, grow, or reproduce. Two main types of cultural control are cultural practices and sanitation.

Cultural Practices

Cultural practices often help decrease pest survival. Common cultural practices in agriculture include:

- Rotating crops.
- Tillage.
- Mulching,
- Varying time of planting or harvesting.
- Planting trap crops.
- Adjusting row width.
- Pruning, thinning, and fertilizing cultivated plants.

Crop rotation is especially valuable in agricultural plant pest control. It is a planting cycle in which different crops are planted in a field from year to year. Crop rotation is one of the most important cultural controls to manage soilborne pathogens, nematodes, insects, and weeds.

Tillage is also useful. "Tillage" means to move the soil around the crop or to disturb the soil before the crop is established. Tillage can:

- Destroy an insect colony.
- Kill weeds by ripping up their roots.
- Bury infested residues harboring plant pathogens.

Sanitation

Sanitation is an important concept in almost every type of pest management. Improving cleanliness, eliminating pest harborage, and increasing the frequency of

garbage pickup are ways to control urban and industrial pests. To discourage ants and other household pests, clean up spills, store food in closed containers, and keep garbage outdoors. Good manure management is essential to control pests of domestic animals. Provide proper drainage in barnyards, get rid of seepage areas, and remove manure from livestock pens often. To lessen the risk of mosquito-borne illness, eliminate places where mosquitoes breed. For example, overturn plant pots and dispose of waste tires.

In agricultural settings, keep fields, seed stock, tools, and surfaces clear of weeds, insect pests, and plant diseases. Remove crop residues to reduce carryover of agricultural pests from one planting to the next. Good sanitation may eliminate the food sources or sheltered areas that attract insect pests. It is the best way to control nematodes. Sanitation techniques emphasize general cleanliness. They provide a way to reduce the levels of pathogens and other pests.

Another form of sanitation that helps prevent pest spread is using pest-free seeds or transplants. In addition, be sure to decontaminate equipment, animals, and other possible carriers before allowing them to enter a pest-free area or leave an infested area. Properly designed food-handling areas can reduce access and shelter for many pests.

Mechanical and Physical Control

Mechanical control is another way to prevent the spread or reduce the size of a pest population. This method includes using various devices and machines to control pests or alter their environment. Traps, screens, barriers, fences, nets, radiation, and electricity may keep pests out of an area. Simply using a hose to wash insects off a plant is one type of mechanical control. Aerating soil is another. Mechanical control includes the use of hand-held tools. Chain saws, string trimmers, shovels, and scythes are examples. Plows, disks, mowers, and cultivators rip out weeds and destroy soil conditions for many pests.

Cleaning up spills is one type of sanitation.

Physical control involves changing certain environmental conditions. These include water, air movement, temperature, light, and humidity. Using heat and refrigeration can change the environment enough to suppress or even eradicate some pest populations. Altering moisture and humidity levels can control some pests, especially insects and disease agents. For example, lowering the humidity of stored grain reduces the chance of damage from mold and certain insects. Increasing air movement in greenhouses may help suppress fungal diseases on plants.

Chemical Control

Pesticides are chemicals used to destroy pests, control their activity, or prevent them from causing damage. As you learned earlier, chemical control works best when combined with other types of control methods. In this way, an IPM approach can provide long-term control with the least impact on the environment. Remember that pesticide status is in a constant state of flux. New products come on the market and others are removed. For this reason, you must keep up to date on what is available and how you may legally apply it.

Not all pesticides kill the pest. Some pesticides either attract or repel pests. Others regulate plant growth or remove foliage. Pesticides are generally the fastest way to control pests. Often, they are the only practical choice.

Pheromones are often useful to monitor a specific pest population. Placed in a trap, for example, they provide a way to estimate pest numbers by attracting only certain insects in a sample area. This technique works especially well with moths, such as the tufted apple bud moth. Pheromones also can be a control tool. Sometimes a manufactured copy of the pheromone that a female insect uses to attract males will confuse males and prevent mating. This results in fewer pests. Applying juvenile hormones to an area can reduce pest numbers by keeping some immature pests from becoming normal, reproducing adults. These chemicals have successfully controlled fleas and cockroaches.

Another effective control technique is the use of microbial pesticides. **Microbial pesticides** are microorganisms (such as bacteria and fungi), or toxins they produce, that have been formulated into pesticides. *Bacillus thuringiensis* (Bt) is a good example of a microbial pesticide. As a rule, these pesticides are safe for people and nontarget organisms. Microbials often target a specific pest or group of pests.

Types of Pesticides

Pesticide users often have many options when choosing a pesticide. Pesticide products vary in a number of ways, including:

- Efficacy.
- Persistence.
- Mobility.
- Toxicity.
- Mode of action.

What do these terms mean? The **efficacy** of a pesticide is its effectiveness: how well it works. The **persistence** of a pesticide is how long it remains active. A persistent (residual) pesticide remains active longer than a nonpersistent (nonresidual) one (see below). The **mobility** of a pesticide is its tendency to run off in water, become a vapor, or otherwise change form or leave the target site. Pesticides that are adsorbed (taken up) by a plant or that cling to soil are less likely to be mobile. The **toxicity** of a pesticide is its ability to cause harmful effects. See Unit 6 for more information on toxicity and exposure. Finally, a pesticide's **mode of action** is how it works: the chain of events or the action that kills or injures pests.

Some pesticides are selective; others are nonselective. Fumigants are nonselective and will control many different types of pests, including fungi, weeds, insects, and nematodes. Some selective herbicides control only certain types of plants. For example, 2,4-D affects only dicot (broadleaf) plants. In contrast, glyphosate, a nonselective herbicide, will harm all plants. Pesticides also differ in how they move through the pest. Contact pesticides are effective only where the pesticide touches the pest. They remain on the surface of the plant or animal and are not absorbed by the treated organism. Systemic pesticides, on the other hand, will move internally (translocate) through an organism after an insect eats them or a plant absorbs them. Systemic insecticides can be fed to or injected into livestock to control flies and other pests. Systemic herbicides are especially useful for perennial weed control because they move into the roots following absorption by leaves.

Certain pesticides, especially herbicides, differ depending on when you apply them. If you apply an herbicide to the soil before the weed seeds germinate, it is preemergent. Germinated and emerged weeds are usually unaffected by these treatments. If you apply an herbicide to the soil or foliage after the weed starts to grow, it is postemergent. You may use a combination of preemergent and postemergent herbicides to control weed problems.

Pesticides also vary in the length of time they remain active. Short-term (nonresidual) pesticides break down quickly into nontoxic

by-products. Long-term (residual) pesticides, in contrast, may remain active (toxic) for weeks, months, or even years. The latter are valuable for insects that present a chronic control problem or to control weed seed germination in a landscape bed for several months at a time.

Here is a list of pesticide types, according to the type of pest they control:

- **Acaricides:** control mites, spiders, and ticks.
- **Attractants:** lure pests to baits, traps, or monitoring devices.
- **Avicides:** control pest birds.
- **Bactericides:** control bacteria.
- **Defoliants:** cause leaves or foliage to drop from plants.
- **Desiccants:** promote drying or loss of moisture from plant tissues.
- **Disinfectants (antimicrobials):** control microorganisms.
- **Fungicides:** control fungi.
- **Growth regulators:** alter the growth or development of a plant or animal.
- **Herbicides:** control weeds and other undesirable plants.
- **Insecticides:** control insects (and may also control some other arthropods).
- **Miticides:** control mites.
- **Molluscicides:** control mollusks (snails and slugs).
- **Nematicides:** control nematodes (roundworms).
- **Piscicides:** control pest fish.
- **Predacides:** control predatory vertebrates.
- **Repellents:** deter or drive away insects, related invertebrates, birds, and mammals.
- **Rodenticides:** control rodents.

If you need help choosing a pesticide, contact Virginia Cooperative Extension. You will learn about new and safer control measures at recertification classes. You can also find out about professional organizations related to your pest control work.

Choose the right pesticide for each situation.

Pesticide Resistance

Pesticide resistance is the ability of a pest population that is repeatedly exposed to a given pesticide to resist and survive its effects. Resistance plays a big part in determining how well a pesticide works on a given population.

For example, an insect population often has "abnormal" (resistant) members that can tolerate exposure to insecticide doses that kill "normal" (susceptible) members. Each time the same insecticide is applied, the susceptible members die, and the resistant members survive. In time, most of the members will be resistant to the insecticide. Unfortunately, it is possible for insects to develop multiple resistance. This occurs when pests can tolerate insecticides from different classes of compounds.

Resistance usually develops in pest populations that have had repeated treatments with a single pesticide or several pesticides with the same mode of action. If a pest survives the effects of one chemical and never has to adapt to a different mode of action, it can successfully reproduce. The trait of resistance will then be passed along to future generations.

Not all pesticides have the same risk of resistance. In general, pesticides that target multiple sites in a pest have a low risk of resistance. Those that target only a single site, on the other hand, have a higher risk.

Preventing Pesticide Resistance

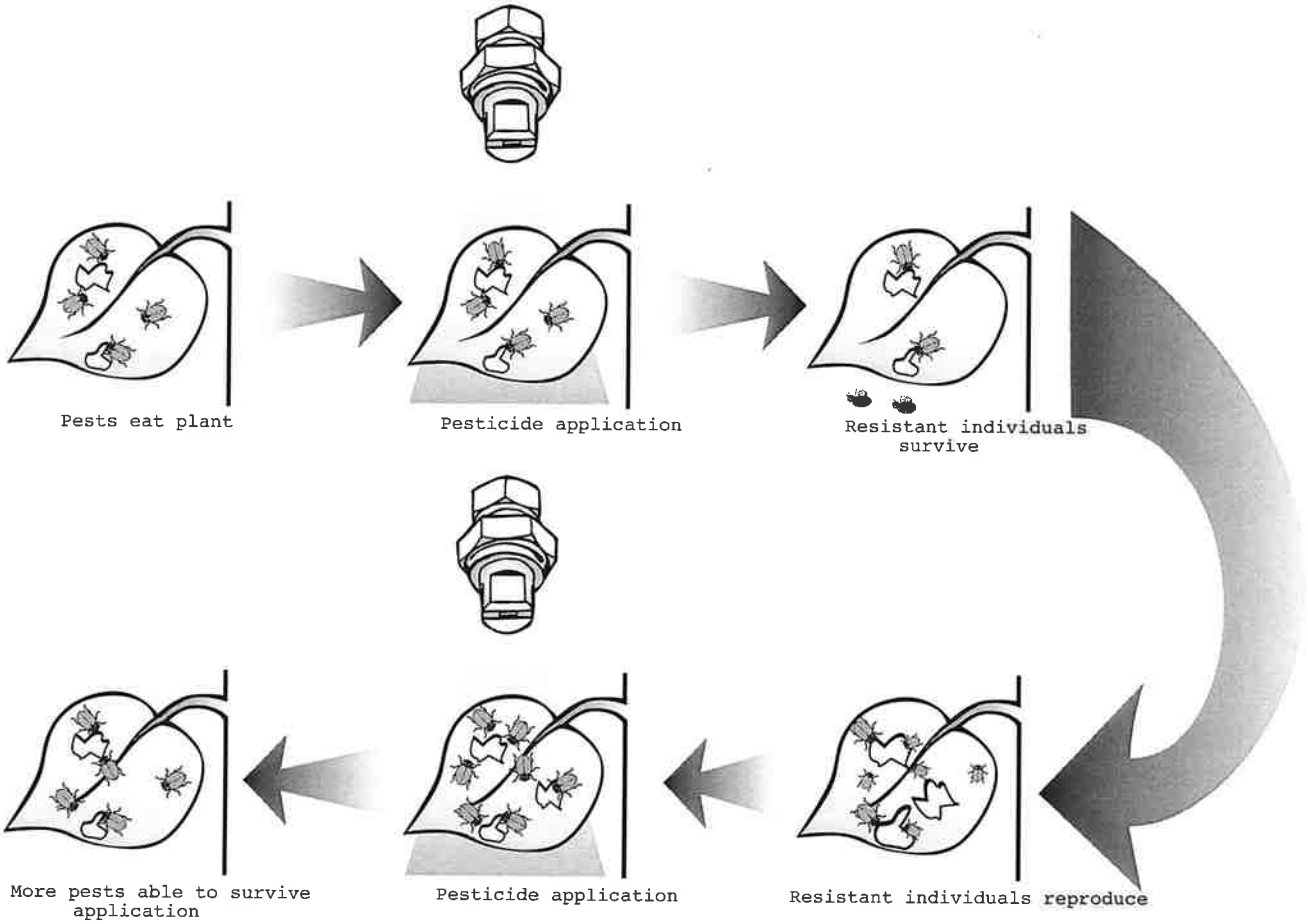
One important way to reduce pesticide resistance is to use nonchemical control methods where feasible. Cultural control, biological control, and other IPM tools may minimize this problem. Another way to prevent pesticide resistance is to rotate or combine pesticides with different modes of action. It is less likely that the pest will be resistant to or tolerant of more than one mode of action. Choose pesticides that target multiple sites, and use new or altered pesticides when available.

Other techniques include treating alternate generations of pests and changing pesticide-use patterns.

Other Pest Control Failures

Sometimes a pesticide application fails to control the pest. Review the situation to determine what went wrong. Here are some possibilities (besides pesticide resistance):

- Did you correctly identify the pest?
- Did you apply the pesticide at the right stage of the pest's life cycle?
- Was the pest in the area of the application? Was it exposed to the pesticide?
- Did you use the right pesticide at the right dosage?
- Did you apply the pesticide correctly?
- Are the surviving pests part of a new infestation that developed after the application?



How pesticide resistance develops.

Pesticide-Use Decision Making

Before using any pesticide, you should answer the following questions:

- Is the problem actually caused by a pest?
- If so, what kind of pest is causing the damage, being a nuisance, or posing a health risk?
- Is the problem severe enough to need chemical control?
- Is pesticide use cost-effective?
- Can the pest be controlled by a pesticide at this stage of its growth or life cycle?

In addition, it is wise to learn what you can do to prevent future problems from this pest.

Recordkeeping

One way to improve the chance that your pesticide application will succeed is to keep records. Always record and evaluate the results of your IPM program – both chemical and nonchemical elements. With accurate records, you can tell over time if certain methods worked and whether nontarget organisms and environmental features were affected. This is especially important when managing pesticide resistance. If you have a written treatment history, you will be better able to detect pesticide resistance when it first appears. See Unit 1 for more information on recordkeeping.

Test Your Knowledge

Q. Explain the differences between key pests, occasional pests, and secondary pests.

A. Key pests are nearly always present and require regular control. Occasional pests are migratory or cyclical and may require intermittent control. Secondary pests require control only under certain conditions, such as the elimination of a key pest or the absence of a natural host.

Q. What should you do first if you observe damage to a plant, animal, or valuable product or commodity?

A. Identify the cause.

Q. What should you do first if you discover a pest that may need to be controlled?

A. Make sure that it is actually responsible for the damage or problem observed. Then, accurately identify the pest.

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

A. It allows you to determine basic information about the pest, including its life cycle and when it is most susceptible to control measures.

Q. Name at least three Virginia Tech facilities that can help you identify a pest and diagnose an infestation.

A. The Weed ID Clinic, the Plant Disease Clinic, the Nematode Assay Laboratory, and the Insect Identification Laboratory.

Q. Name the five basic pest groups discussed in this unit.

A. Weeds, parasites and diseases, mollusks, arthropods, and vertebrates.

Q. Why do weeds present such a challenge to pest managers?

A. Weeds are often hardy, aggressive, and tolerant of harsh conditions. Many produce large numbers of seeds, which can spread over a wide area and remain dormant for a long time. Weeds are fierce competitors for soil moisture, nutrients, and sunlight.

Q. How can you tell a monocot from a dicot plant?

A. Monocots (grasses and sedges) have one seed leaf, parallel leaf veins, flower parts in multiples of three, and fibrous roots. Dicots (broadleaves) have two seed leaves, broad or narrow leaves, netlike veins, and flower parts in multiples of four or five. They usually have taproots.

Q. Why are perennial weeds usually harder to control than annual or biennial weeds?

A. Perennials do not die after a one- or two-year life cycle. Some may live for many years. They also have underground parts to store food and produce new growth each growing season. These parts are harder to reach and control.

Q. Name the pathogens that cause most plant and animal diseases.

A. Fungi, bacteria, mycoplasmas, and viruses.

Q. What sorts of symptoms do viral plant diseases often cause?

A. Stunting, yellow rings on leaves, wilting, and mosaic patterns (yellow or bleached streaks).

Q. How can parasites such as flies, ticks, and lice harm livestock and other animals?

A. These parasites may host and transmit diseases on animals, causing blood loss and physical damage. Parasites can reduce the rate of weight gain, cause a decrease in milk or egg production, interfere with reproduction, and lower the infected animal's resistance to disease.

Q. How do plant-parasitic nematodes harm plants?

A. By attacking the roots, stems, and leaves. Nematode root feeding interferes with a plant's ability to take up water and nutrients. Infected plants wilt and seem to be suffering from a lack of water or nutrients.

Q. How do mollusks harm plants?

A. By feeding on foliage and fruit. Mollusks reduce the value of commercial produce if they feed on harvested plants and fruit.

Q. What are arthropods? How do they differ from vertebrates?

A. Animals with segmented bodies and jointed appendages. Arthropods have an external skeleton and may have specialized appendages such as sucking tubes, chewing mouthparts, egg depositors, antennae, and pincers. Unlike vertebrates, arthropods have no backbone.

Q. What is the difference between gradual and complete metamorphosis? Why is it important to know the life cycle stage of an insect?

A. Gradual metamorphosis includes three stages: egg, nymph, and adult. There is no pupa stage. Complete metamorphosis includes four stages: egg, larva, pupa, and adult. Insects that develop via complete metamorphosis change in body form. Larvae may not look at all like adults, even within the same species. It is very important to recognize the damaging stage(s) for best treatment results. Many insects are pests in one stage (especially the larval stage) but not in another.

Q. How do insects differ from arachnids?

A. Insects have three body parts, one or two pairs of wings, three pairs of legs, and one pair of antennae. Arachnids have two body parts, no wings, four pairs of legs, and no antennae.

Q. What are beneficial insects? Why are they important to agriculture?

A. Insects that are pollinators (such as honeybees and butterflies) or pest predators (such as ladybird beetles and lacewings). Without pollinators, many types of plants could not reproduce. Beneficial predators feed on harmful insects, mites, and weeds.

Q. How do mites harm plants?

A. They suck plant juices, eat the undersides of leaves, and disfigure the plants they feed on.

Q. What types of damage do vertebrate pests cause?

A. Vertebrates may damage property, agriculture, and/or natural resources. They may also threaten human health and safety or spread disease. Some vertebrates may destroy feed or eat the seeds or fruit of crops. Others compete with livestock, cause traffic accidents, and destroy residential landscapes. Some vertebrate predators feed on domestic animals.

Q. What is the main difference between indoor and outdoor vertebrate pest control?

A. Eradication vs. suppression. Indoor vertebrate control usually centers on eradication of rodent pests. Outdoor vertebrate control focuses on suppressing nuisance animals such as coyotes, raccoons, or beavers to an acceptable level.

Q. What is an economic threshold?

A. The level at which economic losses caused by pest damage, if the pest population continued to grow, would be greater than the cost of controlling the pests. Reaching an economic threshold usually prompts some type of pest control action.

Q. How are thresholds important to a sound pest control strategy?

A. Setting a treatment or action threshold is essential to prevent the pests in an area from causing unacceptable injury or harm. Action thresholds vary: sometimes one pest is too many (ex. a rat in a food-processing facility). Thresholds help producers and applicators weigh the cost of pest control against the cost of a pest infestation.

Q. What is monitoring? How is it important to a sound pest control strategy?

A. Regular checking or scouting for pests in a designated area. Monitoring will tell you what pests are present, how many are in the area, and how much damage they are causing. It will help determine if the pest population has reached the treatment threshold and whether control measures have worked.

Q. What is the difference between prevention, suppression, and eradication of pests?

A. Prevention means reducing the chances that a pest will become a problem. Suppression means reducing pest numbers or damage to an acceptable level. Eradication means destroying an entire pest population.

Q. How could you prevent a pest infestation?

A. Plant weed- and disease-free seed, choose plants resistant to diseases and insects, and practice good sanitation. Other preventive techniques include excluding pests from the target area and using preemergent herbicides to kill weed seeds.

Q. How does regulatory pest control differ from pest control at the local level?

A. Regulatory pest control (legal control) includes the efforts of state and/or federal agencies to control pests that endanger public health or are likely to cause widespread damage to crops, livestock, forests, or ornamental plants. Such pests often cannot be successfully managed at the local level. Regulatory pest control may involve eradication and quarantines.

Q. Briefly define integrated pest management (IPM).

A. Integrated pest management is an ecological approach to pest control. It is based on the habitat and life cycle of the pest. IPM combines chemical and nonchemical methods into a single plan or strategy. The goal of an IPM program is to reduce pest populations to an acceptable level in a way that is practical, cost-effective, and safe for the environment as well as human health.

Q. Give several reasons to use IPM instead of using only a pesticide.

A. IPM programs:

1. Often ensure better success at the treatment site.
2. Promote a more balanced ecosystem and are more environmentally friendly.
3. Are less likely to lead to pesticide resistance and secondary pest outbreaks.
4. May reduce pesticide use and can help protect beneficial insects.
5. Are often more acceptable to the public.

Q. Name at least five basic steps in an effective IPM program.

A. 1. Identifying the pest and understanding its biology.

2. Monitoring the target pest.

3. Deciding whether control is justified.

4. Determining a pest control goal.

5. Knowing what control tactics are available.

6. Evaluating the benefits and risks of each tactic or combination of tactics.

7. Choosing the most effective strategies that will cause the least harm to people and the environment.

8. Using each tactic correctly.

9. Observing all applicable local, state, and federal regulations.

10. Recording and evaluating the results.

Q. What is the difference between natural and applied controls?

A. Natural controls are forces, independent of human action, that may either help or hinder pest control. Examples are climate, geographic barriers, and availability of shelter. Applied controls are human-engineered methods (such as an IPM program) to control a pest. Examples are biological control, cultural control, mechanical and physical control, and chemical control.

Q. How do natural enemies help maintain a balanced ecosystem? What happens when there are no natural enemies to control an exotic pest?

A. Natural enemies such as predatory arthropods and pathogens feed on pest species and suppress pest populations. These organisms help maintain a natural balance among different types of organisms. Without natural enemies to hold it back, an introduced (exotic) pest population can get very large and upset this balance.

Q. Name five IPM elements discussed in this unit.

A. Host resistance, biological control, cultural control, mechanical and physical control, and chemical control.

Q. What is the main principle of host resistance?

A. The ability of a plant, animal, or structure to withstand pests. Using resistant varieties, when available, helps keep pest populations below harmful levels by making conditions less favorable for the pests.

Q. What is biological control? What techniques does it include?

A. The use of living organisms to control pests. These organisms, or biocontrol agents, may be natural enemies of the pest, such as predators orparasites that will attack the target pest. Another biocontrol method involves biologically altering the pest. An example is the production and release of large numbers of sterile males.

Q. What is cultural control? What are its main components?

A. Changing the habitat where pests flourish. Cultural control methods can disrupt ideal pest conditions and decrease pest pressure. The two main types are cultural practices and sanitation.

Q. Name at least six cultural practices used to help manage agricultural pests.

A. Pruning, thinning, and fertilizing cultivated plants; rotating crops; tillage; mulching; varying time of planting or harvesting; planting trap crops; and adjusting row width.

Q. What is sanitation? Give several examples of sanitation techniques in different types of pest management.

A. A form of cultural control that uses different hygiene practices to manage pests. Sanitation is important in almost every type of pest management. Some examples:

1. Improve cleanliness, eliminate pest harborage, and increase the frequency of garbage pickup to control urban and industrial pests.
2. Clean up spills, store food in closed containers, and keep garbage outdoors to discourage household pests.
3. Provide proper drainage in barnyards, get rid of seepage areas, and remove manure from livestock pens often to control pests of domestic animals.
4. Eliminate places where mosquitoes breed to lessen the risk of mosquito-borne illness.
5. Keep fields, seed stock, tools, and surfaces clear of weeds, insect pests, and plant diseases to control agricultural pests.
6. Use pest-free seeds or transplants to limit the spread of plant pests.
7. Decontaminate equipment, animals, and other carriers before allowing them to enter a pest-free area or leave an infested area.

Q. What types of mechanical methods could you use to control weeds?

A. String trimmers, shovels, scythes, plows, disks, mowers, and cultivators.

Q. What is physical control, and how can it help manage certain pests?

A. Changing certain environmental conditions, such as water, air movement, temperature, light, and humidity. Such changes can suppress or even eradicate some pests. For example, lowering the humidity of stored grain reduces the chance of mold damage.

Q. Name five important qualities to consider when choosing a pesticide.

A. Efficacy (effectiveness), persistence (period of activity), mobility (tendency to run off or change form), toxicity (harmful effects), and mode of action (how it works).

Q. What is the difference between a selective and a nonselective herbicide?

A. A selective herbicide controls some plants but not all. For example, 2,4-D effectively controls many dicots but does not affect monocots. A nonselective herbicide controls all types of plants.

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

A. A contact pesticide is effective only where it touches the pest. A systemic pesticide will move internally (translocate) through an organism after an insect eats it or a plant absorbs it.

Q. What is the difference between a residual and a nonresidual pesticide?

A. A short-term (nonresidual) pesticide breaks down quickly into nontoxic by-products. A long-term (residual) pesticide, in contrast, may remain active (toxic) for weeks, months, or even years.

Q. Define "pesticide resistance." How does a pest population become resistant to an insecticide or other pesticide?

A. The ability of a pest population that is repeatedly exposed to a given pesticide to resist and survive its effects. An insect population, for example, often has "abnormal" (resistant) members that can tolerate exposure to insecticide doses that kill "normal" (susceptible) members. Each time the same insecticide is applied, the susceptible members die, and the resistant members survive. In time, most of the members will be resistant to the insecticide.

Q. How can you slow down or limit pesticide resistance?

A. 1. Rotate or combine pesticides with different modes of action. It is less likely that the pest will be resistant to or tolerant of all of them.

2. Use pesticides that target multiple sites in a pest.

3. Use new or altered pesticides. New compounds with different modes of action will lessen the chance of resistance development.

4. Treat alternate generations of pests. This decreases the selection for resistance.

5. Use nonchemical control methods where feasible.

Q. You applied a pesticide that failed to control the target pest. Name at least five reasons why your control effort might have failed.

A. 1. You misidentified the pest.

2. You applied the pesticide at the wrong stage of the pest's life cycle.

3. The pest was not in the area of the application and/or was not exposed to the treatment.

4. You chose the wrong pesticide or applied the wrong amount.

5. You applied the pesticide incorrectly.

6. The pest was resistant to the pesticide.

7. The pests are part of a new infestation that developed after the application.

Q. What questions should you answer before using a pesticide?

A. 1. Is the problem actually caused by a pest?

2. If so, what kind of pest is causing the damage, being a nuisance, or posing a health risk?

3. Is the problem severe enough to need chemical control?

4. Is pesticide use cost-effective?

5. Can the pest be controlled by a pesticide at this stage of its growth or life cycle?

Q. Why is accurate recordkeeping important to a successful pest control program?

A. Keeping accurate records helps you evaluate the results of your IPM program. This will tell you whether your methods worked and if nontarget organisms and/or environmental features were affected. Good records will also help you better manage pesticide resistance.

Unit 3. Pesticide Labeling

Learning Objectives

After studying this unit, you should be able to:

- Define the terms "label" and "labeling."
- Distinguish between federal registrations, state registrations, special local need registrations, and emergency exemptions. Explain how they relate to legal pesticide use.
- Explain how "general use" and "restricted use" classification determines who may use a pesticide.
- Determine how a pesticide is classified by reading the product label.
- Define "common name," "chemical name," and "brand name." Locate this identifying information on a pesticide product label.
- Use the label to determine the active ingredient concentration in an end-use, formulated pesticide product.
- Find and use the signal words (and symbols) on pesticide labels to identify relative hazards.
- List the required parts of pesticide labels.
- Explain the different parts of a typical pesticide label and describe the information and instructions they contain.
- Interpret the statement "It is a violation of federal law to use this product in a manner inconsistent with its labeling."
- Explain the difference between a pesticide product label and Safety Data Sheet (SDS). Describe how to get an SDS and use the information it provides.
- State how to obtain other documents relating to a pesticide product and where to get help in interpreting label instructions and proper use.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Active Ingredient (a.i) – A chemical in a pesticide product that affects or controls the target pest.

Acute Effects – Illnesses or injuries that appear soon (within 24 hours) after exposure to a pesticide or combination of pesticides.

Allergic Effects – Harmful effects, such as skin rash or asthma, that some people develop when exposed to a substance that does not cause the same reaction in others. An allergy causes a hypersensitivity to a specific substance, often called the allergen.

Brand Name – The trademarked name given to a pesticide product by the manufacturer. It often includes information about the formulation and percentage of active ingredient (ex. Sevin 50% WP).

Terms to Know cont.

Chemical Name – The technical name that identifies the chemical formula and structure of a pesticide active ingredient (ex. 1-naphthyl N-methyl carbamate).

Common (Chemical) Name – A short name given to a pesticide active ingredient that is officially accepted by the Environmental Protection Agency (EPA) (ex. carbaryl).

Delayed Effects – Illnesses or injuries that that appear more than 24 hours after exposure to a pesticide or combination of pesticides.

Distributor Products – End-use pesticides produced and registered by a manufacturer or formulator and sold under a different name by a distributor.

Emergency Exemption from Registration – An emergency (Section 18) exemption that allows the sale and use of a certain pesticide product for a specific nonregistered purpose for a specified period. EPA grants emergency exemptions at the request of a state regulatory agency. EPA will issue a Section 18 exemption ONLY when there is no other feasible way to respond to a pest emergency.

Establishment Number – The number assigned by EPA to each pesticide production facility.

General-Use Pesticide – An unclassified pesticide that can be purchased and used both by certified applicators and by the public.

Inert Ingredient – Inactive component of a formulated pesticide product added to dilute the pesticide or to make it safer, more effective, and/or easier to handle. Inert ingredients have no direct effect on target pests.

Label – All printed material attached to or part of the pesticide container.

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

Minimum-Risk Section 25(b) Pesticides – Products judged to present a low risk to humans and the environment. These pesticides are exempt from the federal registration process.

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Precautionary Statement – Pesticide labeling statement that warns of possible hazards from use of the pesticide product and that may indicate specific ways to avoid the hazards.

Registration Number – The identification number assigned to a pesticide product when it is registered by EPA.

Reregistration – Review of a labeled pesticide to assess its risks and benefits. EPA conducts reregistration reviews to verify the safety and efficacy of registered pesticides.

Restricted-Use Pesticide (RUP) – Any pesticide classified for restricted use by the administrator of EPA. The "restricted use" classification restricts a product, or its uses, to use by a certified pesticide applicator (commercial or private) or under the direct supervision of a certified applicator.

Terms to Know cont.

Safety Data Sheet (SDS) – Occupational Safety and Health Administration (OSHA) Form 20, designed to contain important safety information about a chemical that is hazardous to handlers due to toxic, fire, or reactive properties. The SDS is a source of information for employees and employers. It contains details about chemical properties, toxicity, first aid, and emergency procedures to follow in case of an accident. Safety Data Sheets are also known as Material Safety Data Sheets.

Signal Word – An indication of the acute human toxicity of a pesticide product. All pesticides must carry a signal word, in large letters, on the front panel of the pesticide label. Signal word options are DANGER—POISON (with a skull and crossbones symbol ☠), DANGER, WARNING, and CAUTION. The signal word is based on the acute toxicity and properties of the entire contents of a formulated pesticide, not just the toxicity of the active ingredient.

Special Local Need (SLN) Registration – A registration, also known as a 24(c) registration, that allows states to expand or limit the uses of federally registered pesticides within their jurisdictions. It is a good option to allow the use of pesticides on regional crops, to manage localized pest problems, or both. Some SLNs permit you to use a pesticide on a site not listed on the federal label. Others may alter the use directions of federally registered products to accommodate conditions in a certain area.

Supplemental Labeling – A term used by EPA for labeling that describes newly approved uses or other changes, such as reduced and/or increased preharvest intervals, added since the last accepted master label was reviewed and approved by the agency. These are partial labels distributed with the product by a registrant or a distributor. Since supplemental labels are partial labels, they must bear a statement referring the user to the product label for complete directions, precautions, and a statement notifying the user that the labeling must be in his or her possession. Both the product label and the supplemental labeling are required to apply the product for its supplemental use safely and effectively.

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

Tolerance – The maximum amount of pesticide residue that may remain on food or feed at harvest or slaughter.

Label vs. Labeling

The pesticide product **label** is the information printed on or attached to the pesticide container. The label is the main method of communication between a pesticide manufacturer and pesticide users. The product label is a binding legal agreement between three entities:

- The product registrant (usually the pesticide manufacturer).
- The Environmental Protection Agency (EPA).
- The end user.

Label instructions are written by the product registrant, following guidelines set by EPA. EPA registers pesticides and reviews most product labels. Pesticide users are required by law to comply with all pesticide label instructions and use directions.

Labeling, on the other hand, includes the label itself as well as additional information about the product and its legal and proper use. Examples include requirements referenced on the label (ex. Worker Protection Standard or protection of endangered species) and information included by the manufacturer about the product. Examples of labeling are brochures, leaflets, and other material that accompany the pesticide product when you buy it. Pesticide labeling tells you how to use the product safely and correctly.

EPA Approval of Pesticide Labeling

No pesticide may be sold in the United States until the Environmental Protection Agency has reviewed the manufacturer's application for registration and determined that the use of the product, as directed by the label, does not present an unreasonable risk to humans or the environment. As part of this product registration process, EPA approves all language that the manufacturer (registrant) proposes to include in the product labeling. (The labels for minimum-risk pesticides are not reviewed. However, EPA sets standards for these labels, too. More information about minimum-risk products and this exemption follows.)

EPA continually reviews pesticide data, including information about environmental fate and human exposure risk. This process, called "**reregistration**," assesses the risks and benefits associated with labeled uses. The goal of reregistration is to identify and reduce risks, based on current scientific knowledge. Only those pesticides that meet current scientific and regulatory standards are eligible for reregistration. In addition, all pesticides with food uses must meet the safety standard of Section 408 of the Federal Food, Drug, and Cosmetic Act (FFDCA), as amended by the Food Quality Protection Act (FQPA) of 1996. EPA must be able to conclude with "reasonable certainty" that "no harm" will come to infants, children, or other sensitive individuals exposed to pesticides.

A great deal of behind-the-scenes work is involved in registering a pesticide product. Manufacturers spend a lot of money on research and development, market analysis, safety and efficacy testing, label development, formulating, and packaging. EPA requires a large amount of data to support every pesticide registration. These data are the basis for the instructions on the pesticide product label.

Safety testing to support a pesticide registration involves many things, including toxicity tests and environmental fate studies.

Toxicity tests: How poisonous is the pesticide to humans? To other organisms? Does it cause any harmful long-term (chronic) effects? Does it cause any skin (dermal) or allergic reactions?

Environmental fate studies: What happens to the pesticide after it is applied? How long does it take the pesticide to break down (degrade) into harmless materials under

various conditions? Does it move in the environment? If so, how and why? For example, some soil-applied insecticides are supposed to move into and protect plants – but *not* move through soil into groundwater. Residue tests are conducted for each application method and each treated site. These tests determine how much pesticide residue remains on (or in) treated surfaces, plants, or animals over various lengths of time.

Residue (and efficacy) tests are the basis for label directions concerning application rate, timing, and number of applications per season. They determine many other instructions on the pesticide product label as well, including **personal protective equipment (PPE)** requirements and **restricted-entry intervals (REIs).** In addition, for food crops, residue test results determine the number of days that must be observed between a pesticide application and harvest of a treated crop (or animal product) or slaughter of a treated animal.

EPA establishes a **tolerance** for each pesticide that may be applied to every food crop or commodity. A "tolerance" is the maximum amount of pesticide residue that may remain on food or feed at harvest or slaughter. Preharvest or preslaughter intervals are often listed on labels of agricultural pesticides. These intervals allow time for the pesticide to break down.

Observing use directions regarding application rate and timing, as well as those dictating preharvest and preslaughter intervals, prevents unacceptable residues on food, feed, or animal products. Because food safety is a serious issue, food and feed are tested to ensure that tolerances are not violated. A commodity with residues exceeding the EPA-set tolerance may be condemned or destroyed. (The same is true if *any* residue of a pesticide that does not have an established tolerance on a particular commodity is detected. Residues of such pesticides can result from off-label applications or drift, for example.)

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

Only after EPA has reviewed the labeling and registered the product can a pesticide product be sold for use. If the manufacturer wants to change the information on the labeling after the product and labeling are registered, EPA must approve the change. The agency also may require changes in labeling that result from its ongoing reregistration process.

Types of Pesticide Registrations

You are responsible for applying only registered pesticides – or pesticides exempted from federal registration by EPA but registered in the Commonwealth of Virginia. You may encounter two major types of EPA registrations, granted under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA):

1. Standard federal registration, Section 3.

2. Special local need registration, Section 24(c).

However, EPA allows emergency (Section 18) exemptions from registration. In addition, the agency exempts certain **minimum-risk pesticides** from registration if the products meet certain conditions.

Federal (Section 3) Registrations

EPA federal (Section 3) registrations are the most common. Most pesticides are registered this way. When buying a pesticide product, look for the official EPA registration number. This number confirms that you are buying a federally registered pesticide product. EPA registration numbers appear on the labels of all legal products except those classified as minimum risk.

Special Local Need Registrations

A "**special local need (SLN)**" is an existing or imminent pest problem for which a federally registered product:

- Is not available for the desired site.
- Cannot be applied without causing unacceptable risks.
- Is necessary to maintain an IPM, resistance management, or minor-use control program.
- Could be replaced by another, less risky formulation.

Special local need registrations are known as SLN or 24(c) registrations. SLNs allow states to expand or limit the uses of federally registered pesticides within their jurisdictions. They are a good option to allow the use of pesticides on regional crops, to manage localized pest problems, or both. Some SLNs permit you to use a pesticide on a site not listed on the federal label. Others may alter the use directions of federally registered (Section 3) products to accommodate conditions in a certain area. This provision of FIFRA allows the Virginia Department of Agriculture and Consumer Services (VDACS) to register a new pesticide product – or an additional use of a federally registered product – for a pest-site problem.

In Virginia, SLNs are available for locally important crops, such as certain vegetables, fruits, peanuts, and tobacco. The commonwealth also has SLNs for local pests threatening "common" crops such as conifers and soybeans.

Pesticide registrants must provide supplemental labeling for each SLN registration. You must have a copy of the SLN labeling in your possession to use a pesticide for a special local need. The registration numbers of SLN labeling (SLN number) include a standard two-letter abbreviation code for the state issuing the registration. In Virginia, SLN registration numbers begin with the letters "VA." These registrations are legal ONLY in the region, state, or local area specified in the labeling. Applying a pesticide that has an SLN registration from another state or region in Virginia is illegal. If you do this, you are subject to civil and criminal penalties.

Emergency Exemptions

Emergency (Section 18) exemptions are responses to pest problems for which no pesticides are registered. EPA can issue an emergency exemption at the request of a state regulatory agency. In Virginia, this agency is VDACS. First, VDACS must acknowledge the need and consider it appropriate. EPA will issue a Section 18 exemption ONLY when there is no other feasible way to respond to the pest emergency. Section 18 exemptions allow the sale and use of a certain pesticide product for a specific nonregistered purpose for a specified period.

24(c) Supplemental Label

FOR DISTRIBUTION AND USE ONLY WITHIN THE STATE OF VIRGINIA

FOR USE ONLY UNDER THE SUPERVISION OF FEDERAL, STATE, COUNTY, OR MUNICIPAL FOREST LAND MANAGERS

Special Local Need Supplemental Label

There are four types of emergency exemptions:

1. **Specific exemption** – to avert a significant economic loss or major risk to endangered species, threatened species, beneficial organisms, or the environment.

2. **Quarantine exemption** – to control the introduction or spread of any pest.

3. **Public health exemption** – to control a pest that will cause significant risks to human health.

4. **Crisis exemption** – to permit the use of a pesticide when the time from discovery of the emergency to the time when the pesticide use is needed is too short to allow for one of the other types of exemptions.

If neither a federal nor an SLN registration could be obtained in time to respond to a new and significant pest problem, an emergency registration may be issued.

The Virginia Agricultural Research and Extension Centers (ARECs) normally initiate and submit requests for emergency exemptions to VDACS. Then, an independent, special-registration review committee evaluates the information submitted with each request for Section 18 specific exemption. The committee reviews the economic, environmental, and human health impacts of the product and its requested unregistered use. The request for exemption then goes to EPA for authorization.

Regulations impose strict controls and recordkeeping for all emergency uses. You must understand all of the special requirements and responsibilities involved whenever you use pesticides with emergency exemptions. VDACS dictates application rates, safety precautions, and other vital use information. You must have a copy of the Section 18 approval in your possession to use a product under emergency exemption conditions. Although they are often called "labels" or "labeling," Section 18 use instructions are not true labels. This is because the product and/or product use has not been registered by EPA. However, applicators must follow the instructions on the EPA approval letter to the Commonwealth of Virginia authorizing the Section 18 exemption.

Minimum-Risk Pesticides

In 1996, EPA chose to exempt certain pesticides from the registration process. These products were judged as "minimum risks" to humans and the environment. The agency took this action under Section 25(b) of FIFRA. Exempting minimum-risk products from federal registration reduces costs and regulatory burden on businesses. It also allows EPA to focus the agency's resources on pesticides that pose a greater risk.

However, to be exempt from registration requirements, minimum-risk products must meet certain conditions. EPA reviewed candidate minimum-risk compounds and produced a list of low-risk active – and inert – ingredients. To be exempt, all of the active and inert ingredients in a pesticide product must be on this list.

Products exempt from registration under Section 25(b) of FIFRA do not require EPA label approval or review. Their labels do not have an EPA registration number, EPA establishment number, or signal word. They also do not have PPE requirements. However, Section 25(b) product labels must list ALL ingredients. In addition, they cannot have any false or misleading claims. It is important to note that these labels may not claim to control microorganisms in a way that links the microorganism to a human health threat. In addition, they may not claim to control a pest that is a disease vector (such as an insect or rodent) in a way that links the pest to a specific disease. For example, a 25(b) product may list mosquitoes, ticks, or rodents as pests controlled. However, it may not claim to control any disease that a mosquito or tick transmits to humans.

NOTE: All pesticides used or sold in Virginia must be registered with VDACS, Office of Pesticide Services. Section 25(b) pesticides are NOT exempt from Virginia registration requirements.

Virginia Cooperative Extension (VCE) specialists and agents, the Virginia **Pest Management Guide** (PMG) series, pesticide dealers, and other professionals can help you learn about legal and effective pest management options in Virginia. A current list of all SLNs and Section18s in effect in Virginia is available on the website of the VDACS Office of Pesticide Services.

Plastic Pesticide Container with Label

Classification of Pesticide Uses

EPA classifies some pesticide products as "restricted use." Other products are unclassified, or "general use." In some cases, certain products having a specific active ingredient may be restricted use while others with the same active ingredient are unclassified. This may be due to the formulation, active ingredient concentration, package size, application site, and/or intended end user. In these cases, the products will have entirely different packaging and labeling. However, in most cases, all the uses of a particular formulation are classified as restricted use or all are unclassified (general use).

Restricted-Use Pesticides

Restricted-use pesticides (RUPs) are those, according to EPA, that need "additional regulatory restrictions" to avoid "potential unreasonable adverse effects" on the environment or on their handlers. The word "use" in this phrase is a general term. It refers to all of the routine activities associated with a pesticide application. These include:

- Treating the target area or site.
- Mixing and loading.
- Transporting, storing, or handling pesticides after the manufacturer's seal is broken.
- Caring for and maintaining application and handling equipment.
- Disposing of pesticides and their containers.

EPA classifies pesticides as RUPs based on supporting data. These data indicate that such pesticides may harm humans, livestock, wildlife, other nontarget organisms, or the environment – even when used according to label directions.

Handling restricted-use products requires special skill and care. For that reason, only certified applicators, or trained people working under their direct supervision, may use them. Certified applicators have demonstrated that they have the knowledge to use pesticides safely and effectively. Farm employees can handle and apply RUPs under the direct supervision of a certified private applicator. Similarly, a certified registered technician may use RUPs only under the direct supervision of a certified commercial applicator.

Certified Pesticide Applicators

Under federal law, there are two types of certified pesticide applicators: private applicators and commercial applicators.

Private applicators are certified applicators who use – or supervise the use of – restricted-use pesticides to produce an agricultural commodity. This production must occur on property owned or rented by the grower, his or her employer, or another person with whom they trade services. In Virginia, **commercial applicators** use – or supervise the use of – any pesticide for any purpose other than for agricultural production on private property.

The Commonwealth of Virginia requires training and competency testing for certification. To become a Virginia-certified applicator, persons must pass an exam to demonstrate that they understand how to handle pesticides safely and effectively. See Unit 1 for information about certification requirements and procedures, as well as how to keep a certificate in force.

Parts of the Pesticide Label

If you look at a pesticide label, you will see that the information on the label is grouped in sections. This makes it easier to find the information you need. By law, some information must appear on a specific part of a label. Other facts may go wherever the manufacturer chooses.

Label information falls into four general categories:

1. Identifying information.
2. Precautionary statements.
3. Directions for use.
4. Conditions of sale (including limitation of warranty and liability).

Some labels are easy to understand. Others are complicated and difficult to read. It is the user's responsibility to read, understand, and follow label directions. Read the label before buying a pesticide to be sure you can use it as directed. You should also read the label at every step while using the product.

Each of the EPA-required label components is described in this section. An example of a pesticide label is located at the end of this unit. Some of the "Test Your Knowledge" questions in this unit test label comprehension.

Identifying Information

Pesticide labels provide the basic information necessary to identify the product. Most identifying information is on the front panel of every label.

Trade, Brand, or Product Name

Pesticide manufacturers have brand names for each of their products. Most register each unique name as a trademark. No other company may use this name without permission. Different manufacturers use different trade or brand names for products with the same active ingredient. The brand or trade name is displayed prominently on the front panel of the label. It is the name used in advertisements and by company salespeople. The name of the product registrant usually appears on the front panel, close to the trade or brand name.

Often, a product name identifies the pesticide class and use pattern. It may also indicate the formulation type and the percentage of active ingredient the product contains. For example, a product named "NoPest 50WP" is a sample trade name for a 50% wettable powder formulation. (For more information about formulations, see Unit 4.)

Pesticide handlers must beware of choosing a pesticide product by trade or brand name alone. This is true for several reasons:

1. If an active ingredient is no longer protected by a patent, several product registrants may sell it. Each may use a different trade or

brand name. Other manufacturers may opt to use the **common (chemical) name** in the product name.

2. Many companies use the same basic name with only minor variations to designate very different products. For example:

   - DePesto may contain active ingredient A.
   - DePesto Extra may contain active ingredients A and B.

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

   - De-Weed 2E may be a 2-pound-per-gallon EC formulation of a specific active ingredient, produced by one company.
   - Weed-X EC may also be a 2-pound-per-gallon EC formulation of the same active ingredient, sold by another company.

To learn what active ingredient(s) a product contains, read the ingredient statement.

Ingredient Statement

The ingredient statement identifies the name – and the percentage by weight – of each active ingredient in a specific pesticide product. It also tells you the percentage – again, by weight – of other inert ("inactive") ingredients.

- **Active ingredients** are chemicals in pesticide products that affect or control the **target pest**.
- **Inert (inactive) ingredients** of a pesticide formulation dilute the pesticide or make it safer and/or more effective. In addition, many make end-use products easier or more convenient to handle. Inert ingredients have no direct effect on target pests.

Each pesticide label has a contents list, which plainly displays what percentage of the total product is active vs. inactive ingredients. The ingredient statement lists the official **chemical name** and/or common chemical name for each active ingredient. Inert ingredients are often trade secrets and are not usually listed. However, the label must show what percent of the total contents they make up.

NOTE: If there are any hazardous inert or inactive ingredients in a formulated product, they will appear on the product's Safety Data Sheet (SDS). There is a short section about the SDS at the end of this unit.

A product's official chemical name is a long, complex term that identifies the chemical components and structure of the pesticide. Pesticides also have common chemical names. These are the names most often used to identify pesticide active ingredients. For example, the solvent methanol or methyl alcohol is often called "wood alcohol." Similarly, ethanol or ethyl alcohol is usually called "grain alcohol." The technical name of the pesticide with the common chemical name "diazinon" is O,O-Diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate.

Only common names officially accepted by EPA are permitted in pesticide label ingredient statements. For example, the label ingredient statement for a "Sevin® 50% WP" product would read:

Active ingredient: carbaryl
(1-naphthyl N-methyl carbamate) 50%

Inert ingredients 50%

In this example, the active ingredient chemical name (in parentheses) follows the common name. When you buy a pesticide, look for the common chemical names. This will ensure that you get the right active ingredient – no matter what the trade or brand name.

Often, the ingredient statements of liquid formulations indicate the total amount of active ingredient, by weight, contained in a gallon of liquid product. Here are the ingredient statements of two different pesticide products. Note that both contain the same active ingredient.

Active Ingredient:	
triclopyr: 3,5,6-trichloro-2- pyridinyloxyacetic acid, butoxyethyl ester	60.45%
Other ingredients	39.55%
Total	100.0%

Acid equivalent: triclopyr - 43.46% - 4 lb/gal

Ingredient Statement for Garlon 4 Ultra

Active Ingredient:	
triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, triethylamine salt	44.4%
Inert ingredients	55.6%
Total	100.0%

Acid equivalent: triclopyr - 31.8% - 3 lb/gal

Ingredient Statement for Garlon 3a

Net Contents (Net Weight)

The net contents (net weight) statement identifies the weight or volume of pesticide in the container. Placed on the front panel, it tells you how much product is in the container. This can be expressed as pounds or ounces for dry formulations and as gallons, quarts, pints, or fluid ounces for liquids. Note that in some cases, you will find the net contents (container volume) printed on the container but not on the attached paper label.

Type of Pesticide

The type of pesticide usually is given on the front panel of the label, too. This short statement (in italics below) often follows the brand or trade name. It indicates, in general terms, what the product will control. It may also describe, again in general terms, where it may be used. Here are some examples:

- Insecticide *for control of certain insects on fruits, nuts, and ornamentals.*
- Algicide.
- Herbicide *for control of trees, brush, and weeds.*
- *Turf and ornamental* fungicide.
- *Soil* fumigant.
- Insect growth regulator – *controls cockroaches, drain and fruit flies, bed bugs, and stored product pests.*

Type of Formulation

The front panel of some pesticide labels will tell you what kind of formulation the product is. The full name of the formulation may appear, or the label may show only an abbreviation. Examples include WP (wettable powder), D (dust), and EC (emulsifiable concentrate).

EPA Registration and Establishment Numbers

Pesticide handlers need EPA registration and establishment numbers in case of an exposure or poisoning, regarding claims of misuse, and/or to settle liability claims.

Registration Number

The EPA **registration number** is the single most important piece of information used to identify a specific pesticide product. Each product has a unique registration number. The EPA registration number must appear on the front panel of the product label. This number indicates that the product is registered with EPA and that the agency approved the label. Pesticide application records – those required by the Commonwealth of Virginia and by federal regulations – ask for the EPA registration number.

Most EPA registration numbers are in two sets. Here is an example: EPA Reg. No. 100-497. The first set of numbers, "100," identifies the manufacturer or company (product registrant). The second set, "497," identifies a specific product produced by that company.

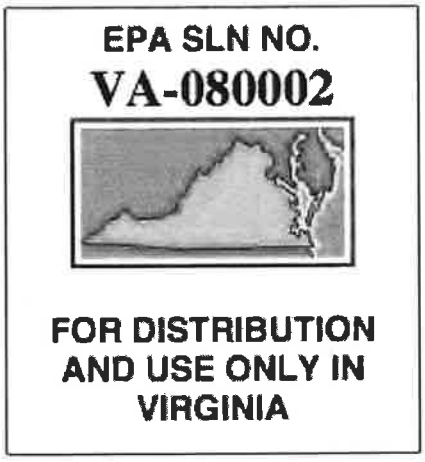
Additional letters and numbers are sometimes part of an EPA registration number. This is because a distributor's identification number appears on labels of distributor products. In another example, EPA Reg. No. 3120-280-1492, "3120" identifies the manufacturer, "280" identifies the specific product, and "1492" identifies the distributor.

When a pesticide is registered by a state because of a special local need, the registration

number on the supplemental label will differ from the basic patterns described above. For example, 279-3313 is the EPA Section 3 registration number for a product labeled for use on cotton, corn, succulent peas and beans, and brassica only. However, in 2008, this product was registered in Virginia for a special local need: use in conifer seed orchards to manage cone worms, seed bugs, and seed worms. It was assigned the following special local need registration number: EPA SLN No. VA-080002. In this case, "VA-080002" is the registration number for a specific use, allowed in Virginia, for a product that already has a Section 3 label. Here, "VA" indicates the state; "08," the year. Finally, "0002" indicates this was the second SLN issued in Virginia in 2008. Special local need registration numbers appear on the supplementary labeling for the SLN use, not on the front panel of the Section 3 product label.

Establishment Number

The EPA **establishment number** identifies the facility that produced the pesticide product. For example, here is an EPA establishment number: 100-LA-001. (This is an establishment number for the same product used above to illustrate how EPA registration numbers are coded.) The first set of numbers, "100," identifies the manufacturer or company (product registrant), as is the case with the EPA registration number. The letters "LA" indicate that this product was produced in Louisiana. The third number, "001," means that this company was the first such facility in the state. The EPA establishment number usually appears next to the EPA registration number. The establishment number is important in case of questions or concerns about the pesticide. Identification of the production facility and the specific batch is critical to deal with problems regarding product performance. The same is true if there were a case of actual or suspected contamination and the company issued a recall.



Special Local Need Registration Number

NOTE: Many specimen labels posted on the Internet do not have EPA establishment numbers. Moreover, registration and establishment numbers will NOT appear on Section 25(b) (minimum-risk) products, which are exempt from registration.

Use Classification Statement (If Applicable)

As noted earlier, EPA classifies every pesticide product as either "restricted use" or "unclassified/general use." Every product that EPA classifies as "restricted use" must have the following statement at the top of the front panel of the label:

RESTRICTED-USE PESTICIDE

Due to very high toxicity to humans and birds.

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

All restricted-use pesticide products must have the proper label statement.

Below this heading, you may find a statement indicating the reason for the restricted-use classification. Examples include:

- Toxicity to fish and aquatic organisms.
- Ground- and surface-water concerns.
- Acute dermal toxicity.
- High inhalation toxicity and carcinogenicity.
- Avian and aquatic toxicity.
- Acute toxicity and groundwater contamination.

Statements like these are helpful because they name specific hazards associated with the RUP product. This, in turn, allows you to focus your attention on risk-reduction handling tactics.

Unclassified products are the equivalent of over-the-counter drugs. Their labels have no designation. These end-use products are lower in toxicity and are less likely to harm people and/or the environment than RUPs. This is because of the active ingredient they contain and/or the concentration of active ingredient in the formulated product. Anyone may purchase and use general-use pesticides without special permits. Other than the requirement to follow all label directions, they have no special restrictions. However, most are clearly labeled to indicate the type of user for which they are – or are NOT – intended. Here are some examples:

- For sale to, use by, and storage by commercial nursery, turf, and landscape personnel only.
- Not for use on home lawns.
- For home use only.

Mode of Action Classification

Fungicide, herbicide, and insecticide resistance action committees have grouped some pesticide active ingredients based on how they work and affect treated pests. Product labels may display one or more group numbers, which indicate the mode(s) of action. If two pesticide products in the same class -- fungicide, herbicide, or insecticide -- have the same group number on their label, they work in more or less the same way. Using label code number(s), you can make good decisions regarding rotating or combining products to manage resistance.

Name and Address of Manufacturer

By law, the label must state the name and address of the product manufacturer or formulator. This tells you who made or sold the product.

Precautionary Statements

Pesticide labels contain basic information about product risks. They also include specific handling requirements and practices to reduce exposure. Most precautionary statements are on the front panel or placed in sections near the beginning of product labels.

Signal Words and Symbols

Signal words (DANGER—POISON, DANGER, WARNING, or CAUTION) appear in large letters on the front panel of most pesticide labels. The signal word indicates the formulated product's relative acute toxicity to humans and other mammals. Look for the signal word just below the statement "Keep out of reach of children." This statement must appear on every pesticide label.

Exemptions:

- Minimum-risk Section 25(b) products are exempt from federal registration. As a result, they are not required to have a signal word.
- Formulated products that are very low in toxicity (Category IV by all routes of exposure), although registered with EPA, are no longer required to carry a signal word. However, many manufacturers still place a CAUTION signal word on labels of such products.

The signal word is based on the total contents of the formulated product – not on the active ingredient alone. It reflects the hazard of ALL active ingredients, carriers, solvents, or inert ingredients. The signal word indicates the risk of **acute effects** from four routes of exposure to a pesticide product:

- Oral (by mouth).
- Dermal (absorbed through exposed skin).
- Inhalation (respiratory; breathing in).
- Ocular (eye).

The signal word assigned to the product is based on the most hazardous exposure route. The signal word does NOT indicate the risk of delayed or **allergic effects**.

Use the signal word to help you decide what precautionary measures are necessary. Remember that you, your coworkers, and other persons (or animals) may be exposed to the pesticide. If several pesticide products will give you the level of pest management you want, use the signal word to choose the least toxic one.

- **DANGER—POISON *with* a skull and crossbones ☠ symbol:** Appears on all highly toxic pesticides. These products are very likely to cause acute illness, regardless of how they enter the body. The word "POISON" will be printed in red. The word "PELIGRO" (Spanish for "DANGER") must also appear on the label. Pesticides assigned to this category can cause serious illness or death, even if an exposed person receives a very low dose.

Signal words indicate the toxicity of a pesticide product.

- **DANGER:** Tells you that the pesticide product is hazardous in some manner or through some method of exposure. For example, it may cause severe eye damage or skin irritation. The word "PELIGRO" must also appear on the label.

- **WARNING:** Tells you that the product is moderately toxic by some route of entry: oral, dermal, or inhalation exposure. It may also mean that the product is likely to cause moderate skin or eye irritation. The word "AVISO" (Spanish for "WARNING") must also appear on the label.

- **CAUTION:** Tells you that the product is slightly toxic. This means that it is less likely to cause acute illness from oral, dermal, or inhalation exposure than products with DANGER or WARNING signal words. Products with CAUTION signal words may cause slight skin or eye irritation.

Refer to Unit 6 for detailed information about toxicity classification and categories.

First Aid (Statement of Practical Treatment)

The first aid section lists recommended treatments for poisoning or accidental exposure. As a rule, you will find first aid measures on the front panel, near the signal word. These instructions may be in sections, based on the type of exposure:

- IF SWALLOWED.
- IF INHALED.
- IF IN EYES.
- IF ON SKIN OR CLOTHING.

Some labels have information useful for pesticide handlers (NOTE TO APPLICATOR) in this section. For example, you might find descriptions of possible allergic reactions and other indications of exposures. You may be told to seek medical help for affected persons. A NOTE TO PHYSICIAN subsection has specific information about the product's characteristics. It includes detailed instructions for medical professionals treating people who were exposed to or poisoned by the pesticide.

All products with a DANGER signal word – and many others – will have a NOTE TO PHYSICIAN subsection. Always have the product container and label with you when you call a poison control center or a doctor, and when seeking medical treatment. Look for a telephone number to call for emergency medical treatment information. Use product label instructions to respond to emergencies properly. Learn about first aid procedures for specific products before handling them.

KEEP OUT OF REACH OF CHILDREN

WARNING **AVISO**

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

FIRST AID

IF SWALLOWED

Call a poison control center or doctor immediately for treatment advice. Do not give any liquid to the person. Do not induce vomiting unless told to do so by a poison control center or a doctor. Do not give anything by mouth to an unconscious person.

IF INHALED

Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.

IF IN EYES

Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eyes. Call a poison control center for treatment advice.

IF ON SKIN OR CLOTHING

Take off contaminated clothing.

Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

NOTE TO PHYSICIAN

If on skin, after drying apply vitamin E cream or oil if available. If not available, apply vegetable oil liberally over painful areas. The oil or cream may be used repeatedly until relief is achieved.

Contains xylene range aromatic solvent - vomiting may cause aspiration pneumonia.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-441-3637 for emergency medical treatment information.

First Aid Section of a Pesticide Label

Keep Out of Reach of Children (KOOROC) Statement

The keep out of reach of children (KOOROC) statement (child hazard warning) appears on almost all end-use pesticide products. Usually, you will find it near the product label signal word.

Keep Out of Reach of Children

CAUTION **PRECAUCION**

KEEP OUT OF REACH OF CHILDREN

WARNING

AVISO

KEEP OUT OF REACH OF CHILDREN

DANGER POISON

PELIGRO

However, a few products will not have a KOOROC statement. For example, it is unnecessary on labels of pesticides that are intended for use on children (ex. products labeled for control of head lice).

Other Precautionary Information and Label Sections

Often, statements will indicate which route or routes of entry are especially hazardous. For example, a product with a DANGER signal word may also have statements like these:

- "Fatal if swallowed."
- "Corrosive – causes irreversible eye damage."

A product with a WARNING signal word may state:

- "Harmful or fatal if swallowed."
- "Causes skin and eye irritation."

A product with a CAUTION signal word may have routes of entry precautionary information like this:

- "Harmful if swallowed."
- "May irritate eyes, nose, throat, and skin."

Similarly, a label may have specific action statements – mandatory, enforceable handling requirements. Examples include:

- "Do not breathe vapors or spray mist."
- "Do not get on skin or clothing."
- "Wear chemical-resistant gloves."
- "Do not induce vomiting."
- "Do not apply within 66 feet of wells."
- "Do not apply directly to water."
- "Keep away from heat, sparks, and open flame."
- "Do not enter into treated areas for 12 hours."

- "Do not apply when wind speed exceeds 15 mph."

Some labels also include advisory statements. Some of these statements may tell the users about specific properties of the formulated product. Others may give advice regarding safety and efficacy. Such statements cannot conflict with mandatory action statements, nor can they be false or misleading. Examples include:

- In the physical and chemical hazards section: "Opening aluminum phosphide containers outdoors or indoors near an exhaust fan or other ventilation ensures that the gas will be rapidly dispersed if the product flashes."
- In the directions for use/mixing section: "Apply this product immediately after preparation to ensure that it is in suspension. If application is delayed, agitate to remix and ensure proper blending."

In addition to the signal word, first aid, and child hazard warning sections, labels have additional precautionary information. In most cases, you will find such statements in these sections:

- Hazards to humans and domestic animals.
- Protective clothing and equipment statements.
- Engineering controls.
- Environmental hazards.
- Physical or chemical hazards.

Some labels place emergency contact information in the precautionary statements section.

Hazards to Humans and Domestic Animals

If a product is hazardous to humans or domestic animals, precautionary statements that describe the particular hazard, route of exposure, and precautions to take must appear on the label. In this section, you may find information about acute (immediate), delayed, and/or allergic effects. For example, a delayed effects statement will tell you if the product has been shown to cause problems such as tumors or reproductive problems in laboratory animals. In most cases, this section of a label will have both product information and specific action statements.

Examples of descriptive product information (warnings) include:

- "Corrosive."
- "Causes irreversible eye damage."
- "Harmful if swallowed or absorbed through skin."

Here are some examples of specific instructions for handlers:

- "Do not breathe vapors or spray mist."
- "Remove contaminated clothing and wash before reuse."
- "Do not contaminate food or feed."
- "Do not use or store in a house."

Precautionary Statements

Hazards to Humans and Domestic Animals

Causes Moderate Eye Irritation • Harmful If Swallowed • Prolonged Or Frequently Repeated Skin Contact May Cause Allergic Reactions In Some Individuals

Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco.

Protective Clothing and Equipment Statements

The personal protective clothing and equipment section will list the minimum PPE you must wear and/or use when handling the product. PPE requirements are based on known hazards. For example, a product that may cause eye injury will require handlers to wear eye protection.

Here are some examples of labels with specific sections devoted to PPE requirements:

Causes substantial but temporary eye injury. Harmful if swallowed. Do not get in eyes or on clothing.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks
- Protective eyewear

Personal Protective Equipment (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks

Sometimes, a label will require different PPE for different tasks. For example, handlers mixing and diluting liquid concentrates may need to use more PPE than those applying end-use dilutions. Similarly, PPE requirements may depend on the engineering controls or safety systems used. They may also vary according to the application site and situation.

Personal Protective Equipment (PPE)

Some of the materials that are chemical-resistant to this product are listed below. For more options, follow the instructions for Category A on an EPA chemical-resistant category selection chart.

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Chemical-resistant gloves made of any waterproof material such as polyethylene or polyvinyl chloride
- Shoes plus socks
- Protective eyewear

Mixers and loaders who- do not use a mechanical system (probe and pump) must wear:

1. Coveralls
2. Chemical-resistant apron

As this product is contained within a water soluble packet, handlers should wear shirt, pants, socks, shoes and waterproof gloves.

All pesticide handlers must wear protective eyewear and a respiratory device when working in a non-ventilated or poorly ventilated spaces, such as crawl spaces and attics. Use a NIOSH approved respirator with an organic vapor (OV) cartridge or canister with any N, R, P or HE prefilter.

As a rule, PPE requirements appear in a section dedicated to that topic, as shown above. However, this is not always the case, as shown here:

Precautionary Statements

Hazards to Humans and Domestic Animals

DANGER: Corrosive. Causes irreversible eye damage and skin burn. May be fatal if absorbed through skin. Harmful if swallowed. Do not get in eyes on skin or on clothing. Wear goggles, face shield, or safety glasses, protective clothing and chemical resistant gloves. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Wash thoroughly with soap and water after handling and before eating, drinking and using tobacco. Remove contaminated clothing and wash before reuse.

Some labels do not have any specific PPE requirements, although this is rarely true for products used by certified applicators. Others list only one – or several – items applicators must use (ex. chemical-resistant gloves). They do not specifically mention garments we assume that handlers will wear (ex. trousers, a shirt, shoes, and socks).

However, you will find generic statements such as these, indicating the need for PPE:

- "Harmful if swallowed, absorbed through skin, or if inhaled."
- "Avoid breathing spray mist or contact with skin, eyes, or clothing."

When selecting PPE, read the signal word, route of entry information, and specific action/mandatory statements. Read the application directions. Consider the application situation and site. Evaluate both the amount of handling involved in preparing for an application and exposures that may result from your application method. Consider using additional PPE for:

- Mixing/loading operations.
- Applying with hand-held equipment (excluding "spot spraying").
- Making applications that may include a high exposure risk, such as:
  - Making aerosol or fogging applications, especially indoors.
  - Using high-pressure sprayers or power dusters.
  - Treating a target that requires you to direct spray upward and overhead.

Pesticide users are required <u>by law</u> to follow all instructions on the product label, including wearing the label-mandated PPE. However, always use good judgment and common sense when deciding what to wear. The lack of a PPE statement – or the mention of only one or a few specific items – does NOT rule out the need for additional protection.

Engineering Controls

The engineering controls section will tell you if any specific devices are required when handling a product. It will also inform you of any special precautions to take for a specific application method (ex. aerial application or chemigation).

ENGINEERING CONTROLS STATEMENT

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

- **For containers of 5 gallons or more:** Do not open pour product from this container. A mechanical system (such as a probe and pump or spigot) must be used for transferring the contents of this container. If the contents of a non-refillable pesticide container are emptied, the probe must be rinsed before removal.
- **For containers greater than 1 gallon but less than 5 gallons:** When handlers use a mechanical system (probe and pump), enclosed caps or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(4)], the handler PPE requirements may be reduced or modified as specified in the WPS.

Environmental Hazards

Some general statements regarding environmental protection appear on the labeling of nearly every pesticide. For example, most labels warn you not to contaminate water when you apply the pesticide, to clean your application equipment, or to dispose of pesticide wastes. Labels contain specific precautionary statements if the pesticide poses a known hazard to the environment. For example, it may warn you that the product is highly toxic to bees.

ENVIRONMENTAL HAZARDS

This pesticide is extremely toxic to fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not apply when weather conditions favor drift from treated areas. Drift and runoff from treated areas may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when cleaning equipment or when disposing of equipment washwaters.

This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops if bees are visiting the treatment area.

WILDLIFE PROTECTION IS EVERYONE'S RESPONSIBILITY

Here are some examples of environmental hazard statements:

- "This product is extremely toxic to fish and aquatic invertebrates."
- "This product is extremely toxic to birds."

Consider environmental hazards when choosing a pesticide for a particular use. If special precautions appear on the label, as shown in the example above, follow them.

Physical or Chemical Hazards

The physical or chemical hazards section will tell you about any special fire, explosion, or chemical hazards the product may pose. For example, if the product is corrosive or highly flammable, the label will state this. It will also instruct you to keep the product away from heat or open flame. **Smoking while handling flammable pesticides is extremely dangerous.**

Here are some examples of physical or chemical hazards statements:

- "Flammable."
- "DO NOT store near heat or open flame."
- "Combustible."
- "Corrosive."

Physical or Chemical Hazards

Do not use, pour, spill, or store near heat or open flame.

Physical or chemical hazard statements are not always located in the same place on pesticide labeling. Some labels group them in a physical or chemical hazards box or subsection within the precautionary statements section. However, you may also find this information on the front panel, beneath the signal word. Other labels discuss physical and/or chemical hazards in sections with headings such as "Note" or "Important" – or in the storage and disposal section. If there are no unusual physical or chemical hazards, there may be no statement in the labeling. Before you handle a pesticide, read the entire label carefully. Look for specific information about physical or chemical hazards. Follow all special handling precautions.

Emergency Contact Information

Most labels provide emergency contact information. Often, you will find a telephone number to use in case of an accident or emergency in the precautionary statements label section.

Directions for Use

The directions for use section of a label usually has a wealth of detail and technical information. Read it carefully, and follow all directions.

Directly under the heading "Directions for Use" on pesticide labels, you will find this statement:

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

Just below that statement, you will find detailed instructions on how to handle and use (mix, load, and apply) the product. The directions for use section will tell you:

- What pest(s) the manufacturer claims the product will control.
- Legal application sites (plant, animal, or site the product is intended to protect – where it may be used).
- Mixing and other handling instructions.
- How much to apply, when, and how often (application rate, timing, and interval).
- How close to harvest the product may be used (also called the "preharvest interval"), if applicable.
- Application equipment and/or methods, including detailed information about those that are required or specifically prohibited.
- Restrictions regarding planting subsequent crops, composting, grazing, or other uses of the treated area or surface.
- Storage and disposal instructions.

You may also find information about:

- The active ingredient's mode of action.
- Recommended additives or adjuvants.
- Tank-mixing procedures and incompatibility.
- Cleaning spray equipment.
- Ways to protect sensitive crops or sites and methods to prevent offsite movement (ex. drift, leaching, and runoff).
- Whether the product is likely to cause unwanted injuries or stains to treated plants (phytotoxicity), animals, or surfaces – and if so, how to manage these undesirable effects.

There may be advice or specific restrictions prohibiting applications under certain conditions (ex. low humidity, high wind, or inversions for spray applications). You may find detailed instructions on how to set up your application equipment. For spray applications, there may be advisories or requirements concerning droplet size.

Agricultural Use Requirements

In addition, labels of products with uses covered by EPA's **Worker Protection Standard (WPS)** will have an agricultural use requirements section. If a product has both agricultural and nonagricultural uses, it will have both agricultural use requirements and nonagricultural use requirements sections. As a rule, you will find these instructions in boxes at the beginning of the directions for use section of the label.

Worker Protection Standard

The Worker Protection Standard regulates pesticides used on farms, in greenhouses and nurseries, and in forest production. WPS targets workers who perform hand labor operations (ex. cultivation, harvesting, or watering) on agricultural establishments where pesticides are used in the production of plants. Agricultural establishments may include farms, fields, forests, nurseries, and enclosed space production facilities, such as greenhouses. WPS also impacts employees who handle pesticides (ex. mix, load, and apply) for use in those locations. In addition, WPS covers workers who clean or repair pesticide application equipment and/or clean or launder pesticide-contaminated PPE. See Unit 6 for more information about WPS.

Labels of pesticides used in agricultural plant production, nursery or greenhouse operations, and forestry cite WPS requirements. The instructions in the agricultural use requirements section of product labels include:

- Use of personal protective equipment.
- Notification of treated areas (oral, written, or both).
- Restricted-entry intervals.

The agricultural use requirements box also refers to label-referenced requirements, including employee training, information that must be displayed at a central location, decontamination supplies and sites, and emergency assistance. Label-referenced WPS requirements are included in a separate document: **How to Comply with the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Owners and Employers Need to Know.**

Here are examples of agricultural use requirements and nonagricultural use requirements boxes for a pesticide product.

Agricultural Use Requirements

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

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 48 hours.

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

- Coveralls
- Shoes plus socks
- Protective eyewear
- Chemical-resistant gloves (≥ 14 mils) such as butyl rubber, natural rubber, neoprene rubber or nitrile rubber

Non-Agricultural Use Requirements

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Entry Restrictions for Non-WPS Uses: For applications to non-cropland areas, do not allow entry into areas until sprays have dried, unless applicator and other handler PPE is worn.

Note that ONLY agricultural uses have specific restricted-entry intervals (REIs). REIs state how much time must pass between a pesticide application and the reentry of unprotected workers – employees NOT wearing the PPE required by the product label – into a treated area. In the example above, the REI is 48 hours (two days). In some cases, agricultural use products have several REIs. These may vary by crop and/or application method.

Note also that REIs are intended to protect farm workers who are exposed to pesticide-treated plants in the course of their work. They do not apply to anyone not employed by an agricultural plant producer (ex. farm, greenhouse or nursery, or forest products). REIs also do not apply in other situations, such as ornamental turf, landscape, rights-of-way, or public health applications. Specific reentry times are not usually listed for these kinds of uses. However, nonagricultural use requirements statements often caution you to keep people and pets out of treated areas until sprays dry or dusts settle. This is the case for the example shown above.

Directions for Use by Reference

Some directions that pesticide users must follow are not written on the product label. Instead, they are explained in documents referred to by product labels. These are called "label-by-reference" requirements. For example, many WPS requirements are referenced, but not spelled out in every detail, on the labels of products registered for agricultural plant production. Similarly, EPA has adopted – or is considering – additional requirements concerning:

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

In most cases, label-by-reference requirements apply to some – but not all – product users. WPS requirements are a good example.

However, in other cases, instructions and restrictions will apply only in certain geographic areas or to certain uses of a pesticide product. In all cases, affected users must get and follow additional directions.

Label by reference is a relatively new practice. The intention is to minimize additional label language and avoid confusion in cases where a restriction or requirement applies to only some product uses and/or users.

You, the pesticide applicator, must determine whether the regulation, bulletin, or other document referenced on the pesticide product labeling applies to your situation and intended use of the pesticide. If so, you must comply with all the specific directions for use and other requirements that the document contains. These documents do not always accompany the end-use pesticide product. They may not be available at the point of sale. You may have to get the additional directions and requirements from other sources, such as EPA, VDACS, pesticide dealers or company representatives, industry or commodity organizations, land-grant universities, or Extension agents.

Another example of label by reference is EPA's Endangered Species Protection Program (ESPP). This program involves pesticide-use limitations in specific geographic areas. It was established to protect endangered and threatened species. Some pesticide product labels will refer to enforceable use limitations. These labels will tell you how to find more information about restrictions and learn whether they apply to you.

In this case, users of products that refer to possible ESPP use limitations must seek additional information to learn if there are any restrictions regarding use of that product in the area(s) they plan to treat. If there are, they must abide by them. ESPP bulletins are effective and enforceable as part of the product label. The bulletin used to support a specific application must be dated within six months of the pesticide application date. Pesticide users who fail to follow the label, including any applicable bulletin restrictions, will be subject to enforcement under the misuse provisions of FIFRA and state law. This is true regardless of whether that failure results in harm to a listed species. It is important to note that:

- Not all pesticide active ingredients will have ESPP restrictions.
- Not all pesticide uses are banned in areas with ESPP restrictions.

If you use a product that references ESPP restrictions, check for bulletins periodically to ensure that you are in compliance.

EPA's decision to use label by reference means that not all of the directions for use may appear on the label attached to or distributed with every pesticide product. This places greater responsibility on the pesticide user. One sentence or paragraph on a pesticide label may be the only notice you will receive about additional use directions. **Nonetheless, you must get and follow these additional directions to use the product in compliance with its labeling**. You must:

- Determine whether you are affected.
- Locate any additional applicable directions for use.
- Comply with these additional instructions and requirements.

> This product may have effects on endangered species. When using this product, you must follow the measures contained in the Endangered Species Protection Bulletin for the area in which you are applying the product. To obtain Bulletins, consult *www.epa.gov/espp,* or call 1-800-447-3813 no sooner than six months before using this product. You must use the Bulletin valid for the month and year in which you will apply the product.

Example of a Label-by-Reference Statement

Use Inconsistent with the Labeling

It is illegal to use a pesticide in any way not permitted by the labeling. A pesticide may be used only on the sites named in the directions for use section of the product label. A site can be a location, such as a lawn or structural perimeter or fence line. It can also be a specific type of plant or animal, such as ornamental turfgrass, field corn, or beef cattle. You may not use higher dosages, higher concentrations, or make more frequent applications. You must follow all directions for use, including those 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. The use directions and instructions are not advice – they are legal requirements.

However, federal law does allow you to use pesticides in some ways not specifically mentioned in the labeling. Unless you would be violating Virginia laws and regulations, you may:

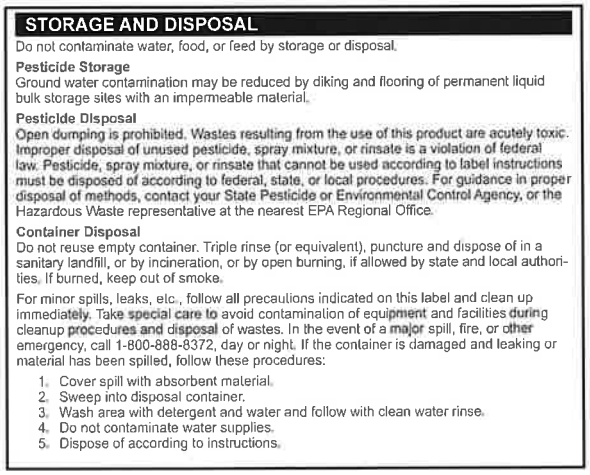
- Apply a pesticide at any dosage, concentration, or frequency less than that listed on the labeling.
- Apply a pesticide against any target pest not listed on the labeling if the application is to a plant, animal, or site that is listed.
- Use any appropriate equipment or method of application that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

Storage and Disposal

All pesticide labels contain some instructions for proper storage. These may be general advisory statements, such as "Keep out of reach of children and pets" and "Do not contaminate water, food, or feed by storage or disposal." Alternatively, they may provide specific instructions, such as "Do not store at temperatures below 32°F."

Pesticide labels may also provide some general information about how to dispose of excess pesticide and containers in ways that are acceptable under federal regulations. State and local laws vary, however, so the labeling usually does not give specific disposal instructions.

Storage and disposal statements usually appear in a special subsection of the label called "Storage and Disposal," within the directions for use section. As a rule, it will contain information about storage, product disposal, and container disposal. You may also find guidance about how to deal with spills or leaks in this section.



STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

Pesticide Storage
Ground water contamination may be reduced by diking and flooring of permanent liquid bulk storage sites with an impermeable material.

Pesticide Disposal
Open dumping is prohibited. Wastes resulting from the use of this product are acutely toxic. Improper disposal of unused pesticide, spray mixture, or rinsate is a violation of federal law. Pesticide, spray mixture, or rinsate that cannot be used according to label instructions must be disposed of according to federal, state, or local procedures. For guidance in proper disposal of methods, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office.

Container Disposal
Do not reuse empty container. Triple rinse (or equivalent), puncture and dispose of in a sanitary landfill, or by incineration, or by open burning, if allowed by state and local authorities. If burned, keep out of smoke.

For minor spills, leaks, etc., follow all precautions indicated on this label and clean up immediately. Take special care to avoid contamination of equipment and facilities during cleanup procedures and disposal of wastes. In the event of a major spill, fire, or other emergency, call 1-800-888-8372, day or night. If the container is damaged and leaking or material has been spilled, follow these procedures:

1. Cover spill with absorbent material.
2. Sweep into disposal container.
3. Wash area with detergent and water and follow with clean water rinse.
4. Do not contaminate water supplies.
5. Dispose of according to instructions.

Conditions of Sale (Including Limitation of Warranty and Liability)

Name and Address of Manufacturer

As explained earlier, the law requires the maker or distributor of a product to put the name and address of the company on the label. This information may be placed on the front panel. However, it often appears at the very end of the label, within or at the end of a box or section entitled "Limitation of Warranty and Liability."

Limitation of Warranty and Liability Statement

Most products have a disclaimer statement. Product registrants include this information voluntarily.

The Federal Insecticide, Fungicide, and Rodenticide Act

A law passed by Congress in 1947 and amended in 1972, 1975, 1978, and 1988 regulates the registration, manufacture, sale, transportation, and use of pesticides. This law, the Federal Insecticide, Fungicide, and Rodenticide Act, is commonly referred to by its initials: FIFRA.

FIFRA affects certified applicators in many ways. For example, it provides that:

- EPA must register pesticides and pesticide uses.
- All pesticides must be used only as directed on the labeling.
- EPA must classify as "restricted-use" those uses of pesticides that may cause unreasonable adverse effects to the environment, including humans, even when used as directed on the product labeling.
- Persons who buy or use restricted-use pesticides must be certified as competent pesticide applicators or must be directly supervised by a certified applicator.
- States may establish stricter standards governing pesticides, but not more permissive standards.
- Persons who use pesticides in a way that is "inconsistent with the pesticide labeling" are subject to penalties.

If you violate FIFRA, or regulations issued under it, you are subject to civil penalties. They can be as much as $5,000 for each offense ($1,000 for private applicators). Before EPA can fine you, you have the right to ask for a hearing in your own city or county. Some violations of the law may also subject you to criminal penalties. These can be as much as $25,000 and/or one year in prison for commercial applicators; $1,000 and/or 30 days in prison for private applicators. States may establish harsher penalties.

Virginia Service Container Labeling Requirements

Whenever possible, pesticides should remain in their original containers. In Virginia, containers other than the original pesticide container may be used for the temporary storage or transportation of pesticide concentrates or end-use dilutions. However, these service containers must have abbreviated labeling to identify the contents.

Pesticide Concentrates

If the pesticide being temporarily stored or transported is a concentrate that will be further diluted before use, the container must have a securely attached label with the following information found on the product label:

1. Product (brand) name.
2. EPA registration number.
3. Name and percentage of active ingredient(s).
4. Appropriate signal word; i.e., DANGER—POISON, DANGER, WARNING, or CAUTION.

Pesticide End-Use Dilutions or End-Use Concentrates

If the pesticide being temporarily stored or transported will be applied without further dilution, the container must have a securely attached label with the following information found on the product label:

1. Product (brand) name preceded by the terms "Diluted" or "End-Use Concentrate."
2. EPA registration number.
3. Name of active ingredient(s) and percentage(s) of end-use dilution.
4. Appropriate signal word; i.e., DANGER—POISON, DANGER, WARNING, or CAUTION.

Service container labeling is not required for the following kinds of containers:

1. Application devices for end-use dilutions (such as hand-held sprayers) holding up to 3 gallons liquid or 3 pounds dry capacity.

2. Containers used by farm supply dealers to temporarily store or transport pesticide concentrate or end-use dilutions. However, sales invoices or delivery tickets adequately identifying the pesticide(s) must be with each shipment or delivery.

3. On-farm concentrate or end-use dilution containers or application equipment used to temporarily store or transport pesticides for agricultural use.

4. Aircraft-mounted containers used to temporarily store or transport concentrate or end-use dilution pesticides. However, aircraft logs or other documents adequately identifying the pesticide(s) must be with the aircraft.

Source: 2VAC20-20-21 0

Safety Data Sheets

A **Safety Data Sheet (SDS)** is a useful document for a professional pesticide handler. SDSs provide detailed information about a product's physical and chemical properties (ex. melting point, boiling point, flash point, and reactivity). They also display its toxicity and health effects as well as the procedures to follow in case of an accident (first aid, spill/leak response, and remediation procedures).

As a rule, an SDS includes the following:

1. Chemical product/company identification.
2. Hazards identification.
3. Composition/information on ingredients.
4. First aid measures.
5. Firefighting measures.
6. Accidental release measures.
7. Handling and storage.
8. Exposure controls/personal protection.
9. Physical and chemical properties.
10. Stability and reactivity.
11. Toxicological information.
12. Ecological information.
13. Disposal considerations.
14. Transport information.
15. Regulatory information.
16. Other information.

Safety Data Sheets are part of the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (HCS) program. HCS ensures chemical safety in the workplace. It requires chemical manufacturers and importers to evaluate the hazards of the chemicals they produce or import. It also tells companies to develop and distribute a product's SDS to convey hazard information to their employees and "downstream" customers.

The SDS is meant for:

1. Employees who may be exposed to a hazard at work.
2. Employers who need to know the proper methods for storage, transport, and other procedures.
3. Emergency responders such as firefighters, hazardous material crews, emergency medical technicians, and emergency room personnel.

Note that:

- The SDS is designed for occupational users and handlers. For example, an SDS for an herbicide may not be much use to someone who treats his or her lawn once a year. However, it is extremely important to a

person who works in the factory where the same herbicide is produced and/or packaged. The SDS is also useful to people who use pesticide products on the job.

- For the applicator and/or handler of a pesticide product, the label is the law. If, for example, a product label and its SDS differ in PPE requirements or other instructions, the pesticide handler must follow the product label directions.

- A pesticide label and the SDS for the same product may provide different information. This is because they are produced by different agencies and serve different purposes. For example, an SDS will often have more detailed information about emergency response measures. The hazards identification section of an SDS will display pictograms (symbols) indicating the type of hazard(s) associated with the product. The SDS signal word may or may not correspond to the pesticide product label signal word. There are only two signal words on an SDS: DANGER and WARNING. In cases where the hazards identification and/or toxicological information section of an SDS differs significantly from the pesticide label for the same product, EPA recommends that registrants include FIFRA label hazard (precautionary statement) information in the regulatory information section of the SDS.

- In 2012, OSHA adopted some features of the United Nations' Globally Harmonized System (GHS). The GHS is an international method intended to convey accurate information about chemical hazards in a consistent manner.

Safety Data Sheets are extremely useful to certified applicators. They provide product-specific technical information about environmental and human health effects. They also give you invaluable information about how to respond to an accident or incident involving a pesticide product.

In addition to the SDS, you can get more information about pesticides from:

- Virginia Cooperative Extension (agriculture and natural resources agents, specialists, and publications).
- Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services staff.
- Product manufacturers or registrants.

Summary

People who handle pesticides should read the label (and supporting or reference documents and supplemental labeling) thoroughly, carefully, and often.

Read the label first.

Read the label:

Before purchasing – Be sure you are buying the right product for the job. To use a pesticide legally, it must be registered for use on the plant, animal, or site you intend to treat. Be sure you have the proper PPE and application equipment. Confirm that there are no restrictions or conditions that will prohibit you from using the product as you plan. Buy only what you need to minimize waste or disposal problems. Remember that label directions can and do change. A new package of a product you have used in the past may have different legal application sites, application rates, or other instructions.

Before mixing, loading, and applying – The label will tell you how to mix, how much to mix, and how to apply a product safely and effectively.

Before storing – Proper storage will prolong shelf life and prevent accidents, container leaks, and fire hazards.

Before disposal – The label will tell you how to dispose of unused or unwanted product and properly cleaned, empty containers.

A pesticide product label is a binding, legal agreement between three parties:

1. The registrant or manufacturer that wrote the label instructions.
2. The federal agency (EPA) that registered the product (determining that its use as directed does not pose an unreasonable risk and is warranted based on the benefits of the use).
3. The applicator or end user, who must follow the label directions.

Remember that it is a violation of federal law to use a pesticide product in a manner inconsistent with its labeling.

The sample label is not from an actual pesticide product. It was created to show you where to find key label sections and help you read and understand label instructions.

GROUP 3 INSECTICIDE

PestChemCo

X-PEST-EC

Non-Systemic Insecticide with contact and stomach action

For control of insect pests of ornamental plants in nurseries and landscapes.

Active Ingredient:

alphabetamethrin: (1,2-phenoxybenzyl)-cyclopropanecarboxylate...23.5%
Inert Ingredients:.....76.5%
Total:.....100.0%

Contains petroleum distillates.
Contains 2.0 lbs of alphabetamethrin per gallon.

EPA Registration No.: 991-015 EPA Establishment No.: 991-VA-001

Keep Out of Reach of Children

WARNING **AVISO**

First Aid

If Swallowed:	Call a doctor or Poison Control Center immediately for treatment advice. Do not induce vomiting.
If on Skin:	Wash exposed skin with mild soap and water. Get medical attention.
If in Eyes:	Flush with water for 15 minutes. Get medical attention.
If Inhaled:	Move affected person to fresh air. If not breathing, give artificial respiration, preferably by mouth to mouth. Get medical attention.
Note to Physician:	Alphabetamethrin is a pyrethroid. Treatment is symptomatic and supportive. If large amounts are ingested, the stomach and intestines should be evacuated. Digestible fats, oils, or alcohol may increase absorption and so should be avoided. This product contains petroleum distillates; vomiting may cause aspiration pneumonia.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Causes Severe Skin and Eye Irritation. Harmful if Swallowed.

Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco products.

Environmental Hazards

This pesticide is extremely toxic to fish and aquatic invertebrates. Do not apply directly to water. Drift and runoff from treated areas may be hazardous to aquatic organisms. Do not contaminate water when cleaning equipment.

This product is extremely toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops if bees are visiting the treatment area.

Notice: Read the entire label. Use only according to label directions. Before buying or using this product, read "Warranty Disclaimer" and "Inherent Risks of Use" sections, found at the end of this label.

In case of an emergency, call 1-800-999-1111. If you wish to obtain additional product information, visit our website at *www.PestChemCo.com*

Agricultural Chemical: Do not ship or store with food, feed, drugs, or clothing.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Read all Directions for Use carefully before applying. Do not apply this product in a manner that will contact workers or other persons, either directly or through drift.

Storage and Disposal

Do not contaminate water, food, or feed by storage and disposal. Open dumping is prohibited.

Pesticide Storage: Store in original container in a secure, dry area. Prevent cross-contamination with other pesticides or fertilizers. Do not store above 112° F. Preferred storage temperature range is between 100-32° F. Agitate before use.

Pesticide Disposal: Wastes resulting from the use of this product (that cannot be used according to label instructions) may be disposed of at an approved waste disposal facility.

Container Disposal: Triple-rinse or equivalent. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill. Do not reuse empty container.

Sample Label (for education/demonstration purposes only)

AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to nursery uses.

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

Do not enter or allow workers to enter treated areas during the restricted-entry interval (REI) of 12 hours.

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

- Coveralls
- Chemical-resistant gloves
- Shoes plus Socks

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to all use sites on this label except for nursery uses.

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Entry Restrictions for Non-WPS Uses: For application to non-cropland areas, do not enter treated areas without protective clothing until sprays have dried.

General Use Precautions and Restrictions

When applying this product in tank mix combination, follow all applicable use directions, precautions, and limitations on each manufacturer's label. Test for compatibility before applying.

This label must be in the possession of the user at the time of application.

Chemigation: Do not apply this product through any type of irrigation system.

Do not apply with ground equipment within 15 feet or by air within 150 feet of lakes, reservoirs, rivers, permanent streams, marshes or natural ponds, and commercial fish farm ponds.

For ground boom and aerial applications, use medium or coarser spray nozzles according to ASAE 572 definition for standard nozzles or a volume median diameter (VMD) of 300 microns or greater for spinning atomizer nozzles.

Make aerial or ground applications when the wind velocity favors on-target deposition (3-10 mph). Do not apply when wind velocity or gusts exceed 15 mph. Low humidity and high temperatures increase the evaporation of spray droplets and therefore the likelihood of drift. Avoid spraying in conditions of low humidity and/or high temperature.

Personal Protective Equipment (PPE)

Mixing and Loading:

- Long-sleeved shirt and long pants
- Shoes and socks
- Protective eyewear
- Chemical-resistant gloves
- Chemical-resistant apron

Application:

- Long-sleeved shirt and long pants
- Shoes and socks

Calibrating and Cleaning Equipment:

- Long-sleeved shirt and long pants
- Shoes and socks

Physical and Chemical Hazards

Flammable. Do not use, pour, spill, or store near sparks or open flame. Do not allow this product to freeze. Do not store at temperatures above 112° F. Store in a secure, well-ventilated area.

Engineering Controls

When handling containers of 5 gallons or more:

Do not open pour product from container. Use a mechanical transfer system (probe/pump or spigot).

Application Instructions

To control grasshoppers, leafhoppers, stink bugs, thrips, leaf beetles and beetle larvae, and lepidopteran larvae on ornamental plants (woody and herbaceous) in nurseries and landscapes:

Mix thoroughly, using clean water. Use agitation to keep the spray mixture evenly distributed.

Mixing directions (product / water) for spot treatments:

- 4 oz / gallon
- 2.5 pints (40 oz) / 10 gallons

When making a broadcast treatment, apply 4 oz product in 1-2 gallons of finished spray per 1,000 ft², covering the target foliage in a uniform manner.

Application interval = 7 days.

NOTE: Do not apply to Flowering Crabapple, Redbud, Begonia, or Impatiens as foliage injury may result.

Warranty Disclaimer

PestChemCo warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below.

Inherent Risks of Use

It is impossible to eliminate all risks associated with this product. Plant injury, lack of performance, or other unintended consequences may result if used contrary to label instructions or due to factors beyond the control of PestChemCo. All such risks shall be assumed by the buyer.

PestChemCo LLC
123 North Main Street, Richmond, VA 23123 USA
1-804-555-1111

Test Your Knowledge

Q. Explain the differences 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 you receive from the manufacturer about the product when you buy it.

Q. What is "reregistration" of a pesticide? What is its goal?

A. The ongoing review of a registered pesticide to assess the risks and benefits associated with its labeled uses. The goal of reregistration is to identify and reduce risks, based on current scientific knowledge.

Q. What is a "tolerance"? Why is it important?

A. The maximum amount of pesticide residue that may remain on food or feed at harvest or slaughter. Tolerance levels are set by EPA. Observing tolerances is crucial in ensuring food safety.

Q. When and why might a pesticide product be registered for a special local need (SLN)?

A. If a manufacturer wants to register a pesticide for use only on a regional crop or to manage a localized pest problem. SLN registrations allow states to expand or limit the uses of federally registered pesticides within their jurisdictions. This provision of FIFRA allows VDACS to register a new pesticide product – or an additional use of a federally registered product – for a pest-site problem in Virginia.

Q. What is a federal (Section 3) registration? How do you know if you have bought a Section 3 pesticide?

A. An EPA-registered product with a label reviewed and approved by that agency. Most pesticides are registered this way. Federally registered pesticides will have an official EPA registration number.

Q. True or false: ALL pesticide products must be registered with EPA. This agency reviews the labels of ALL pesticide products sold in the United States.

A. False. EPA exempts "minimum risk" pesticides from the federal registration process. These products are considered a low risk to humans and the environment. However, all pesticides used or sold in Virginia must be registered with VDACS, Office of Pesticide Services. Minimum-risk pesticides are NOT exempt from Virginia registration requirements. In addition, people who use these products on the job may still need to be certified in the commonwealth.

Q. Under what conditions may a pesticide be labeled "minimum risk" and thus be exempt from federal registration? How do labels of minimum-risk Section 25(b) products differ from those that are EPA registered (Section 3)?

A. EPA has produced a list of minimal-risk active and inert ingredients. To be exempt, all of the active and inert ingredients in a pesticide product must be on this list. Minimum-risk Section 25(b) product labels must list all ingredients. In addition, they cannot have any false or misleading claims.

Minimum-risk product labels do not have an EPA registration number, EPA establishment number, or signal word. They also do not have PPE requirements.

Q. Are "minimum risk" products exempt from Virginia's state registration requirements?

A. No. All pesticides that are sold or used in the Commonwealth of Virginia must be registered with VDACS Office of Pesticide Services.

Q. What are emergency (Section 18) exemptions? List the four types.

A. Responses to pest problems for which no pesticides are registered. Section 18 exemptions allow the sale and use of a certain pesticide for a specific nonregistered purpose for a specified period. The four types of emergency exemptions are: specific, quarantine, public health, and crisis.

Q. What do the words "restricted-use pesticide" tell you about a pesticide product?

A. Restricted-use pesticides (RUPs) require special care and handling. The restricted-use designation limits the use of a pesticide product. RUPs are for sale only to properly certified applicators. Only trained persons, or people under their direct supervision, may handle and apply restricted-use pesticides.

EPA classifies pesticides as restricted use for different reasons. Some are highly toxic to humans. Others may cause long-term health effects. Still others are restricted because of environmental effects, such as groundwater pollution risks.

Q. Where would you look to find out whether a pesticide is classified as restricted use?

A. In a box on the front panel of the pesticide label. The words "restricted-use pesticide" will appear there if a pesticide is so classified.

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

A. The chemical name is a complex term that identifies the chemical components and structure of the pesticide. A common name is a shorter name that EPA recognizes as a substitute for the product's chemical name. A brand name is the name – usually a trademark – used by a chemical company to identify a pesticide product. The common name is usually the best way to identify the active ingredient in a pesticide product.

Q. What problems might arise from choosing a pesticide by its brand or trade name alone?

A. 1. If an active ingredient is no longer protected by a patent, it may be sold by several product registrants. Each may use a different trade or brand name.

2. Many companies use the same basic name with only minor variations to designate very different products.

3. Sometimes several companies sell the same pesticide product under different brand names.

To learn what active ingredient(s) a product contains, read the ingredient statement.

Q. Where should you look to find a pesticide product's EPA registration number and establishment number? When and why would a professional pesticide handler need to know or use these numbers?

A. The EPA registration number must appear on the front panel of the product label. This number is the single most important piece of information to identify a specific pesticide product. This number indicates that the product is registered

with EPA and that the agency approved the label. The registration number is one of the data elements required for pesticide recordkeeping.

The EPA establishment number is usually placed next to the EPA registration number on the label's front panel. This number identifies the manufacturer of the pesticide product. The establishment number is important if questions or concerns arise about the product.

In addition to recordkeeping, these identification numbers are crucial in case of an exposure or poisoning, regarding claims of misuse, and/or in settling liability claims.

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

A. DANGER—POISON with a skull and crossbones ☠ symbol appears on all highly toxic pesticides. These products are very likely to cause acute illness, regardless of how they enter the body. Pesticides in this category can cause serious illness or death, even in a very low dose.

DANGER tells you that the pesticide is hazardous in some way or due to some method of exposure. For example, it may cause severe eye damage or skin irritation.

WARNING indicates that the product is moderately toxic by some route of entry or that it is likely to cause moderate skin or eye irritation.

CAUTION signifies that the product is slightly toxic and is less likely to cause acute illness. Products with CAUTION signal words may cause slight skin or eye irritation.

Q. Can you use the signal word and/or symbol on a pesticide label to judge the likelihood of suffering acute, delayed, or allergic effects after exposure to the product? Explain.

A. Signal words and symbols indicate the likelihood of experiencing acute harmful effects from pesticide exposure. However, signal words do not tell you anything about the risks of delayed or allergic effects.

Q. What types of hazard statements should you look for in the pesticide labeling?

A. Precautions about hazards to humans and domestic animals, environmental risks, and physical or chemical hazards.

Q. What is the first aid statement (statement of practical treatment)? Why is it important?

A. A section that lists recommended treatments for poisoning or accidental exposure to pesticides. This section tells pesticide handlers what effects might result from exposure to a pesticide product. It also has detailed instructions for medical professionals about how to treat people who were harmed by the pesticide.

Q. Explain the meaning of the statement: "It is a violation of federal law to use this product in a manner inconsistent with its labeling."

A. Basically, it is illegal to use a pesticide in any way not permitted by the labeling. You must follow all directions for use, including safety, mixing, diluting, storage, and disposal. You may not use higher dosages, higher concentrations, or more frequent applications than those specified on the label. You must also wear any label-specified PPE.

Q. Does the pesticide label <u>always</u> contain the complete instructions and directions for use needed to use the product safely and legally?

A. No. For some pesticide products, more instructions and directions are in other labeling that accompanies the product (such as supplemental labeling for SLN use). In other cases, the label may

reference separate documents with specialized instructions and directions. Worker Protection Standard requirements and Endangered Species Protection Program restrictions are examples. This is also called "label by reference."

Q. If you transfer a pesticide (concentrate or diluted) into another container, do you have to label the secondary container?

A. Yes, to temporarily store or transport pesticide concentrates or end-use dilutions. These service containers must have abbreviated labeling to identify the contents. Otherwise, leave pesticides in their original labeled containers.

Q. What is FIFRA? What is its basic purpose?

A. The Federal Insecticide, Fungicide, and Rodenticide Act, passed by Congress in 1947 and amended several times. FIFRA regulates the registration, manufacture, sale, transportation, and use of pesticides. It specifies how pesticides must be registered and used, the required training and certification of applicators, and the classification of restricted-use pesticides, among other things.

Q. When and why might you use a Safety Data Sheet (SDS) for a pesticide product?

A. To get technical information about the environmental and human health effects of a pesticide product. You could also consult an SDS to find out how to respond to an accident or incident.

Q. Which document has authority in specifying PPE requirements: a product label or its SDS? Why?

A. The product label. If a label and its SDS differ in PPE requirements, the pesticide end user must follow the product label instructions. The label is the law.

Use the sample label at the end of this unit to answer the rest of the questions.

Q. What is the product's brand name, EPA registration number, and EPA establishment number?

A. The brand name is X-Pest-EC. The EPA registration number is 991-015, and the EPA establishment number is 991-VA-001.

Q. What kind (class) of pesticide is it? What is the common chemical name of the active ingredient? How much of the formulated product is composed of the active ingredient? The inert (inactive) ingredients?

A. X-Pest-EC is an insecticide. The first aid section tells you that it is a pyrethroid insecticide. The common chemical name of the active ingredient is alphabetamethrin. This product contains 23.5% alphabetamethrin (2 pounds of the active ingredient per gallon). The rest of the formulated product (76.5%) consists of inert (inactive) components.

Q. Does this product name tell you anything useful about its properties?

A. Yes. The "EC" in the product name means that the product is an emulsifiable concentrate. Letters and numbers used in pesticide product names often describe properties of the formulated product. Refer to Unit 4 for more information about product formulations.

Q. Is this a Section 3 federal label or a 24(c) (special local need) label?

A. A Section 3 federal label. There is no indication that this is a 24(c) (special local need) supplemental label. The front panel and the directions for use are for woody and herbaceous ornamentals, not regional crops. The pests controlled are widespread and common, not localized.

Q. Is X-Pest-EC classified as restricted use?

A. No. If X-Pest-EC were classified as an RUP, you would see these statements at the top of the front panel of the label: "RESTRICTED-USE PESTICIDE" and "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."

Q. What company makes X-Pest-EC? Where is this firm located? How could you contact the manufacturer?

A. PestChemCo. The environmental hazards label section provides you with emergency contact information (phone number and website). The warranty disclaimer/inherent risks of use section gives the location (Richmond, VA) and telephone number of the company.

Q. Is this product ready-to-use? How is it applied?

A. No. The net contents indicate that it is a liquid concentrate. The application instructions section tells you to mix it with water and gives you the mixing proportions. The general-use precautions and restrictions section provides directions and restrictions for spraying – including drift-reduction tactics.

Q. When you visit a retail outlet that sells agricultural products, you see a 2%, ready-to-use, granular (G) formulation product that contains alphabetamethrin. However, this 2% G product is labeled only for use on turf. Can you purchase the 2% G product and legally use it around ornamental plantings or nursery containers?

A. No. The directions for use section of a label will tell you what plants, animals, or sites the product is intended to protect: where it may be used legally. The front panel of X-Pest-EC tells you it is a "non-systemic insecticide with contact and stomach action – for control of insect pests of ornamental plants in nurseries and landscapes." The application instructions for X-Pest-EC specify use on woody and herbaceous ornamentals in nurseries and landscapes. The WPS agricultural and nonagricultural use requirements refer to nursery production. X-Pest-EC is legal to use on ornamentals, but the granular product described (with use directions for turfgrass only) is not.

Q. Can you legally use X-Pest-EC on a home vegetable garden?

A. No. The directions for use section of a label will tell you what plants, animals, or sites the product is intended to protect – where it may be used legally. The front panel of X-Pest-EC tells you it is a "non-systemic insecticide with contact and stomach action – for control of insect pests of ornamental plants in nurseries and landscapes." The application instructions for X-Pest-EC specify use on woody and herbaceous ornamentals in nurseries and landscapes. The WPS agricultural and nonagricultural use requirements refer to nursery production. There is no mention of (or directions for use on) food crops anywhere on the label.

Q. What hazard rating would you give this product, based on information you find on its label: high, moderate, or (relatively) low?

A. Moderate. Here are some reasons:

1. The signal word is WARNING (between DANGER and CAUTION).
2. The concentration of active ingredient in the product is modest (more than 10% but less than 50%).
3. X-Pest-EC is NOT classified as a restricted-use pesticide.
4. As a rule, the minimum PPE required for handlers of professional products is: long-sleeved shirt, long pants, shoes, and socks. In addition, X-Pest-

EC mixers and loaders must wear protective eyewear, chemical-resistant gloves, and a chemical-resistant apron. The label tells you that exposure to this product can cause skin and eye irritation. However, handlers are not required to use a respirator. Also, once the product is diluted and ready for end use, PPE requirements are minimal.

5. The restricted-entry interval (REI) is 12 hours (neither the shortest nor the longest REI required by WPS).
6. The treatment interval is a week. Some products can be applied daily or as needed. Others can be applied only once per season.
7. The engineering controls section of the label requires mixers and loaders handling large containers to use a transfer device. (This product is a skin or eye irritant. Large containers are harder to handle. As a result, spills or splashes are more likely to occur.)

Q. What physical or chemical hazards does this product pose to the handler?

A. The label tells you it will irritate your eyes and skin. The product contains petroleum distillates, and it is flammable. These properties pose some risk to pesticide handlers.

Q. What personal protective equipment is required for mixers and loaders?

A. Long-sleeved shirt, long pants, shoes, socks, protective eyewear, chemical-resistant gloves, and a chemical-resistant apron.

Q. What PPE is required for applicators?

A. Long-sleeved shirt, long pants, shoes, and socks.

Q. What PPE is required for people who repair, clean, or calibrate spray equipment?

A. Long-sleeved shirt, long pants, shoes, and socks.

Q. What PPE is required for employees who work for a production nursery and must enter treated fields sooner than 12 hours after plants were sprayed?

A. Coveralls, chemical-resistant gloves, shoes, and socks.

Q. What is the restricted-entry interval for this product?

A. 12 hours.

Q. Does the REI apply to people who hire a landscaper to treat an ornamental bed for them, or to people who visit landscaped areas in a public park?

A. No.

Q. As an applicator of X-Pest-EC, how long should you keep people from walking through treated landscape beds in a public park or in front of a home (unless they are wearing long pants, a long-sleeved shirt, shoes, and socks)?

A. Until sprays are dry.

Q. You want to spot treat some azaleas in a landscaped area. By reading the label and doing a test run using water only, you estimate that you will need 2 gallons of spray mix to do the job. How much product should you put in your backpack sprayer to make this application?

A. The label rate is 4 ounces of product per gallon. Therefore, you will need to use 8 ounces of X-Pest-EC.

Q. You want to make a broadcast application to treat herbaceous annuals in an ornamental bed that measures 10 feet by 50 feet (500 square feet in area). How much water and how much X-Pest-EC will you need for the job?

A. The application instructions give a broadcast application rate of 4 ounces of product per 1,000 square feet, delivered in 1 to 2 gallons of spray mix. To treat an area half that size, you will use half the materials: 2 ounces of product and 1/2 to 1 gallon of finished spray. (You will need to calibrate your sprayer when making a broadcast application. The exact volume of water needed depends on your application rate.)

Q. What kind of application equipment do you need to apply this product?

A. Look at the application instructions to decide. They direct you to mix the product with water and apply it as either a spot or broadcast treatment. They also tell you to cover ornamental plant foliage uniformly with the spray mixture. To do this, you will need a low-pressure sprayer (boom, backpack, or small estate sprayer). Since the product is an emulsifiable concentrate (EC), you will need a sprayer with some kind of agitation. (See Unit 4 for more information about formulations and their properties.)

Q. Can you use X-Pest-EC on flowering dogwoods? Flowering crabapple?

A. Yes. The label clearly states that this product may be used on woody and herbaceous ornamental plants. This includes dogwoods. However, the label advises against using X-Pest-EC on a few kinds of ornamentals, including flowering crabapple, to avoid foliage injury.

Q. Is it legal to apply this product through an irrigation system?

A. No. The general-use precautions and restrictions section specifically prohibits making this type of application (chemigation).

Q. Should this product be used with an adjuvant?

A. The label has no instructions regarding adjuvants. See Unit 4 for more information on adjuvants.

Q. Does the label give sprayer cleanup directions?

A. No. See Unit 8 for more information on equipment cleanup.

Q. List any specific environmental restrictions or precautions on the label.

A. The label states that this product is highly toxic to fish and aquatic invertebrates. Specific restrictions include:

1. Do NOT apply this product directly to water.
2. Do NOT contaminate water by off-target movement (drift or runoff) or disposal of equipment wash water.
3. Observe buffer zones (15 feet for ground applications; 150 feet for aerial applications).
4. Manage drift as described in the general-use precautions and restrictions section.
5. Use the correct spray nozzle to control droplet size.
6. Do not apply X-Pest-EC in any type of irrigation system.
7. Observe restrictions on application sites and timing to protect bees.

Q. Are there any restrictions regarding environmental conditions during application?

A. Yes. The X-Pest-EC label has specific prohibitions regarding wind speed. (It also advises applicators to avoid making an application when the temperature is high and/or humidity is low due to the risk of drift.) There is no specific information about spraying when rain is expected.

Q. Are tank-mix instructions or compatibility precautions provided?

A. Yes, in the general-use precautions and restrictions section. However, this label provides only minimal information.

Q. Can you apply this product aerially? Are aerial application directions provided?

A. Yes, although there are no specific instructions for aerial application. There is no statement prohibiting aerial application, and the general-use precautions and restrictions section of the label tells you to leave a 150-foot buffer zone between areas treated by air and water bodies. This section also includes general instructions on droplet sizes for aerial applications.

Q. Does the X-Pest-EC label give instructions about container disposal?

A. Yes, in the storage and disposal section. It recommends the following: "Triple-rinse or equivalent. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill. Do not reuse empty container."

Q. List any instructions or requirements on the label regarding disposal of unwanted product or excess mix.

A. 1. "Do not contaminate water, food, or feed by storage and disposal. Open dumping is prohibited."

2. "Pesticide Disposal: Wastes resulting from the use of this product (that cannot be used according to label instructions) may be disposed of at an approved waste disposal facility."

Q. Does the label tell you how to store this product?

A. Yes. The storage and disposal section gives specific information on how to store the product. This section also instructs: "Do not use, pour, spill, or store near sparks or open flame. Do not allow this product to freeze. Do not store at temperatures above 112°F. Store in a secure, well-ventilated area." In addition, the front panel tells you the product contains petroleum distillates, and the physical and chemical hazards section states that it is flammable.

Q. Does the label tell you what to do in case someone is harmed by X-Pest-EC?

A. Yes. The first aid section lists specific instructions for different types and degrees of exposures.

Q. Does the label state any restrictions on using land after an application, planting rotational crops, grazing treated areas, using treated clippings for animal feed, or composting treated plants?

A. No. As a rule, these kinds of prohibitions are not found on insecticide products registered for use on ornamental plants. However, if you are treating food or fiber crops, look for such precautions and/or prohibitions.

Q. Are there any requirements that X-Pest-EC users must follow that are NOT on the label? If so, to whom do they apply? What document explains these procedures?

A. Yes. People who use X-Pest-EC to produce nursery stock (agricultural plants) have additional requirements to protect their workers or handlers. Some of these are referenced by, but not stated on, the label. These include employee training, information that must be displayed at a central location, decontamination supplies and sites, and emergency assistance. Label-referenced WPS requirements are explained in this document: **How to Comply with the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Owners and Employers Need to Know.**

Unit 4. Pesticide Formulations

Learning Objectives

After studying this unit, you should be able to:

- Describe what a pesticide formulation is.
- Explain why pesticides are formulated for users.
- Distinguish between active and inactive (inert) ingredients.
- Recite the names of and abbreviations for common formulations.
- Discuss the properties of common formulations.
- Identify the equipment needed to apply each common formulation.
- List factors to consider when choosing a formulation.
- Choose the best formulations for specific purposes.
- State the purpose of adjuvants.
- Describe the properties and uses of several types of adjuvants.
- List the steps involved in preparing a pesticide (or pesticide-fertilizer) tank mix.
- Describe the signs of incompatibility.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

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

Absorption – The process of taking in (soaking up) a substance.

Acidic – The opposite of alkaline; having a pH less than 7.

Active Ingredient (a.i) – A chemical in a pesticide product that affects or controls the target pest.

Adjuvant – A substance added to a pesticide formulation or tank mix to increase its effectiveness or safety (ex. emulsifier or wetting agent).

Adsorption – The process of adhesion; coating a particle or binding something to a surface.

Agitation – The process of stirring or mixing.

Alkaline – The opposite of acidic; having a pH greater than 7.

Carrier – The primary material used to allow a pesticide to be dispersed effectively. Examples include talc in a dust formulation, water mixed with a wettable powder before a spray application, and air that disperses the pesticide in an air-blast application.

Conductivity – A measure of water's ability to conduct electricity. Dissolved substances (ex. soluble salts) increase the conductivity of water.

Dilute – To make less concentrated.

Emulsion – A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other, and each retains its identity and properties. Agitation may be necessary to prevent separation.

Terms to Know cont.

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

Impregnates – Solid materials with one or more pesticide active ingredients incorporated into them (ex. livestock ear tags, plastic pest strips and adhesive tapes, and pet collars).

Incompatible – A combination of ingredients that is not usable, stable, safe, or effective.

Inert Ingredient – Inactive component of a formulated pesticide product added to dilute the pesticide or to make it safer, more effective, and/or easier to handle. Inert ingredients have no direct effect on target pests.

Insoluble – Does not dissolve in a liquid.

Microbe – An organism (such as a bacterium or protozoan) that cannot be seen without the aid of a microscope.

Mixture – Two or more substances that are not chemically bound to one another. Mixtures may be uniform and homogeneous (ex. a dilute solution of saltwater) OR non-uniform and heterogeneous (ex. a piece of granite, a bag of M&Ms, or oil and vinegar salad dressing).

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Petroleum Based – Made from petroleum products (ex. xylene, refined oil, and kerosene).

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

Phytotoxicity – Injury or damage to a sensitive plant caused by a chemical exposure.

Precipitate – An insoluble, solid substance that forms because of a chemical change. Precipitation is the formation of a solid in a solution resulting from a chemical reaction.

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

Solution – Homogeneous (uniform) mixture of two or more substances. Liquid solutions are transparent and do not separate (ex. form layers) if allowed to sit.

Solvent – A liquid that will dissolve a substance and form a true solution. Common solvents include water, acetone, refined oil, and alcohol.

Surfactant – A surface-active ingredient that alters the dispersing, spreading, or wetting properties of spray droplets. Surfactants are one type of adjuvant.

Suspension – A substance that contains undissolved particles mixed throughout a liquid. Suspensions are cloudy or opaque. They will usually separate (ex. form layers) without agitation or some other treatment. An emulsion is a type of suspension.

Tank Mixing – Combining two or more crop production products (pesticides or fertilizers) in one tank in order to apply them at the same time.

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

Turbidity – A measure of water cloudiness caused by suspended particles (ex. undissolved chemicals and soil sediments). Turbid water often appears brown or muddy.

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

What Are Pesticide Formulations?

A pesticide **formulation** is a combination of active and inert (inactive) ingredients that forms an end-use pesticide product. Pesticides are formulated to make them safer or more convenient to use. This is true because many of a pesticide's **active ingredients**, in "pure" (technical grade) form, are not suitable for end use. Some of these pesticides are extremely toxic. Many do not mix well with water. Some are unstable and, in concentrated form, are not easy (or safe) to handle, transport, or store. As a result, manufacturers of pesticide products add inert (inactive) ingredients. These ingredients have one or more of these functions:

- Improve efficacy (effectiveness).
- Dilute the pesticide.
- Make end-use products safer and/or more convenient to handle and store.
- Make them easier to measure, mix, and apply.

Inert ingredients do not have any pesticidal activity. Some simply serve as **diluents** or carriers. These inactive ingredients dilute the active ingredient, reducing toxicity. In many cases, they also make the formulated product safer (for handlers and treated surfaces, including plants) or easier to handle.

Other inert ingredients are adjuvants: substances added to a formulated product to improve its effectiveness and/or safety. Usually, an active ingredient is combined with inert materials and packaged to make an end-use product. Many formulated products also contain other ingredients, such as stabilizers and dyes. Stabilizers prolong shelf life, and dyes help to identify the product. Dyes also indicate contamination, exposure, and areas treated.

Most pesticides are available in several different formulations and concentrations of active ingredient. Some are ready-to-use (RTU). Others need further dilution with water, a petroleum-based **solvent,** or air (as in air-blast or ultra-low-volume [ULV] applications) before they are applied. Each has a descriptive name and abbreviation.

The amount of active ingredient in a formulated product is listed on the product label, in the ingredient statement or net contents chart. The product trade name often indicates the formulation type and active ingredient concentration. For example,

- 80 WP means the product contains 80% of the active ingredient, by weight, formulated as a wettable powder.
- 0.15 EC most likely contains 0.15 pound of active ingredient per gallon, formulated as an emulsifiable concentrate.
- A 2G product is probably a 2% granule.
- 4F means the product is a flowable formulation with 4 pounds of the active ingredient per gallon.

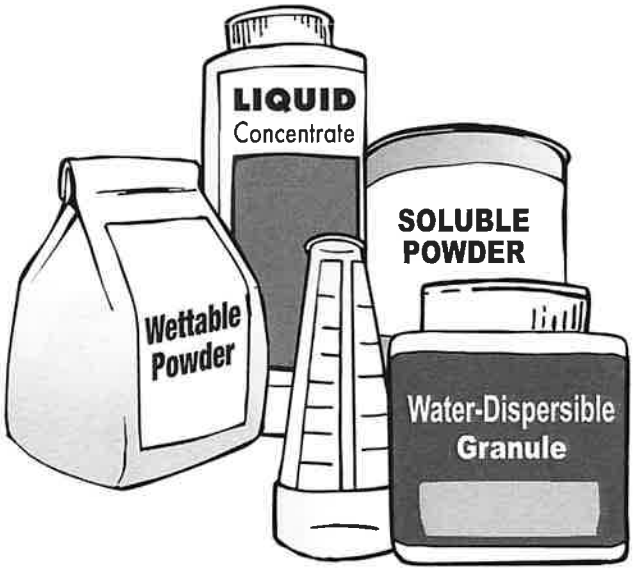
Other abbreviations in a trade name may describe other characteristics. For example, TC (termiticide concentrate) indicates how the product should be used. LO (low odor) and LV (low volatility) describe formulation properties.

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

- Do I have the necessary application equipment?
- Is the formulation safe to apply under the conditions in the application area?
- Will the formulation reach the target and stay in place long enough to control the pest?
- Is the formulation likely to harm the surface I plan to treat?

- Which of the available formulations is most effective?
- Which formulation option(s) is/are least hazardous to handle and apply – and, if necessary, to store?

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



Chemical companies sell many different pesticide formulations.

Formulations: An Overview

Pesticide active ingredients come from many sources. Some, like nicotine, rotenone, or insect growth regulators, come from plants or animals. Others, like copper, sulfur, and boric acid (and other boron-based insecticides), are minerals. Still others are microbes or microbial by-products (ex. *Bacillus thuringiensis*). However, most are produced in laboratories.

Some active ingredients, like synthetic pyrethroids, are derivatives of the plant extract pyrethrum. Others, like the neem tree extract azadirachtin, are cheaper and easier to manufacture in a laboratory than to extract and isolate from the plant source. Many are designed by chemists or discovered by screening chemical compounds for pesticidal activity.

Regardless of where they come from or how they are produced, pesticide active ingredients vary considerably in their physical and chemical properties. One variable is solubility. Some dissolve in water, but many do not. Some are soluble in oils or organic solvents. However, many such solvents are not available to applicators or safe to use. A few active ingredients do not dissolve readily in any solvent. Solubility and the intended use of the pesticide are two factors that determine how an active ingredient will be formulated – made into an end-use product.

Liquid pesticide products are usually one of the following:

- A solution.
- A suspension.
- An emulsion.

A **solution** is the result of dissolving a substance in a liquid. A true solution is a **mixture**, but it cannot be separated by mechanical means such as filtration. Once made, a true solution will not "settle out" and does not need shaking or stirring (agitation) to keep the mixed components in solution. Solutions are transparent: they will allow light to pass through them. (However, this may not be obvious if one or more components of the mixture are dark in color and the solution is very concentrated.) Sweetened iced tea and saltwater are examples of solutions.

A **suspension** is also a mixture. However, a suspension is formed by dispersing fine (very small) solid particles in a liquid. These solid particles do not dissolve in the liquid carrier. Suspensions must be agitated to maintain even particle distribution. Otherwise, the undissolved parts of suspension mixtures will settle (or float to the top). Most suspensions are cloudy or opaque: they will not allow light to pass through them. Pesticide products formulated as suspensions are not water soluble. For this reason, they

form more dilute suspensions when mixed with water to make a finished spray. Label directions for suspension formulations will instruct the user to shake them well before mixing. The label will further state the need to apply these products only if using spray equipment that has enough **agitation** to keep the final mixture evenly distributed in the spray tank during application. A mixture of flour and water is an example of a suspension.

An **emulsion** is a special kind of suspension: a mixture made by suspending droplets of one liquid in another. Each ingredient retains its unique properties and identity. To make an emulsion, an active ingredient is dissolved in an oil-based solvent and then further diluted with water. Some agitation is necessary to keep an emulsion from separating. However, most emulsion pesticide product formulations have additives (emulsifiers or emulsifying agents) that prevent the product from settling. As a rule, emulsions have a milky appearance. An emulsifiable concentrate (E or EC) is an emulsion. Homogenized milk and some salad dressings are examples of emulsions.

Most dry products are made by adhering the active ingredient to some solid carrier, such as talc, silica (the mineral quartz), or plant residues (ex. ground corncobs).

Some pesticide products are sold in concentrate form and must be mixed or diluted before use. **Concentrates** come in both liquid and solid form. An emulsifiable concentrate (E or EC) is an example of a liquid concentrate (LC). Wettable powders (WP), soluble powders (SP), and water-dispersible granules/dry flowables (WDG/DF) are examples of concentrated materials sold in solid form.

Other formulations are sold ready-to-use. You can apply ready-to-use products without any further dilution or mixing. Examples include liquids prepared as end-use dilutions and aerosol (A), dust (D), pellet (P), granule (G), and bait (B) formulation products.

Concentrates are often less expensive per treatment/unit area treated than ready-to-use formulations. However, they present other problems. For example, concentrates are usually more toxic than dilute formulations of the same active ingredient. More handling is required to mix and load them. As a result, concentrates present a higher exposure risk to the handler.

Most pesticide active ingredients are available in more than one formulation type. A short description of each common formulation, together with its pros and cons, follows. Choose a product based on:

- Applicator safety.
- Environmental safety.
- Pest biology.
- Application equipment available.
- Target (surface to be treated).

Cost is always a consideration, but pesticide and pest management concerns should come first.

Liquid Formulations

Most liquid formulations are diluted with water to make a finished spray. However, some labels direct users to mix the product with another solvent such as crop oil or another light oil as a carrier.

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains an oil-soluble liquid active ingredient, one or more petroleum-based solvents, and a mixing agent. This agent 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. ECs are among the most versatile formulations. They help to manage agricultural, ornamental and turf, forestry, structural, food processing, livestock, and

Abbreviations for Common Formulations

A = Aerosol

AF = Aqueous Flowable

B = Bait

C = Concentrate

D = Dust

DF = Dry Flowable (see WDG)

E = Emulsifiable Concentrate

EC = Emulsifiable Concentrate

F = Flowable

G = Granule

L = Liquid

LC = Liquid Concentrate

M= Microencapsulated

P = Pellet

PS = Pellet

RTU = Ready-to-Use

S = Solution

SP = Soluble Powder

ULV = Ultra-Low Volume

W = Wettable Powder

WDG = Water-Dispersible Granule (see DF)

WP = Wettable Powder

WS = Water Soluble

WSB = Water-Soluble Bag (see WSP: Water-Soluble Packet)

WSC = Water-Soluble Concentrate

WSL = Water-Soluble Liquid

WSP = Water-Soluble Powder *or* Water-Soluble Packet (see WSB)

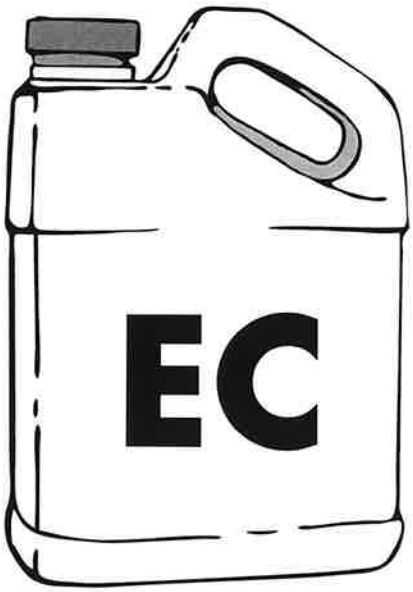
public health pests. Emulsifiable concentrates are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Advantages:

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

Disadvantages:

- High concentration of active ingredient makes it easy to overdose or underdose through mixing or calibration errors.
- May damage treated plants or surfaces. (Petroleum-based solvents or overdosing may cause **phytotoxicity**.)
- Easily absorbed through skin of humans and/or animals.
- Spills and splashes may be difficult to clean up and/or decontaminate.
- Many have a strong odor.
- Solvents cause equipment wear and tear. For example, rubber or plastic hoses, gaskets, seals, pump parts, and other exposed surfaces may deteriorate.
- May cause pitting or discoloration of painted finishes or other treated surfaces.
- Flammable – should be used and stored away from heat or open flame.
- May be corrosive.



Emulsifiable concentrates (ECs) are versatile pesticide formulations.

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based solvent. When mixed with the solvent, they form a solution that will not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the solvent (carrier or diluent), and one or more other ingredients. Solutions are suitable for any type of sprayer – indoors or outdoors. Consequently, they are registered for many sites, including structural, institutional, public health, and household pest control; livestock and poultry pest management; space sprays in barns and warehouses; and treatment of food and fiber crops, turf, and ornamental plants.

Ready-to-Use (RTU)

Ready-to-use solutions are products that contain the correct amount of solvent when you buy them. They have been diluted by a liquid or a solid carrier. Therefore, no further dilution is required before application. These formulations contain small amounts (often 1% or less per unit volume) of active ingredient. Some ready-to-use products contain petroleum-based solvents; others are water based. Many RTU products are produced for pest management professionals (structural and institutional pests) and for household use.

Advantages:

- Convenience – neither measuring nor mixing is required.
- Some are packaged and sold in an application device. If this is the case, no loading is required.
- Less personal exposure risk due to reduced toxicity and handling.

Disadvantages:

- Limited availability.
- High cost per unit of active ingredient.

The time saved and convenience of using RTU products may outweigh the increased cost.

Concentrate Solutions (C, LC, or WSC/WSL)

Other solutions are available as concentrates that require further dilution with a liquid solvent before you apply them. Often, the solvent is water, but it may also be a refined oil- or petroleum-based solvent. When diluted with the label-specified carrier, these formulations form true solutions.

Advantages:

- Relatively easy to handle, transport, and store; easy to pour and measure.
- No agitation necessary.
- Not abrasive.
- Do not plug screens or nozzles.
- Do not usually leave visible residues on treated surfaces.

Disadvantages:

- Limited availability, especially water-based solutions.
- Spills and splashes may be difficult to clean up and/or decontaminate.
- Some are easily absorbed through skin of humans and/or animals.

The other benefits and drawbacks of concentrated solutions vary. They depend on the concentration of active ingredient, solvent or diluent used, application site, and application equipment.

Liquid Baits

Some insecticides and rodenticides are now formulated as liquid baits. Most liquid insecticides are concentrated sugar solutions. Most are packaged in ready-to-use bait stations. They will manage ants and, to some extent, cockroaches.

As a rule, liquid rodenticide baits are mixed with water and placed in specially designed bait stations. They are useful in sites where sanitation is poor. This is because traditional food-based baits must compete with other food sources.

Advantages:

- Liquid ant baits are very useful in controlling sugar-feeding ants.
- Ants that feed on liquid baits carry this material to the colony.
- Liquid rodenticide baits will often control rodents in areas where food is abundant, but water is scarce or lacking altogether.

Disadvantages:

- Not all ants, cockroaches, and rodents will feed on liquid baits.
- You must replace liquid-containing bait stations frequently.

For information about solid-formulation baits, refer to "Baits" in the "Dry Formulations" section.

Ultra-Low Volume (ULV)

Ultra-low-volume concentrates may approach 100% active ingredient. They are used as is or diluted with only small quantities of specified solvents. These special-purpose formulations are most suitable for outdoor applications, such as in agricultural, forestry, ornamental, and mosquito-control programs. You apply most ULV products as very fine droplets at very low rates per unit area (or volume).

Advantages:

- Relatively easy to handle, transport, and store.
- Little or no agitation required.
- Not abrasive to equipment.
- Do not plug screens and nozzles.
- Leave little visible residue on treated surfaces.

Disadvantages:

- High drift hazard due to small droplet size.
- Specialized equipment required.
- Easily absorbed through skin of humans or animals; high dermal and inhalation exposure risks (concentrated product applied as fine droplets).
- Products and/or solvents added for application may cause rubber or plastic hoses, gaskets, seals, pump parts, and other surfaces to deteriorate.

Aerosols (A)

Aerosol 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:

1. The ready-to-use type (often sold in pressurized, sealed containers that serve as application devices).
2. Those made for use in electric or gasoline-powered aerosol generators that release the formulated product as a smoke or fog.

Ready-to-Use Aerosols

Ready-to-use aerosol formulations are usually small, self-contained units that release pesticide when the nozzle valve is triggered. An inert pressurized gas pushes the pesticide through a fine opening when the gas is released, creating fine droplets. These products are effective 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.

Aerosol Can

Advantages:

- Ready-to-use; convenient.
- Portable.
- Easily stored.
- Convenient way to buy and apply a small amount of pesticide.
- Retain potency for some time.

Disadvantages:

- Practical for only a few limited or specialized uses.
- Risk of inhalation exposure.
- Hazardous if punctured, overheated, or used near an open flame.
- May be difficult to confine to target site or pest.

Formulations for Smoke or Fog Generators

Aerosol formulations for smoke or fog generators are not packaged and sold 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, the machines produce and distribute very fine droplets. These formulations are used mainly for insect control in structures such as greenhouses, barns, and warehouses and for mosquito and biting fly control outdoors.

Advantage:

- Easy way to fill an entire space with pesticide.

Disadvantages:

- Highly specialized use sites and equipment.
- Difficult to confine to target site or pest.
- Spills and splashes may be difficult to clean up and/or decontaminate.
- May require respiratory protection to prevent inhalation exposure.

Invert Emulsions

Invert emulsions contain a water-soluble pesticide dispersed in an oil carrier. These products require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. Invert emulsions are low drift because oil evaporates more slowly than water. When applied on a hot, dry day, a water-based droplet will become smaller as the water portion of the droplet evaporates. Invert emulsion droplets do not shrink as rapidly when applied in the same weather conditions. This means less drift and more pesticide on the target. Invert emulsions are thick mixtures, with the consistency of mayonnaise. In addition, invert emulsions are applied as very large droplets, which reduces drift.

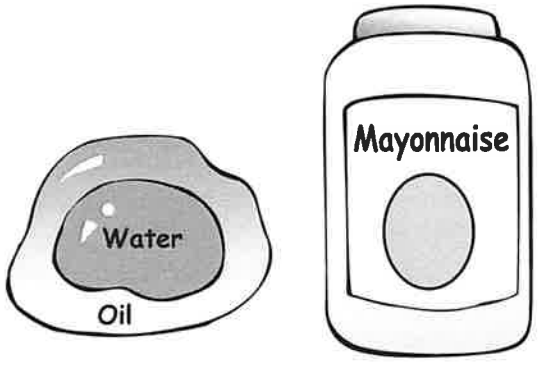
The oil phase of this kind of formulation also serves as a sticker-spreader. This improves rain-fast properties and surface coverage. It also increases absorption and/or penetration. This, in turn, reduces loss due to runoff. Invert emulsions are relatively uncommon. They are most often used for weed control on rights-of-way to reduce the chance of drift to susceptible nontarget plants or sensitive areas.

Advantages:

- Low drift.
- Increased rate of penetration and/or absorption.
- Increased rain-fastness and reduced runoff.

Disadvantages:

- Difficult to treat the underside of foliage or other targets because droplets are large and heavy.
- Limited availability.



An invert emulsion resembles mayonnaise.

Flowables (F, AF)/Liquids (L)

Some active ingredients are insoluble solids: substances that will not dissolve in either water or oil. These may be formulated as flowables. (Some products have the letter "F" by the trade name to designate that the formulation is a flowable. Others use the letter "L," meaning that an insoluble material is presented in liquid form.) Most flowables are prepared by first impregnating them onto a dry carrier such as clay. Then, the active ingredient plus carrier (or the active ingredient alone) are ground into a fine powder. Next, the fine powder is suspended in a very small amount of liquid (and perhaps other inert ingredients). The resulting product is a thick liquid suspension.

Flowables combine many of the characteristics of liquid emulsifiable concentrates and dry wettable powders. They appear in the "Liquid Formulations" section because the end-use product is a thick liquid. Flowables are often used for the same types of pest control operations as ECs.

Advantages:

- Easy to handle and apply; low exposure risk.
- Generally not phytotoxic.
- Seldom clog nozzles.
- Splashes are less likely than with other liquid formulations.

Disadvantages:

- May settle; need shaking before pouring and mixing.
- Difficult to remove all of product from the container. Containers may be difficult to rinse.
- Require moderate agitation.
- May be **abrasive**; contribute to wear and tear of spray application equipment.
- Spills may be harder to clean up.
- May leave a visible residue on treated surfaces.

Dry Formulations

Many dry formulations are ready-to-use. Others are concentrates, which must be mixed with water and applied as a spray.

Dusts (D)

Most dust formulations are ready-to-use and contain a low percentage of active ingredient (usually 10% or less by weight). A few dust formulations, however, are concentrates and contain a high percentage of active ingredient. These must be mixed with dry inert carriers before application.

Dusts have one or more active ingredients plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies, but all are quite small. Due to their small size, dusts need careful handling to prevent nontarget exposure, including drift. They are not water soluble. Therefore, do not mix them with a liquid solvent.

Dusts are always used dry. They are often used as seed treatments and in some other agricultural operations. Some ornamental and garden pest management products aimed at homeowners are dust formulations. In structures, dust formulations are useful to treat cracks and crevices and for spot treatments to control insect pests. Dusts are also a good tool to control lice, fleas, and other external parasites on pets and livestock.

Special dusts known as tracking powders are effective for insect and rodent monitoring and control. These products are finely ground dusts with an adsorbed stomach poison. Insects and rodents walk through the dust, pick it up on their legs and bodies or feet and fur, and ingest the poisonous dust when grooming. Tracking powders are effective in sites and situations where bait acceptance is poor; for example, where food is abundant.

NOTE: You can use nontoxic powders such as talc or flour to monitor and track rodent activity in buildings.

Advantages:

- Usually ready-to-use – no mixing.
- A good alternative where moisture from a spray might cause damage.
- Require simple application equipment.
- Effective in hard-to-reach indoor areas.

Disadvantages:

- Easily drift off target during application.
- Residues do not adhere to treated surfaces, including foliage, as well as liquids do and may easily wash off or blow away.
- May irritate eyes, nose, throat, and skin; pose a relatively high inhalation exposure risk to handlers.
- Dampness may cause product to clump and equipment to clog.
- Some kinds of application equipment and devices are hard to calibrate.
- Difficult to get an even distribution of particles.

Granules (G)

Granular formulations are similar to dust formulations; however, granular particles are larger and heavier. Like dusts, they are not water soluble. They are ready-to-use: not intended to be mixed with water and applied as a liquid suspension. The coarse particles that serve as carriers for granular formulations are **adsorptive** substances like clay or **absorptive** plant material such as ground corncobs or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1% to 15%.

Because many granular formulations use carriers that absorb moisture, humidity will affect particle size and mass. This, in turn, will affect flow rate. Also, different batches of the same formulation may differ slightly in size or shape and density. For these reasons, you must calibrate granular application devices often.

Once applied, granules slowly release the adsorbed or absorbed active ingredient. Some require soil moisture, rain, or watering to initiate the release of the active ingredient. Other granules do so as they decompose.

Granular pesticides are mostly used to apply chemicals to the soil to control weeds, nematodes, and insects living there or to be absorbed by plant roots. Granules are a

common choice in many sites and situations, including:

- Agricultural.
- Structural.
- Ornamental.
- Turf.
- Aquatic.
- Right-of-way.
- Forestry.
- Public health pest control operations.

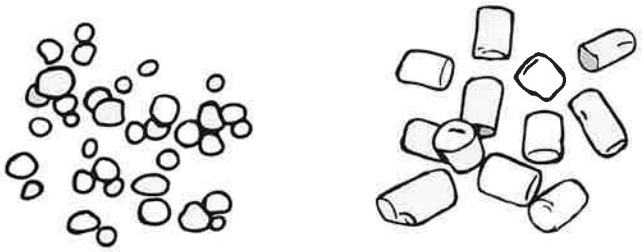
Airplane or helicopter applications sometimes use granular formulations to reduce drift or to penetrate dense vegetation. Granular formulations are also useful in aquatic situations to control mosquito larvae and aquatic weeds.

Advantages:

- Ready-to-use – no mixing.
- Drift hazard is low, and particles settle quickly.
- Low applicator hazard – no spray, little dust.
- Weight carries the formulation through foliage to soil or water target.
- Applied with simple application equipment, such as seeders or fertilizer spreaders.
- May break down more slowly than WPs or ECs because of a slow-release coating.

Disadvantages:

- Application equipment needs frequent calibration.
- Application equipment is not as convenient to calibrate as spray equipment. Released particles are measured by weight instead of by volume.
- Uniform application may be difficult with some devices (ex. rotary spreaders).
- Granules do not stick to foliage or other nonlevel or uneven surfaces. For this reason, contact products are rarely formulated this way.
- May need to be incorporated into soil or planting medium.
- May need moisture to release the active ingredient.
- May not be effective in drought conditions.
- May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the grain- or seedlike granules.
- Bulky; low percentage of active ingredient per unit volume.



Granules (left) are more irregularly shaped than pellets.

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations in their uses, advantages, and disadvantages. However, in pellet formulations, all the particles are more or less the same weight and shape. They are produced by combining the active ingredient with inert materials to form a "**slurry**" – a thick liquid mixture. This mixture is then extruded under pressure. As a result, pellets are round in cross section and cut to a specific length. Because pellet particles are more uniform, you can apply them with precision. However, in many cases, pellets are applied as spot treatments. A few fumigants are formulated as pellets. These will be clearly labeled as such to avoid confusing them with nonfumigant pellets.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts. Most include wetting and/or dispersing agents. Usually, they must be mixed with water and applied as a spray. A few products, however, may be applied dry – the applicator may choose.

Wettable powders contain 5% to 95% active ingredient, usually 50% or more. Wettable powder particles do not dissolve in water. When mixed with water, they form a suspension. They will settle out quickly without constant agitation to keep them suspended. To prepare a spray suspension, applicators must form a slurry by mixing a WP with a small amount of water, then dilute this slurry mixture further.

Wettable powders are one of the most widely used pesticide formulations. They are effective for most pest problems and in most types of spray equipment where agitation is possible. They have excellent residual activity and do not usually harm treated surfaces. When you apply a WP spray suspension to a target, most of the pesticide remains on the surface. This is true even for porous materials such as concrete, plaster, and untreated wood. In such cases, only the water carrier penetrates the porous material. The wettable powder particles remain on the treated surface.

Advantages:

- Easy to store, transport, and handle.
- Less likely than ECs and other petroleum-based formulations to harm treated plants, animals, and surfaces.
- As a rule, not phytotoxic.
- Less risk of skin and eye absorption than ECs and other liquid formulations.

Disadvantages:

- Not easy to measure; must be weighed.
- Not easy to mix.
- Inhalation hazard to applicator while measuring and mixing the concentrated powder.
- Suspended particles require constant, vigorous agitation (usually mechanical) in the spray tank and quickly settle out if agitation stops.
- Abrasive to pumps and nozzles; cause equipment wear.
- Difficult to mix in very hard or very **alkaline** water.
- Often clog nozzles and screens.
- Residues may be visible on treated surfaces.

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

Water-dispersible granular formulations are wettable powder formulations compressed into dust-free, granule-sized particles. Most come with a precalibrated measuring device, based on product density (weight per unit volume). Because of this and the fact that they flow or pour out of their containers readily, they are easier to measure and cleaner to handle than WPs. Like wettable powders, most water-dispersible granules are mixed with water and applied as a spray suspension. 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. However, they have two other benefits. First, they are easier to remove from the container and measure. Second, they pose a lower inhalation hazard to the applicator.

Soluble Powders (SP or WSP)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily

in water and form a true solution. After a thorough mixing, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15% to 95%; it usually is more than 50%. Soluble powders have all the advantages of WPs but only one of the disadvantages: inhalation hazard during mixing. Not many pesticides are available in this formulation because very few active ingredients dissolve in water.

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. Many baits are solid (blocks, granules, or pellets), but some are liquids, pastes, or gels. Eating the bait with the pesticide it contains kills the pest. The amount of active ingredient in most bait formulations is quite low, usually less than 5%.

Baits are used inside buildings to control ants, cockroaches, flies, and other insects. Outdoors, they can control vertebrate pests such as rodents, other mammals, and birds. Other outdoor uses include management of snails, slugs, and some insects.

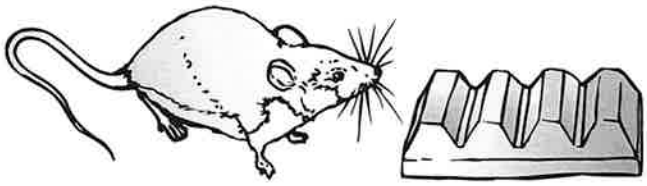
Advantages:

- 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:

- May be attractive to children and pets.
- May kill domestic animals and nontarget wildlife.
- Require careful placement and inspection.
- Pest may prefer the crop or other food to the bait.
- Dead vertebrate pests may cause odor problems.
- If baits are not removed after the pesticide stops working, they may serve as a food supply for the **target pest** or other pests.
- May not work in situations where pests have many other food or water sources.

For information about liquid baits, see "Liquid Formulations" above.



Bait Block

Other Formulations

This section describes other formulations that:

- Are not easily classified as liquid or dry/solid.
- Are formulated and/or applied as gases.
- Have some special packaging or delivery method.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. They deliver the active ingredient to the target site in the form of a gas. Some active ingredients are liquids when packaged under high pressure but become gases when released. Other active ingredients are **volatile** liquids. They may be enclosed in an ordinary container and not packaged under pressure. Still others are solids that release gases after application under conditions of high humidity or in the presence of water or water vapor. Fumigants are used for structural pest control, in food

and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders. In agricultural pest control, fumigants are effective in soil, greenhouses, and commodity storage areas such as grain bins.

Advantages:

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

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping.
- Nonspecific and highly toxic to humans and all other organisms.
- High inhalation exposure risk.
- Most require the use of specialized protective equipment, such as respirators specifically designed and approved for use with fumigants.
- May require the use of specialized application equipment.

Fumigation often requires using a tarp or other cover to enclose the target site.

Microencapsulated Pesticides (M)

Microencapsulated pesticides are dry particles or liquid droplets surrounded by a coating. Coatings may be plastic, starch, or some other material. Microencapsulated pesticides are mixed with water and applied as a spray. Once applied, the pesticide is released from the capsule. The encapsulation process can provide timed slow release of the active ingredient. Depending on the physical properties of the coating, breakdown of the microcapsule and release of the pesticide active ingredient may be weather dependent. If breakdown is slower than normal (for example, due to dry or cool weather), residues may remain on treated plants or surfaces longer than expected. As a result, some microencapsulated products have relatively long restricted-entry or preharvest intervals.

Most microencapsulated pesticide products are highly toxic materials with a coating to increase handler safety. Others are microencapsulated for other reasons, such as to reduce staining or odor. These pesticides may be very hazardous to bees. This is because many microencapsulated particles are the same size as pollen grains. Foraging bees may collect them and carry them back to the hive. When the coatings break down and release the pesticide, the colony may be poisoned.

Advantages:

- Coatings provide increased safety to applicator.
- Easy to mix, handle, and apply.
- Timed release of active ingredient prolongs effectiveness. Applicators may not need to make as many applications; application timing may be less critical.
- Reduced volatility.
- Reduced odor, risk of staining or otherwise damaging treated surfaces, and phytotoxicity.

Disadvantages:

- Constant agitation may be necessary in spray tank (depending on the properties of the coating).
- Risk of injuring or killing bees (if the microencapsulated product is toxic to them).
- Long restricted-entry or preharvest intervals for highly toxic products.

Water-Soluble Packaging

More and more pesticide products are available in water-soluble bags (WSBs). A special plastic film packages a precise amount of wettable powder, soluble powder, or gel containing the pesticide active ingredient(s). When added to water in a spray tank, the bag dissolves and releases the contents, which are then suspended or dissolved. This packaging method reduces handler exposure risk. It also simplifies measuring. However, water-soluble packaging is just that – it will NOT dissolve in organic solvents or undiluted ECs. As a result, mixers and loaders must follow label instructions when preparing a spray mixture. Store water-soluble products in a dry place. Do not handle them with damp or wet gloves.

Advantages:

- Accurate premeasured unit doses.
- Increased handler safety; greatly reduced exposure risk.
- Lower risk of spills.

Disadvantage:

- Package size may not match volume of prepared solution needed and/or spray tank volume.

Impregnates

Some pesticide products consist of a pesticide active ingredient incorporated into a solid material, usually some kind of plastic. The pesticide evaporates or is released over time, and the vapors control nearby pests. Common examples include:

- Livestock ear tags.
- Plastic pest strips and adhesive tapes.
- Pet collars.

Fertilizers may also be impregnated with pesticides.

Animal Systemics

Animal systemics are absorbed by, enter the tissues of, and move within the treated animal. Usually, these pesticides are applied externally or orally. They can control fleas and other external blood-feeding insects as well as worms and other internal parasites. External application methods include pour-on liquids, sprays, and dusts. Oral applications include food additives and premeasured capsules, pastes, or liquids.

Pour-on liquids are an effective way to treat livestock.

Pesticide-Fertilizer Combinations

Many pesticide products – usually granule and pellet formulations – are combinations of fertilizers and pesticides. Such products are convenient because they allow the applicator to control pests and apply nutrients at the same time. Some are prepackaged:

homeowners commonly use these for their lawns. Dealers or growers may custom mix pesticides with fertilizers to meet specific crop requirements.

Pesticide Mixtures

Sometimes, product manufacturers combine pesticides with other pesticides or pesticides with fertilizers for sale as premixes (see "Pesticide-Fertilizer Combinations" above). However, when premixes are not available (or not offered in the desired combination), applicators may combine products at the time of application. **Tank mixing** – combining two or more crop production products (pesticides and/or fertilizers) and applying them at the same time – is convenient and cost-effective. This practice can save the time, labor, fuel, and equipment wear involved in multiple applications. Tank mixing also reduces soil compaction and the risk of mechanical damage to crops or treated areas.

Situations appropriate for tank mixing include combining fungicides and insecticides to treat fruit trees or field crops. Another common example is combining herbicides to increase the number of weed species controlled (control spectrum). However, products must be compatible in order to be tank mixed.

Federal law allows applicators to combine pesticides unless the labeling of one or more components of the intended tank mix specifically prohibits it. If no prohibitions exist, applicators may:

- Mix pesticide with fertilizer.
- Mix two or more pesticides.

When pesticides are tank mixed, all of the dosages must be at or below the label rate for each separate component of the mixture.

Compatibility and Incompatibility

Not all pesticide (and pesticide-fertilizer) mixtures work well when mixed together. Combinations must be **compatible** – that is, mixing them must not reduce their safety or effectiveness in any way. (As a rule, the more products you mix, the greater the odds of unwanted effects.)

An **incompatible** mixture is not usable, stable, safe, or effective. Incompatibility occurs when one component of a tank mix reacts with or adversely affects another. There are two main types of incompatibility: physical and chemical.

Physical incompatibility is due to physical properties of the tank-mix ingredients. For example, one material may not form a solution or remain in suspension when another is present. Physical changes are changes in size, shape, and state. Layering or separation is a common result of physical incompatibility.

Chemical incompatibility may result if the ingredients of the mixture react chemically to form new, unlabeled, or unknown substances. Chemical changes produce new products. Clues indicating that a tank mix is chemically incompatible are:

- Heat.
- Color change.
- Formation of a gas or a precipitate.
- The appearance of surface scum or foam.
- Formation of gel or sludge.

Physically incompatible mixtures may be difficult or impossible to apply. They may clog equipment tanks, hoses, pumps, and nozzles. Chemical incompatibility, by definition, yields new products. In such cases, you no longer have the same ingredients you originally combined. Chemical incompatibility can cause a loss of effectiveness against target pests, increased toxicity to handlers, increased residues, and injury to treated surfaces, plants, or animals.

Some pesticide product labels list pesticides (and other chemicals) known to be compatible with that formulation. Many have

very helpful tank-mixing instructions. If you cannot find information about tank mixing on one or more products you wish to combine, do a jar test. Test a small amount of the mixture before you mix a large quantity.

Compatibility Testing

To test for compatibility, first put on personal protective equipment (PPE). Consult the label of each component of the mixture, and wear what the strictest label requires. If you mix pesticides with a DANGER—POISON signal word with WARNING or CAUTION products, treat the mixture as a DANGER—POISON pesticide. (If you apply a tank mixture, wear the maximum safety equipment and follow all other label instructions, precautions, and restrictions. If the labels vary regarding a specific point – for example, if one requires a buffer zone between the treated area and an adjacent water source and the others do not – follow the more restrictive label.)

Next, use a large, clear, clean glass container to hold the test mixture. Use the same water (or other diluent) you will use when preparing the finished spray. Add the water and each of the products in the same proportions as you will mix them in the spray tank. Do your math ahead of time. Be sure that you add the water (or other carrier) and all of the products in the same proportions as you will tank mix them. Unless one or more labels have other instructions, use the W-A-L-E jar-test mixing order:

1. Add some of the diluent (water) first.
2. Add **W**ettable powders (WP), other powders (SP or WSP), and water-dispersible granules/dry flowables (WDG/DF). First, mix with a small amount of water to form a slurry, then add the slurry to the diluent.
3. **A**gitate well, then add the remaining diluent.
4. Add water-based **L**iquids. Examples include pesticides, fertilizers, or adjuvants that are aqueous solutions (S or LC) or suspensions (F or L), also called flowables .
5. Add **E**mulsifiable concentrates (EC).
6. Add any other nonaqueous components of the tank mix (such as crop oil or oil-based antifoaming or drift control agents).

Shake the jar for 10 seconds after adding each component. After adding the final component, shake the jar vigorously for at least 10 seconds and let it stand for 15 to 30 minutes. Observe your tank mix during this waiting period for signs of incompatibility. If you see any, try using a compatibility agent. (For more information about compatibility agents, see "Types of Adjuvants" below.) If you redo the test with the compatibility agent, add the agent to the diluent first (as part of step 1) and mix well. Then, add the pesticides (or fertilizers) in the above order (steps 2-6).

If you see signs of incompatibility and a compatibility agent does not help, consider a legal substitute for one or more of the mix components. Otherwise, do not tank mix this combination of products. Apply them separately.

If you see no signs of incompatibility, test the mixture for efficacy and phytotoxicity on a small area before using it on a large scale.

Methods to Avoid or Manage Incompatibility

To avoid or minimize pesticide incompatibility, follow these steps:

- Use the recommended (or tested) mixing order.
- Use plenty of water.
- Monitor and manage the pH of the carrier (water). Avoid extremely alkaline or **acidic** water (pH 5.5 to 7.0 is best).
- Use clean water (check **conductivity** and **turbidity**).
- Apply pesticides promptly after mixing; do not delay application.
- Follow temperature recommendations, if any, for application and product storage.
- Use sufficient agitation if/as directed.

Some pesticide labels may suggest mixing in a different order. ALWAYS follow the label!

After doing a jar test, you will have a mixture to use or dispose of. Apply a compatible mixture according to the directions on the product labels. For example, you can add the small batch used for the jar test to a sprayer tank and apply it to the target site. An incompatible "mess" requires careful disposal. Here are some disposal options suggested by pesticide safety educators and product registrants:

1. Neutralize the material, then spread it out on fallow ground or on the target site. (Consult the label for ideas on how to neutralize it. For example, either bleach or vinegar may change the pH, deactivating it. Another way to neutralize chemicals is to add activated charcoal.)

2. Apply the material to a labeled site, knowing it may not work – or may be phytotoxic. (The volume, hence the treated area, will be very small.)

3. Dispose of it in a pesticide or hazardous waste collection program. (Check with your county Extension agent or local government about availability and collection times.)

4. Contact a hazardous waste collection and disposal service.

If you choose option 3 or 4, be sure to keep the material high and dry and properly labeled until you can dispose of it.

Adjuvants

An **adjuvant** is a chemical that affects how a pesticide works. Adjuvants:

- Improve the action of a pesticide.
- Change the characteristics of a pesticide formulation or a spray mixture (suspension or solution).

Manufacturers often add adjuvants to a pesticide formulation. Alternatively, applicators may add them to a tank mix. Many adjuvants increase effectiveness and/or safety. Although they aid the action of a pesticide or modify the properties of a spray solution, adjuvants alone have no pesticidal activity. Use them to customize the product or formulation for specific needs or to compensate for local conditions. Most pesticide formulations – especially those that are applied to foliage – contain adjuvants.

Because adjuvants have no pesticidal properties, the Environmental Protection Agency (EPA) does not register them. As a result, there are no standards for composition, quality, or performance. If you have specific questions about an adjuvant, contact the manufacturer. Companies that produce these products can provide labels, technical data sheets, Safety Data Sheets (SDS), supplemental labeling, and promotional literature.

Before using any adjuvant, consult the product label(s). Many registered pesticide products have very specific adjuvant recommendations. Others already contain those adjuvants deemed necessary or useful by the product producer. Adding others may actually decrease efficacy.

Types of Adjuvants

There are many types of adjuvants. Here are some commonly used ones:

- **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.
- **Plant penetrants** – allow the pesticide to pass through (penetrate) the outer surface to the inside of treated foliage. Certain plant penetrants may increase penetration on some – but not all – plant species.

- **Drift control additives (deposition aids)** – reduce drift; increase average droplet size and/or lower the number of "fines" (very small droplets) produced.

- **Thickeners** – increase viscosity (thickness) of spray mixtures. Thickeners may reduce drift and/or slow evaporation. (Slowing evaporation is useful when applying systemic pesticides. It increases the time during which the active ingredient can be absorbed by or penetrate plant foliage.)

- **Safeners** – reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.

- **Compatibility agents** – help combine pesticides effectively; reduce or eliminate incompatibility.

- **Buffers or pH modifiers** – allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity. Most pesticide solutions or suspensions are stable between pH 5.5 and 7.0 (slightly acidic to neutral). Water outside this range may cause pesticides to degrade – very rapidly, in some cases. If you use a buffer, add it to the spray tank water first and mix well. The water must be pH neutral or slightly acidic to start, before adding pesticides or other adjuvants.

- **Antifoaming (defoaming) agents** – reduce foaming of spray mixtures that may result from using some surfactants and/or from vigorous agitation.

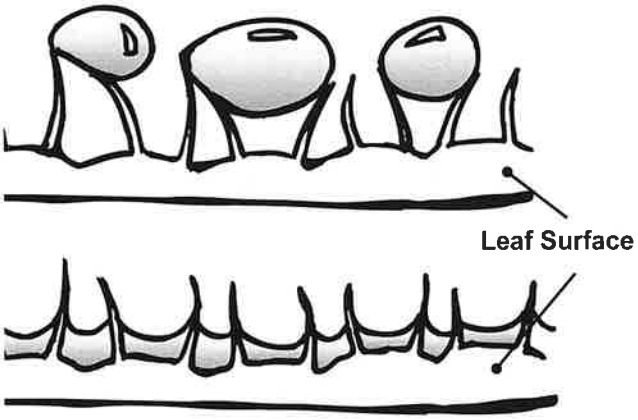
- **Spreaders** – allow pesticide to form a uniform coating layer over the treated surface.

- **Stickers** – allow pesticide to stay on a treated surface. Some types of stickers increase adhesion of solid particles to a treated surface. This reduces the amount of pesticide that washes off due to rain or irrigation. Others reduce evaporation and/or slow photodegradation. (See "Extenders" below.)

- **Extenders** – keep pesticides active on a target for an extended period. Some adjuvant manufacturers use this name for stickers. (See "Stickers" above.)

Surfactants

Some of the most common adjuvants are **surfactants** (**surf**ace **act**ive ingredients) that alter the dispersing, spreading, and wetting properties of spray droplets. Examples of surfactants are wetting agents and spreaders. These products physically change the surface tension of a spray droplet. For some pesticide sprays to perform well, they must be able to wet treated foliage thoroughly and evenly. Surfactants that reduce surface tension enable droplets to spread out instead of bead up. This results in better coverage and increases the odds that the pest will contact the pesticide. Surfactants are particularly helpful when treating plants with waxy or hairy leaves.



Surfactants allow a pesticide to spread more evenly over a leaf surface.

Surfactants are classified by how they "split apart" into charged atoms or molecules, called "ions."

- Anionic surfactants have a negative charge. They are most often used with contact pesticides. These products control the pest by direct contact rather than being absorbed systemically.

- Cationic surfactants have a positive charge. Do not use them as stand-alone surfactants – they are often phytotoxic.

- Nonionic surfactants do not have an electrical charge. They are often used with systemic products and help sprays penetrate plant cuticles. They are compatible with most pesticide products.

A pesticide can behave very differently in the presence of an anionic vs. a cationic vs. a nonionic surfactant. For this reason, you must follow label directions when choosing one of these additives. Selecting the wrong surfactant can reduce efficacy and damage treated plants or surfaces.

The terms used when talking about pesticide additives can be confusing. People sometimes use the words "adjuvant" and "surfactant" interchangeably. However, an adjuvant is ANY substance added to modify properties of a pesticide formulation or finished spray. A surfactant is a specific kind of adjuvant. All surfactants are adjuvants, but not all adjuvants are surfactants. There are many kinds of adjuvants, and some (ex. drift control additives or safeners) have little or no direct effect on pesticidal activity.

Choosing the Right Adjuvant

Here are some factors to consider when deciding whether to use an adjuvant – and how to choose the right one for a particular site and situation.

1. Consult the product label for guidance. Is an adjuvant recommended? If so, what type? Do not make substitutions. Note that some product labels may recommend an adjuvant for one type of use or site but prohibit any kind of adjuvant for another labeled use or site. Because many end-use products already have adjuvants, it is often NOT necessary to add one. In fact, sometimes adding adjuvants on the fly can decrease efficacy. Suppose, for example, that a certain product is formulated with a wetting agent. If you add another agent as you mix and load a foliar-applied spray, the product may not provide better spreading and coverage. Instead, the extra adjuvant may increase runoff, reduce deposition, and even damage the target plant. READ AND FOLLOW THE LABEL.
2. Use only those adjuvants manufactured for agricultural or horticultural uses. Do not use industrial products or household detergents in pesticide spray mixes.
3. Remember that no adjuvant is a substitute for good application practices.
4. Take adjuvant performance claims with a grain of salt. Be skeptical of claims such as "improves root uptake" or "keeps spray equipment clean" unless the manufacturer or the Virginia Cooperative Extension **Pest Management Guides** series provides research-based evidence to support them. Only use adjuvant products that have been tested and found effective for your intended use.
5. Test spray mixes with adjuvants on a small area before proceeding with full-scale use.

Summary

The ingredients of a formulated pesticide include both active and inactive (inert) components. Learn what formulations are available for the pesticide active ingredients you will use. Consider both the benefits and drawbacks of each. Knowing the pros and cons of various formulation types is necessary to decide which one is best for a specific site and situation. Choosing the right formulation is a critical step in any pesticide decision-making process. Your choice can affect efficacy, efficiency, and safety – for handlers, other people, and the environment.

Pesticide handlers must be familiar with formulation types and active ingredient properties in order to understand the characteristics of the products they use and apply them properly. Refer to the pesticide product label(s) when tank mixing and decide if and when to add an adjuvant. If necessary, do a jar test to recognize the signs of an incompatible mixture.

Test Your Knowledge

Q. What is a pesticide formulation?

A. The mixture of active and inert (inactive) ingredients that forms an end-use pesticide product. A formulated pesticide will contain both an active ingredient to control the target pest and a carrier or diluent. Many also contain adjuvants and other ingredients, such as stabilizers or dyes.

Q. What is the difference between active and inert (inactive) ingredients in a pesticide product?

A. Active ingredients are the chemicals that control pests. Inert (inactive) ingredients are the chemicals that are added to dilute the end-use product and/or to make it safer, more effective, and easier to handle.

Q. Why are pesticide active ingredients formulated into end-use products before sale?

A. To make them safer or more convenient to use. Many pesticide active ingredients, in "pure" (technical grade) form, are not suitable for end use. Some of these pesticides are extremely toxic. Many do not mix well with water. Some are unstable and, in concentrated form, are not easy (or safe) to handle, transport, or store. As a result, manufacturers of pesticide products add inert ingredients to improve efficacy and/or safety.

Q. What types of factors should you consider when choosing among formulations?

A. Examine the benefits and drawbacks of each available formulation. Ask yourself these questions:

1. Do I have the necessary application equipment?
2. Is the formulation safe to apply under the conditions in the application area?
3. Will the formulation reach the target and stay in place long enough to control the pest?
4. Is the formulation likely to harm the surface I will treat?
5. Which of the available formulations is most effective?
6. Which formulation option(s) is/are least hazardous to handle and apply – and, if necessary, to store?

Q. What is the term used to describe a mixture formed by dispersing solid particles in a liquid?

A. Suspension. Suspensions contain fine (very small) solid particles, which do not dissolve in the liquid carrier. Suspensions must be agitated to maintain even particle distribution. Most suspensions are opaque: they will not allow light to pass through them.

Q. What is the term used for a mixture made by suspending droplets of one liquid in another?

A. Emulsion. In an emulsion, as in a suspension, each ingredient retains its unique properties and identity. Emulsions have a milky appearance. An emulsifiable concentrate (E or EC) is an example of an emulsion.

Q. What is the difference between a solution and a suspension? How can you tell one from another? Why would an applicator need to know this?

A. A solution is the result of dissolving a substance in a liquid. A true solution is a mixture, but it cannot be separated by mechanical means such as filtration. A true solution will not settle out and does not need to be agitated to keep the mixed components in solution. Solutions are transparent: they will allow light to pass through them.

A suspension is also a mixture. However, a suspension is formed by dispersing fine (very small) solid particles in a liquid. These solid particles do not dissolve in the liquid carrier. Suspensions must be agitated to maintain even particle distribution. Most suspensions are cloudy or opaque: they will not allow light to pass through them. Label directions differ for solutions vs. suspensions. Applicators must understand the differences between solutions and suspensions in order to apply them correctly.

Q. If you could choose between a wettable powder (WP) and a granular (G) formulation for a certain pest control task, which would be better if:

- **Drift is a major concern.**
- **You need to treat foliage and want a pesticide residue to remain on (or be absorbed by) the treated leaf surfaces.**

A. The granular formulation would be better in the first situation. Granules have a much lower drift hazard than wettable powders (which are mixed with water and applied as a spray). However, the wettable powder formulation would be better in the second scenario. Granules do not stick to foliage (or other nonlevel surfaces).

Q. If you could choose between a wettable powder (WP) and an emulsifiable concentrate (EC) to make a spray mixture for a certain pest control task, which would be better if you are:

- **Concerned about harming the treated surface.**
- **Preparing or diluting your spray mixture with very hard or alkaline water.**

A. The wettable powder would be better in the first situation. Emulsifiable concentrates may be corrosive. Many of them cause pitting, discoloration, or other damage to treated surfaces. They may also harm desirable plants. The EC formulation, however, would be better in the second scenario. WPs are difficult to mix (suspend) in very hard or alkaline water.

Q. Name at least one advantage and one disadvantage of emulsifiable concentrate (EC) products.

A. Advantages:

1. Relatively easy to handle, transport, and store; easy to pour and measure.
2. Little agitation required – will not settle out or separate when equipment is running.
3. Not abrasive.
4. Do not usually plug screens or nozzles.
5. Leave little visible residue on treated surfaces.

Disadvantages:

1. High concentration of active ingredient makes it easy to overdose or underdose through mixing or calibration errors.
2. May damage treated plants or surfaces.
3. Easily absorbed through skin of humans and/or animals.
4. Spills and splashes may be difficult to clean up and/or decontaminate.

5. Many have a strong odor.

6. Solvents cause equipment wear and tear. For example, rubber or plastic hoses, gaskets, seals, pump parts, and other exposed surfaces may deteriorate.

7. May cause pitting or discoloration of painted finishes or other treated surfaces.

8. Flammable – should be used and stored away from heat or open flame.

9. May be corrosive.

Q. What is the general term for a formulation that is sold as an end-use dilution (diluted by a liquid or a solid carrier)?

A. Ready-to-use (RTU).

Q. Name at least one advantage and one disadvantage of ready-to-use products.

A. Advantages:

1. Convenience – neither measuring nor mixing is required.

2. Some are packaged and sold in an application device. If this is the case, no loading is required.

3. Less personal exposure risk due to reduced toxicity and handling.

Disadvantages:

1. Limited availability.

2. High cost per unit of active ingredient.

The time saved and convenience of using RTU products may outweigh the increased cost.

Q. Name at least one advantage and one disadvantage of concentrate solution (C, LC, or WSC/WSL) products.

A. Some pros and cons of concentrate solutions vary, depending on the concentration of active ingredient, solvent or diluent used, application site, and application equipment. However, there are generic benefits and drawbacks common to most concentrated solution products.

Advantages:

1. Relatively easy to handle, transport, and store; easy to pour and measure.

2. No agitation necessary.

3. Not abrasive.

4. Do not plug screens or nozzles.

5. Do not usually leave visible residues on treated surfaces.

Disadvantages:

1. Limited availability, especially water-based solutions.

2. Spills and splashes may be difficult to clean up and/or decontaminate.

3. Some are easily absorbed through skin of humans and/or animals.

Q. What formulation is a concentrate that may approach 100% active ingredient?

A. Ultra-low volume (ULV). These concentrates are designed to be used as is or diluted with only small quantities of specified solvents.

Q. What are aerosols? Name and describe the two types.

A. Formulations that contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. The two types are ready-to-use and those designed for smoke or fog generators.

Ready-to-use aerosols are often sold in pressurized sealed containers that serve as application devices. Aerosols designed for smoke or fog generators are used in machines that break the liquid formulation into a fine mist or fog. Using a rapidly whirling disk or heated surface, the machines produce and distribute very fine droplets.

Q. What are invert emulsions? How are they typically used?

A. Thick mixtures that contain a water-soluble pesticide dispersed in an oil carrier. These products require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. They are most often used for weed control on rights-of-way.

Q. Name at least one advantage and one disadvantage of dust (D) formulations.

A. Advantages:

1. Usually ready-to-use – no mixing.
2. A good alternative where moisture from a spray might cause damage.
3. Require simple application equipment.
4. Effective in hard-to-reach indoor areas.

Disadvantages:

1. Easily drift off target during application.
2. Residues do not adhere to treated surfaces, including foliage, as well as liquids do and may easily wash off or blow away.
3. May irritate eyes, nose, throat, and skin; pose a relatively high inhalation exposure risk to handlers.
4. Dampness may cause product to clump and equipment to clog.
5. Some kinds of application equipment and devices are hard to calibrate.
6. Difficult to get an even distribution of particles.

Q. Name at least one advantage and one disadvantage of granule (G) and pellet (P) formulations.

A. Advantages:

1. Ready-to-use – no mixing.
2. Drift hazard is low, and particles settle quickly.
3. Low applicator hazard – no spray, little dust.
4. Weight carries the formulation through foliage to soil or water target.
5. Applied with simple application equipment, such as seeders or fertilizer spreaders.
6. May break down more slowly than WPs or ECs because of a slow-release coating.

Disadvantages:

1. Application equipment needs frequent calibration.
2. Application equipment is not as convenient to calibrate as spray equipment. Released particles are measured by weight instead of by volume.
3. Uniform application may be difficult with some devices (ex. rotary spreaders).
4. Granules do not stick to foliage or other nonlevel or uneven surfaces. For this reason, contact products are rarely formulated this way.
5. May need to be incorporated into soil or planting medium.
6. May need moisture to release the active ingredient.
7. May not be effective in drought conditions.
8. May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the grain or seedlike granules.
9. Bulky; low percentage of active ingredient per unit volume.

Q. Which dry formulation consists of particles that are more or less uniform in size, shape, and weight?

A. Pellet (P).

Q. Wettable powders are widely used pesticide formulations. Why do you think this might be true?

A. Wettable powders have many advantages. They:

1. Are effective for most pest problems and in most types of spray equipment where agitation is possible.
2. Have excellent residual activity.
3. Are easy to store, transport, and handle.
4. Are less likely than ECs and other petroleum-based formulations to harm treated plants, animals, and surfaces.
5. Are not usually phytotoxic.
6. Pose less risk of skin and eye absorption than ECs and other liquid formulations.

Q. Name at least two disadvantages of wettable powders.

A. 1. Not easy to measure; must be weighed.
2. Not easy to mix.
3. Inhalation hazard to applicator while measuring and mixing the concentrated powder.
4. Suspended particles require constant, vigorous agitation (usually mechanical) in the spray tank and quickly settle out if agitation stops.
5. Abrasive to pumps and nozzles; cause equipment wear.
6. Difficult to mix in very hard or very alkaline water.
7. Often clog nozzles and screens.
8. Residues may be visible on treated surfaces.

Q. What is the term for a wettable powder formulation that has been compressed into granule-sized particles?

A. Dry flowable (DF) or water-dispersible granule (WDG).

Q. What is the general term for a pesticide active ingredient formulated with food or another attractive substance?

A. Bait.

Q. What are fumigants? Why are they so dangerous to pesticide applicators?

A. Pesticides that form poisonous gases when applied. They are toxic to a wide range of pests and can be used at many different sites. However, fumigants are highly toxic to humans and all other organisms. They pose a high inhalation exposure risk. Most require the use of respirators and specialized application equipment.

Q. Name and briefly describe four engineering controls or packaging methods discussed in this unit that reduce pesticide handler exposure.

A. 1. **Microencapsulated pesticides** – Dry particles or liquid droplets surrounded by a coating. The encapsulation process can provide "timed" slow release of the active ingredient. (Microencapsulated products may have relatively long restricted-entry or preharvest intervals for this reason.) Microencapsulation is also a way to protect the handler or applicator when using highly toxic materials.

2. **Water-soluble packaging** – Products with a special plastic film enclosing a precise amount of wettable powder, soluble powder, or gel containing the pesticide active ingredient(s). When added to water in a spray tank, the bag dissolves and releases the contents, which then are suspended or dissolved. Water-soluble packaging also simplifies measuring. This packaging method reduces handler exposure risk.

3. **Ready-to-use products** – End-use products that contain the correct dose

of active ingredient when you buy them. RTUs reduce handler exposure. Some are sold in an application device. Examples include premixed solutions, impregnates, baits, prepackaged aerosols, and dry formulation dusts, granules, and pellets.

4. **Animal systemics** – Used to control fleas and other external blood-feeding insects as well as internal parasites. These pesticides are often applied externally or orally. They include premeasured pour-ons or spot-on products; food additives; and premeasured capsules, pastes, or liquids.

Q. Based on exposure risk, in which situation would the handler likely need to use more personal protective equipment (PPE)? Explain your choice.

- **Loading/filling granular application equipment.**
- **Mixing/diluting liquid concentrate and filling a sprayer.**

A. Mixing/diluting liquid concentrate and filling a sprayer. Concentrates are usually more toxic than dilute formulations of the same active ingredient. More handling is required to mix and load them. As a result, concentrates present a higher exposure risk to the handler. Granules, on the other hand, are ready-to-use. They contain a low percentage of active ingredient.

Q. Why must pesticides be compatible if they are tank mixed?

A. Because a mixture that is not compatible may be unusable, unsafe, or ineffective. Incompatibility occurs when one component within a tank mix reacts with or adversely affects another.

Q. What is the difference between physical and chemical incompatibility? What are the signs and consequences of incompatibility?

A. Physical incompatibility is due to the physical properties of the tank-mix ingredients. For example, one material may not form a solution or remain in suspension when another is present. Physical changes are changes in size, shape, and state. Layering or separation is a common result of physical incompatibility. Physically incompatible mixtures may be difficult or impossible to apply. They may clog equipment tanks, hoses, pumps, and nozzles.

Chemical incompatibility may result if the ingredients of the mixture react chemically to form new, unlabeled, or unknown substances. Chemical changes produce new products. Signs that a tank mix is chemically incompatible include heat, a color change, formation of a gas or a precipitate, appearance of surface scum or foam, and formation of gel or sludge. Chemical incompatibility can reduce effectiveness against target pests, increase toxicity to handlers, increase residues, and injure treated surfaces, plants, or animals.

Q. Briefly describe how to determine if two pesticides may be tank mixed safely.

A. Read the product labels. Some labels list pesticides (and other chemicals) known to be compatible with that specific product. Many have very helpful tank-mixing instructions. If you cannot find tank-mixing instructions on the labels, do a jar test. Test a small amount of the mixture before you mix a large quantity.

Q. When and why would you need to do a jar test?

A. When you need to combine several products (pesticides and/or fertilizers) and apply them at the same time, but the product labels do not provide information about compatibility.

Q. What concentration of active ingredient would you expect to find in the following products? Explain.

- **Alpha 40 WP.**
- **Beta 80 DF.**
- **Gamma 5G.**

A. Numbers used in product trade names often indicate the amount of active ingredient. In these examples, you can assume that:

- Alpha 40 WP = 40% active ingredient.
- Beta 80 DF = 80% active ingredient.
- Gamma 5G = 5% active ingredient.

Q. Which product would you expect to contain 4 pounds of active ingredient per gallon: XXX 4F or YYY 3A?

A. Numbers used in product trade names often indicate the amount of active ingredient. You can assume that XXX 4F = 4 pounds of active ingredient per gallon.

Q. How do you think the products listed below are formulated?

- **Alpha 40 WP.**
- **Beta 80 DF.**
- **Gamma 5G.**

A. Product trade names often indicate formulation, using standard abbreviations. In these examples, Alpha 40 WP is a wettable powder, Beta 80 DF is a dry flowable, and Gamma 5G is a granule.

Q. Why are adjuvants sometimes added to pesticide formulations or tank mixes?

A. To increase their effectiveness or safety.

Q. What is the difference between an adjuvant and a surfactant?

A. An adjuvant is a chemical that affects how a pesticide works. It can be ANY substance added to modify properties of a pesticide formulation or finished spray. A surfactant is a specific kind of adjuvant: a "**surface active** ingredient." It affects the dispersing, spreading, or wetting properties of spray droplets. All surfactants are adjuvants, but not all adjuvants are surfactants.

Q. Give two examples of surfactants, and describe a situation where they would be useful.

A. Wetting agents and spreaders. These products reduce surface tension of a spray droplet. This allows droplets to spread out instead of bead up, which gives better coverage. Surfactants are particularly helpful when treating plants with waxy or hairy leaves.

Q. What type(s) of adjuvants should you consider to:

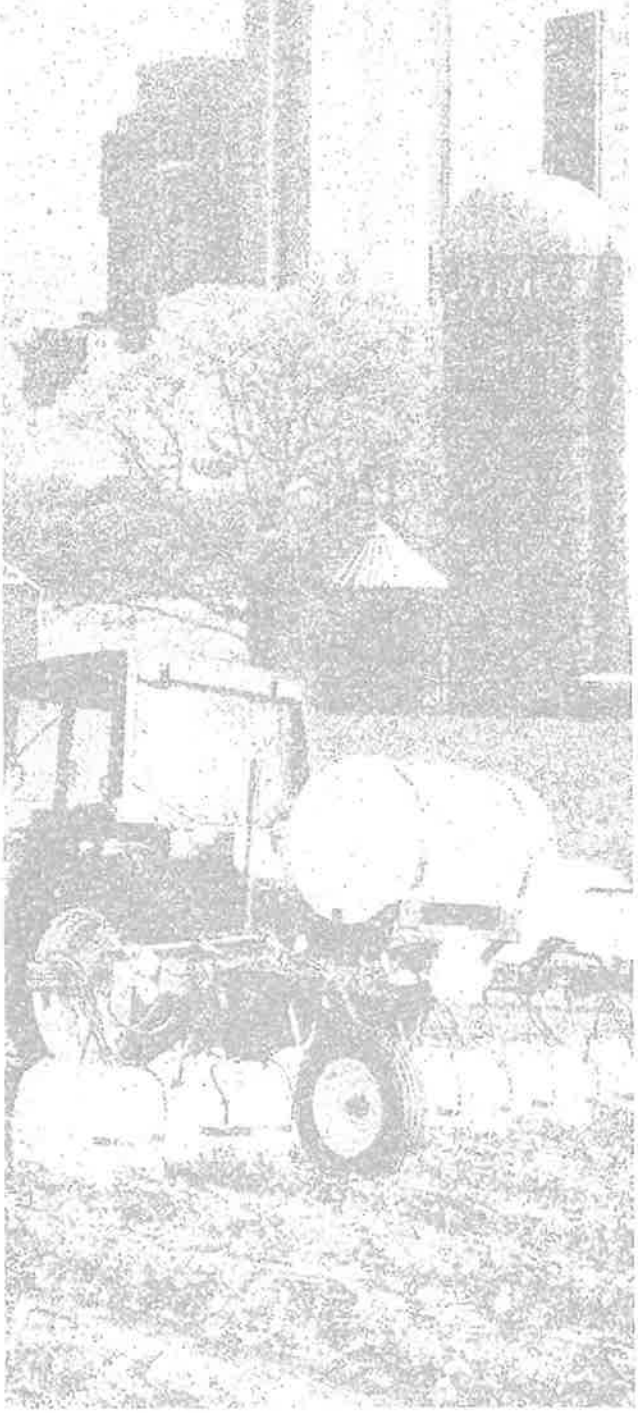
- **Reduce drift.**
- **Coat a surface evenly.**
- **Combine two or more pesticides for one application.**

A. Drift control additives and thickeners help reduce drift. Spreaders help to coat the treated surface with an even layer of liquid pesticide mixture. Compatibility agents help to combine pesticides effectively.

Q. What type of adjuvant helps reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface?

A. Safeners.

Unit 5. Pesticides in Our Environment



Learning Objectives

After studying this unit, you should be able to:

- Explain what "environment" means.
- Recognize sensitive areas at or near the site of a pesticide application.
- Describe and distinguish between point and nonpoint sources of pesticide contamination.
- List the environmental factors to consider before releasing any pesticide.
- Describe how pesticides move offsite in or on air, water, objects, plants, animals, and humans.
- Define pesticide drift and list the factors that contribute to it.
- Describe how pesticide handlers can reduce and manage drift.
- Explain how the solubility, adsorption, and persistence characteristics of a pesticide influence its movement in water.
- Explain how to prevent back-siphoning.
- List several factors that determine if pesticides will contaminate groundwater.
- Describe how to avoid pesticide contamination of groundwater.
- Explain how soil type affects the movement of pesticides into groundwater.
- Describe how the geology of a release site affects the movement of pesticides into groundwater.
- Describe how pesticides may damage various surfaces.
- Recognize how pesticides and their residues harm nontarget plants and animals.
- Define "endangered species" and understand the importance of biological diversity.
- Describe how pesticides may harm endangered species.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Accumulation – Buildup (ex. increasing amounts of pesticides in animals or soil over time).

Adsorption – The process of adhesion; coating a particle or binding something to a surface.

Aquifer – A naturally occurring underground stratum that collects and holds large volumes of groundwater.

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

Biological Diversity – The variety and differences among living things, usually within an ecosystem.

Buffer Zone – A strip of land that separates pesticide-treated areas from untreated areas. Buffer zones act as barriers to keep pesticides out of nontarget areas such as streams or playgrounds.

Collection Pad or Tray – A safety system designed to contain and recover spills, leaks, rinsates, and other pesticide-containing substances.

Drift – The movement of pesticides away from the release site in air.

Endangered Species – Plants or animals whose survival has been designated by a federal or state agency as endangered or threatened. These species have small populations that are vulnerable to extinction, most often due to habitat destruction, disease, or overharvesting.

Environment – The world around us: all physical, chemical, and biological surroundings such as climate, soil, water, air, and living organisms. It also includes manmade elements.

Environmental Hazard Statements – Statements on pesticide labeling that list possible environmental hazards that may result from using a pesticide. These statements may also include specific actions to take to avoid or reduce hazards.

Erosion – The movement of sediment, soil, and rock from the ground surface.

Groundwater – Water beneath the earth's surface. It collects in pore spaces among soil layers, gravel, and rock.

Leaching – The movement of pesticide in water or another liquid downward through soil or other planting medium.

Nonpoint Source Pollution – Contamination from pesticides that comes from a wide, nonspecific area or broadcast applications. Weather events often contribute to this type of pollution.

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

Offsite – Outside the area of the pesticide application, handling, mixing, and loading.

Organic Matter – Materials and debris in the soil that began as living plants or animals.

Permeability – The ability of a substance (ex. rock or soil) to allow liquids or gases to pass through. The more permeable a substance is, the faster water will flow through it.

Persistence – The ability of a pesticide to remain effective over time and not break down.

Point Source Pollution – Contamination that comes from a specific, identifiable place (ex. a leaking container of herbicide).

Pollution – Environmental contamination. The improper release of pesticides into the environment may cause pollution.

Terms to Know cont.

Predator – An animal that attacks, kills, and feeds on other animals.

Residue – An amount of pesticide that remains in the environment (ex. on a plant, an animal, or in the soil) after an application or a spill.

Rinsate – Pesticide-containing water (or other liquid) that results from rinsing a pesticide container, pesticide equipment, or other pesticide-containing materials.

Runoff – The movement of pesticide away from the release site in water or another liquid flowing laterally across the surface.

Secondary Poisoning – When a predator or scavenger ingests pesticide by eating an animal killed by a pesticide. Secondary poisoning may cause sickness or death.

Sensitive Areas – Sites or organisms that are particularly vulnerable to harmful effects from pesticides.

Soil Permeability – A property of soil that allows liquids or gases to pass through. The more permeable a soil is, the faster water will flow through it.

Solubility – The ability of a pesticide to dissolve in a solvent such as water. Highly water-soluble pesticides are more likely to move in solution into water systems.

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

Temperature Inversion – A weather occurrence in which a layer of warm air traps a layer of cool air near the ground surface. Spray drift under these conditions can be severe.

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

Water Table – The dividing line between the saturated zone of water underground and the unsaturated rock or soil above it.

Watershed – The land on which water drains into one particular waterway.

Pesticides in the Environment

The **environment** is everything that is around us. It includes not only natural elements such as forests and rivers but also people and the manmade components of our world. The environment is not limited to the outdoors – it also includes the indoor areas in which we live and work. It is air, soil, water, plants, animals, houses, restaurants, office buildings, factories, and all that they contain. Our very survival depends on how we treat our environment.

Anyone who uses a pesticide – indoors or outdoors, in a city or in the country – must consider how that pesticide will affect his or her surroundings. The pesticide label alerts you to environmental hazards that are specific to that product. Read these **environmental hazard statements** carefully. In addition, use good judgment. The lack of a specific statement does not necessarily mean that the product is not hazardous to you or to the environment.

The Environmental Protection Agency (EPA) studies the environmental effects of each pesticide as part of the pesticide registration or registration renewal process. In the past, hazards to humans were the main reason for EPA to classify a pesticide as restricted use. Now, however, more and more pesticide labels list environmental effects, such as pollution of groundwater or toxicity to birds or fish, as a reason for restricted-use classification. EPA will not register a pesticide, or may cancel an existing registration of a pesticide, if it decides that the risks of the product's uses outweigh the benefits.

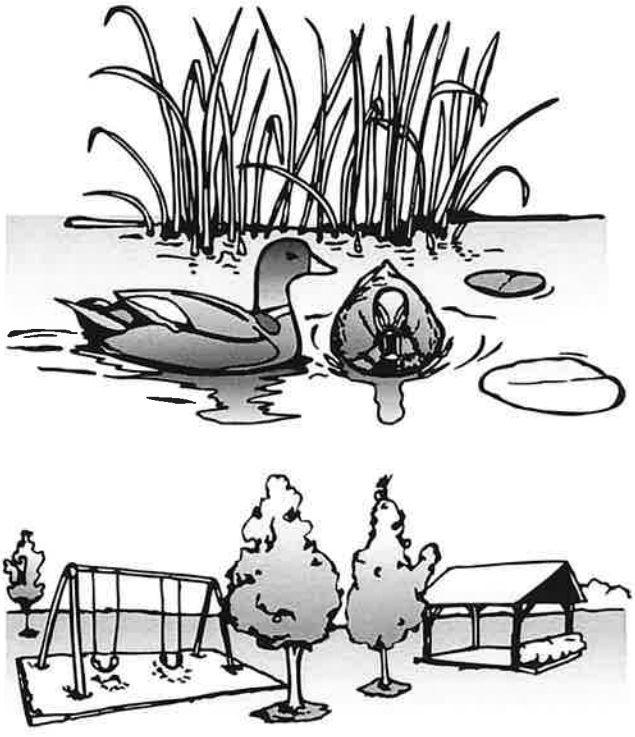
Misuse of pesticides can harm us and the world around us. Responsible pesticide users read and follow the label. Their pesticide applications achieve good pest control while minimizing risk for people and the environment.

Sensitive Areas

Before you choose a pesticide and apply it, identify the areas within or near the application site that are especially vulnerable to pesticide injury. These are called "**sensitive areas**."

Outdoor sensitive areas include locations:

- Near schools, playgrounds, hospitals, and other institutions.
- Where groundwater is near the surface or easily reached (ex. wells, sinkholes, and porous soil).
- In or near surface water (ex. lakes, rivers, and oceans).
- Near the habitats of endangered species.
- Near apiaries (honey bee sites), wildlife refuges, or parks.
- Near ornamental gardens, food or feed crops, or other sensitive plantings.



Sensitive Areas

Indoor sensitive areas include locations:

- Where people – especially children, pregnant women, the elderly, or the sick – live, work, or are cared for.
- Where food or feed is processed, prepared, stored, or served.
- Where domestic or confined animals live, eat, or are otherwise cared for.
- Where ornamental or other sensitive plantings grow or are maintained (ex. greenhouses).

Sensitive areas may be within or near a release site. Be careful not to accidentally contaminate the sensitive area. For example, you should equip a permanent site for mixing/loading or equipment washing with a collection pad or tray to catch and contain leaks, spills, or wastewater. Locate the site as far away as possible from any sensitive areas.

Sometimes it is necessary to apply pesticides to a specific sensitive area, such as a hospital, to control a certain pest. Only skilled professionals should perform these applications.

Typical pesticide labeling statements that alert you to concerns about sensitive areas include:

Do not use in hospital patient quarters.

Remove all animals from building before treatment and keep animals out until spray has dried.

Applications prohibited in areas where food is held, processed, prepared, or served.

Do not use around home gardens, schools, recreational parks, or playgrounds.

In living areas, make applications in a way that avoids deposits on exposed surfaces or introducing the material into the air.

Do not use in or around residences.

Sources of Pesticide Contamination

Pesticide contamination is the result of either point source or nonpoint source pollution. **Point source pollution** comes from a specific, identifiable place (point). A pesticide spill that flows into a storm sewer is an example of point source pollution. **Nonpoint source pollution** comes from a wider area. The movement of pesticides into streams after broadcast applications is an example of nonpoint source pollution.

Examples of nonpoint source pesticide pollution include:

- Over-the-rate broadcast applications of pesticides to farm fields.
- Overapplying weed-and-feed fertilizers on lawns.
- Erosion of pesticide-contaminated soil.

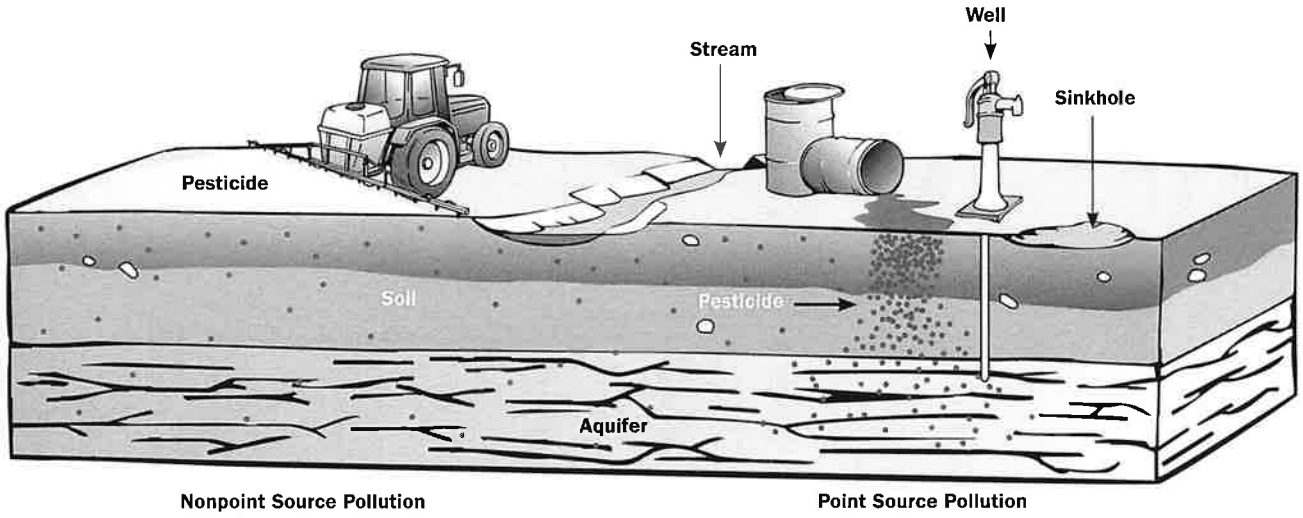
Examples of point source pesticide pollution include:

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

Be aware of environmental contamination risks during every phase of your pesticide operation. Take special care if you use restricted-use pesticides with high environmental toxicity.

Whenever you release a pesticide into the environment – whether intentionally or accidentally – ask yourself:

- Are there sensitive areas at or near the pesticide use site that the pesticide might harm?



Nonpoint Source vs. Point Source Pollution

- Can environmental or site conditions (ex. rain and bare soil) cause the pesticide to move offsite?
- Do I need to change any of my handling or application methods to reduce the risk of environmental contamination?

Pesticide Movement

Pesticides move in several ways, including:

- On or in objects, soil particles, plants, animals, or humans that travel or are moved offsite.
- In air, through wind or air currents generated by ventilation systems.
- In water, through runoff or leaching.

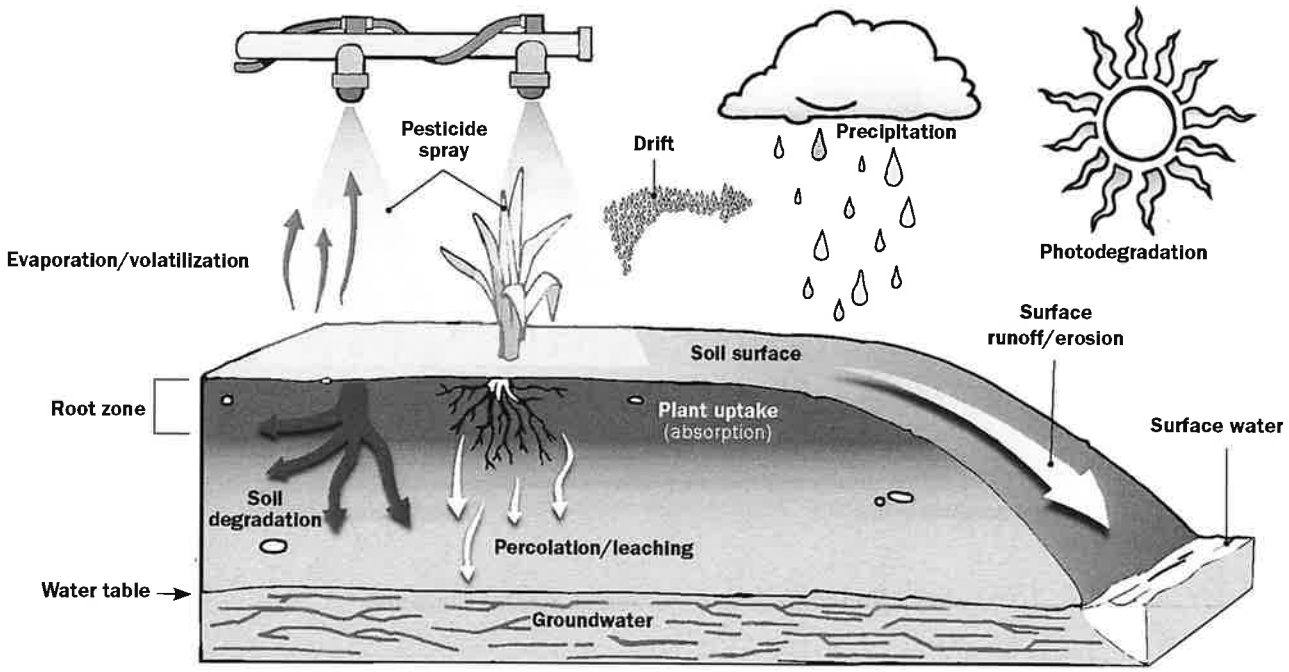
Movement on or in Objects, Plants, Animals, or Humans

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 equipment, shoes or clothing, animal fur, or blowing dust and transfer to other surfaces. What could happen if you bring or wear home contaminated personal protective equipment, work clothing, or other items? Residues can rub off on carpeting, furniture, laundry, pets, and family members.

Pesticides may also stick to treated surfaces, such as lawns, ornamental plants, and carpets. Residues may remain in or on commercial food and feed products, too. To protect consumers, there are legal limits (tolerances) for how much pesticide residue may safely remain on crops or animal products sold for food or feed. Products that exceed these tolerances are illegal and cannot be sold. If you apply pesticides as directed on product labels, residues in crops and animal products should be within tolerance levels.

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 ignored.
- A pesticide is applied off-label, to a site not permitted by label directions.
- Pesticides move out of the release site and contaminate plants or animals nearby.



How Pesticides Move

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

Do not apply within five days of harvest.

Do not apply under conditions involving possible drift to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use, or consumption.

Remove meat animals from treated areas at least one day before slaughter if they were present at application or grazed treated areas within 21 days after application.

Do not pasture or feed treated hay to lactating dairy cattle within 21 days after application.

For systemic insect control only in turfgrass and landscape ornamentals.

Movement in Air

Pesticides may move away (**drift**) from release sites in air. Dry pesticide particles, liquid spray droplets, and vapors all may travel offsite in air. People who mix, load, and apply pesticides outdoors usually know how easily pesticides may drift offsite. People who handle pesticides indoors should also realize that some pesticides move offsite in air currents. These air currents are created by ventilation systems and by forced-air heating and cooling systems.

Formulation Choices

Depending on the type of pesticides you are using, you may be able to pick a formulation that will reduce the risk of drift. Dry, lightweight particles such as dusts are easily carried offsite by moving air. Granules and pellets are much heavier and tend to settle quickly. Therefore, they are much less likely to drift.

Liquid pesticides are the most common type of formulation. Many dry products, such as wettable powders and water-dispersible granules, are mixed with water and applied

as sprays. Whether you are using a backpack sprayer, tractor-mounted wet boom, or helicopter to apply pesticides, drift is a critical factor. Labels often give specific instructions on how to avoid drift by correct nozzle and spray pressure selection.

Small spray droplets produced by fine nozzles and high pressures are very likely to drift. Coarse nozzles and low pressures produce larger droplets with less drift potential.

The chance that pesticide particles and spray droplets will drift offsite depends partly on application methods. Pesticides released close to the ground or floor are less likely to be caught up in air currents than those released from a greater height. Pesticides applied in an upward direction or from an aircraft are most likely to drift.

Drift-reduction adjuvants can be used to reduce the risk of drift and to make the pesticide more effective. For more information on formulations, adjuvants, and their properties, see Unit 4.

Some pesticides and pesticide formulations are **volatile**. If a pesticide volatilizes, the active ingredient changes from a liquid to a gas (vapor) after it is applied. This can occur while a spray droplet is airborne or after deposition. In vapor form, a pesticide can move great distances and injure sensitive plants and animals. Volatility may also contribute to illegal residues that may spoil neighboring food crops.

There are steps you can take to avoid volatility and its associated problems. You should:

- Choose nonvolatile formulations.
- Spray during the coolest part of the day.
- Avoid making applications when temperatures are high and humidity is low.

Read the product label carefully. Look for restrictions or precautions regarding application conditions.

Fumigants and Vapors

Pesticide vapors move about easily in air. Fumigant pesticides form vapors that can reach pests in places that other pesticides cannot. Most fumigants are extremely toxic. Anyone using fumigants must make sure the fumigant remains in a sealed container until it is released at the application site. Seal the release site itself to prevent the vapor from escaping.

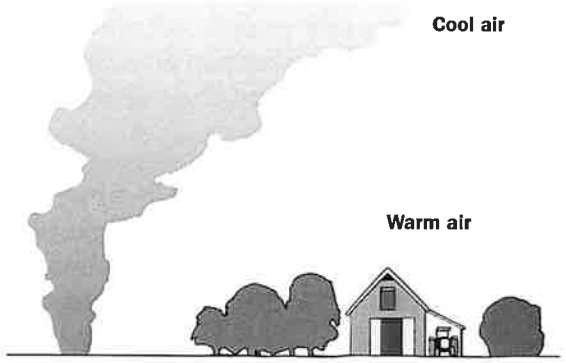
Vapor losses stop or slow down when a pesticide attaches to (is adsorbed by) soil or penetrates (is absorbed by) foliage. Stone and asphalt surfaces, on the other hand, may increase the chances that a pesticide will volatilize. This is because they become much hotter than many other surfaces (such as turf) or the surrounding air.

Weather Factors

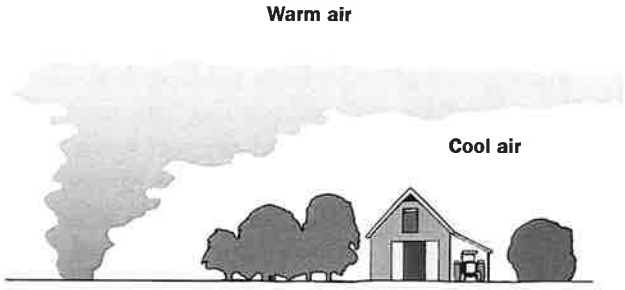
Most pesticide handlers realize that applying pesticides on a windy day can cause drift. Often, labels will caution you against spraying when winds are strong or gusty. Some even have specific, enforceable wind speed restrictions. However, other weather conditions may do just as much harm. Low relative humidity and/or high temperatures can increase drift by reducing the spray droplet size through water evaporation.

A weather event that often goes unnoticed is a temperature inversion. A **temperature inversion** occurs when a layer of warm air traps a layer of cool air at ground level. The warm air acts as a nearly impenetrable barrier for smoke, fumes, and dust clouds. The pesticides applied will stay close to the ground, suspended in the air until the air becomes unstable and mixes. There is usually no wind during the inversion. Once the air layers mix, however, pesticides can drift for miles. When they settle, they may do great harm. Temperature inversions often happen in the early morning and late evening hours. Avoid spraying during these times, especially if there is a dead calm.

How can you spot a temperature inversion? One technique shown in the figure below is to set off a smoke canister. Note whether the smoke disperses into the atmosphere or concentrates and drifts horizontally.



Normal Condition—Smoke rises and disperses



Inversion Condition—Smoke concentrates

Temperature Inversion

Typical pesticide labeling statements that alert you to avoid drift include:

Do not apply when an air temperature inversion exists. An air temperature inversion may be detected by creating a smoke column and observing a layering effect.

Do not allow drift onto plants intended for food or feed.

Do not apply when temperatures exceed 85□F and humidity is low. To aid in avoiding spray drift, use coarse nozzles and low pressure.

Drift from treated areas may be hazardous to aquatic organisms in neighboring areas.

Movement in Water

Pesticides can contaminate both surface water and groundwater. Virginia residents depend on both types of water for household use, farming, manufacturing, and recreation.

Pesticides can move in water across the treated surface (**runoff**) or downward from the ground surface (**leaching**). Runoff and leaching may occur when:

- Too much liquid is applied, leaked, or spilled onto a surface.
- Too much rainwater, irrigation water, or other water gets onto a surface.

Outdoors, runoff may travel into drainage ditches, streams, ponds, or other surface water. Pesticides in solution or adsorbed to soil particles can move great distances offsite with runoff. Pesticides that leach downward through the soil sometimes reach the groundwater.

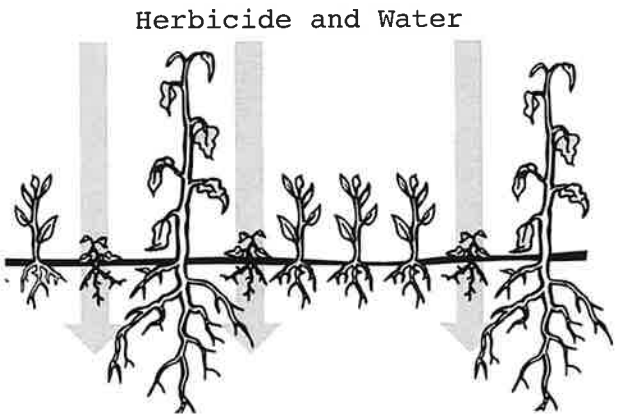
Indoors, runoff may drain into domestic water systems. While most drains lead to domestic wastewater systems, others may lead to creeks or rivers. Sometimes a careless pesticide handler washes pesticide down a sink drain and into the water system. Most domestic water systems cannot remove pesticides from their wastewater. Leaching can occur indoors also. In a greenhouse, for example, pesticides may leach through the soil or other planting medium to floors or benches below.

Persistent pesticides have remained in waterways for decades – even after their use was banned. It is extremely difficult and costly to remove toxic substances from a waterway once it is contaminated.

Pesticide Characteristics

Some pesticides are more likely than others to move offsite in water. Such movement depends mainly on these factors:

Solubility – Some pesticides dissolve easily in water and are more likely to move in solution into water systems.



Herbicide may leach through the soil in water.

Typical pesticide labeling statements that alert you to concerns about runoff and leaching include:

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

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** (layoff distance) of 100 feet from bodies of water.*

This product is water-soluble and can move with surface runoff water. Do not contaminate cropland, water, or irrigation ditches.

Adsorption – Some pesticides become tightly attached to soil particles. However, they will move with eroded soil. If eroded soil is deposited in water, adsorbed pesticides may then move into the water.

Persistence – Some pesticides break down slowly and remain in the environment for a long time. The longer they persist, the more opportunity they have to cause harm.

These three factors are related to one another. Often, a manufacturer intentionally develops a pesticide with certain characteristics to achieve better results. Pesticides that are most likely to move into water are:

- Highly soluble.
- Moderately to highly persistent.
- Not strongly adsorbed to soil.

A nonpersistent pesticide is less likely to move offsite, even if it is highly soluble or not strongly adsorbed to soil. Microorganisms (ex. bacteria) that live in the soil will help break down the pesticide. A pesticide that strongly adsorbs to soil will also be less likely to move offsite even if it is persistent. However, if contaminated soil erodes, the pesticide will move too.

NOTE: See "Harmful Effects from Residues" below for another discussion of pesticide persistence.

Pesticide labeling usually does not tell you about these properties. However, the Safety Data Sheet (SDS) for each pesticide includes water solubility information. The U.S. Natural Resources Conservation Service (NRCS), Virginia Cooperative Extension (VCE), your trade association, or your pesticide dealer may also have specific information about the traits of a given pesticide.

Prolonged heavy rain or too much irrigation will cause excess water to remain on the soil surface. If heavy rain is likely, delay outdoor handling operations – including mixing/loading, application, and disposal. This will help prevent wash-off, surface runoff, or leaching. If irrigation water contains pesticides, do not allow it to flow into waterways. The amount of water used in irrigation is one factor that affects pesticide movement into groundwater. Another is how soon before or after a pesticide application the irrigation occurs.

Protecting Your Water Source

When filling a spray tank, protect your water source by keeping the water pipe or hose well above the level of the pesticide mixture. An air gap prevents contamination of the hose and keeps pesticides from back-siphoning into the water source. If you are pumping water directly from the source into a mix tank, use a check valve, antisiphoning device, or backflow preventer to prevent **back-siphoning** if the pump fails. Backflow prevention devices are required by regulation in Virginia.

Always take special precautions to protect water sources when mixing and loading. Avoid mixing or loading pesticides in areas where a spill, leak, or overflow could allow pesticides to get into water systems. Place your mixing equipment where spills, leaks, and overflows will not flow toward a drain or into the water supply. If necessary, install dikes or other barriers, or grade the soil to divert the flow. If you will be mixing or loading at the site often, you might want to install a collection pad or tray.

Typical pesticide labeling statements that alert you to concerns about water source contamination include:

Take care when using this product to prevent back-siphoning into wells. Check valves or antisiphoning devices must be used on all mixing and/or irrigation equipment.

Do not spill or empty into streams, ponds, or any other body of water.

Equipment should be equipped with automatic shutoff devices and valves to prevent backflow into the water source.

Protecting Groundwater

Groundwater is water located beneath the earth's surface. Many people think that groundwater occurs in vast underground lakes, rivers, or streams. Usually, however, it is located in pores of rock and soil layers. Typically, it moves very slowly through irregular spaces within the bedrock or seeps between particles of sand, clay, and gravel. An exception is in limestone areas (also known as "karst"), where groundwater may flow through large underground channels or caverns. Surface water may move several feet in a minute or even a second. In contrast, groundwater usually moves only a few feet in a month or a year. An **aquifer** can provide large amounts of water to wells or springs. Pesticide contamination of aquifers can be disastrous – they are often sources of drinking, washing, and irrigation water. It is almost impossible to restore an aquifer and use the water once it has been polluted.

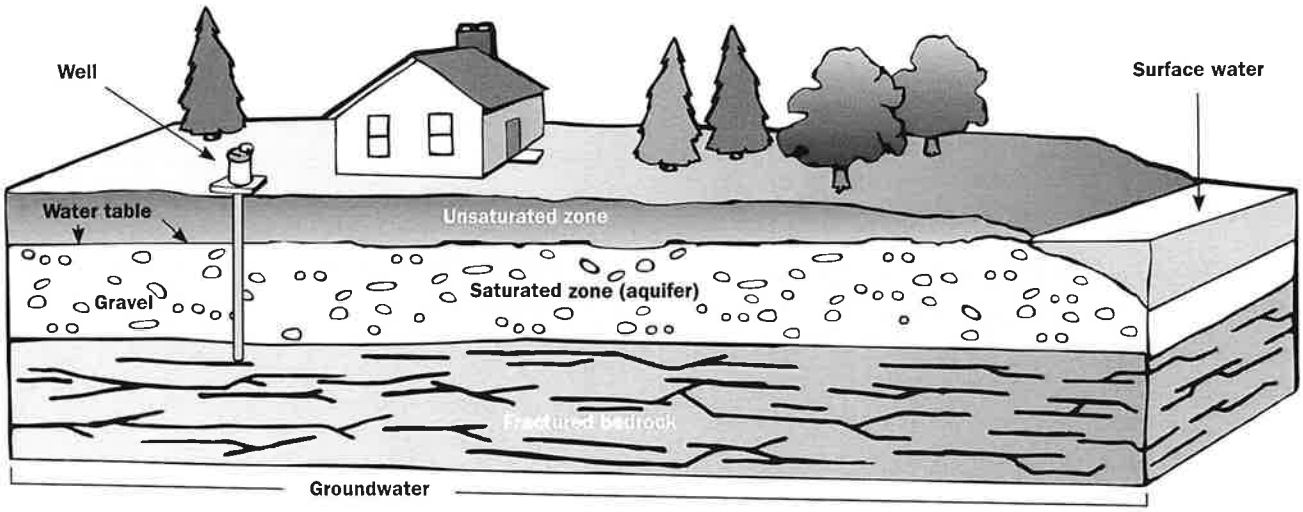
Sources of Groundwater

Groundwater is recharged (replaced) mostly from rain or snow that enters the soil. However, some water from lakes, streams, and irrigation also becomes groundwater. Water that is above the ground can move in three ways: evaporate into the air; move across the surface, as in a stream or river; or move downward from the surface. Plants and other organisms absorb some of the water that moves downward. Another part of the downward-moving water remains in the upper layers of the soil. The rest moves down through the root zone and a relatively dry soil zone until it reaches a zone saturated with water. The **water table** is the dividing line between the saturated zone and the unsaturated rock or soil above it.

Pesticide Contamination of Groundwater

Five major factors determine whether a pesticide will reach groundwater:

1. Practices of pesticide users.
2. Presence or absence of water on the surface of the pesticide release site.
3. Chemical characteristics of the pesticide.
4. Soil type at the pesticide release site.
5. Local geology – such as depth of the water table and the type of rock formations above it.



Location of Groundwater

Recognizing these factors will help you handle pesticides in a way that will reduce the chance of groundwater contamination.

Good 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 the label directs. Overapplying will increase both the cost of pest control and the odds that the pesticide will reach groundwater. Overapplying is also illegal. Keep pesticide use to a minimum to reduce the risk of groundwater contamination.

- Consider whether your application method presents any special risks. For example, soil injection of some pesticides may be unwise when groundwater is close to the surface.

- Be careful to 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. This will prevent groundwater contamination from floods, runoff, or firefighting water.

- Whenever possible, locate mixing/loading and equipment-cleaning sites at least 100 feet from surface water or from direct links to groundwater. This buffer zone will help prevent runoff and spills from contaminating the water sources. If one of these work sites must be near a water source, use methods such as dikes, sump pits, and containment 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 local, state, tribal, and federal laws.

Soil Factors

Soil is also an important factor in the breakdown and movement of pesticides. Your local NRCS can help you determine the types of soil in your area and how they affect breakdown and movement. The three major soil characteristics that affect pesticides are texture, permeability, and organic matter or content.

Soil texture indicates the relative proportions of sand, silt, and clay in the soil.

Coarse, sandy soils generally allow water to pass through rapidly. Pesticides in a water solution will leach readily through coarse-textured soil. Finer-textured soils generally slow the downward movement of water. These soils contain more clay (and sometimes organic matter) to which pesticides may cling.

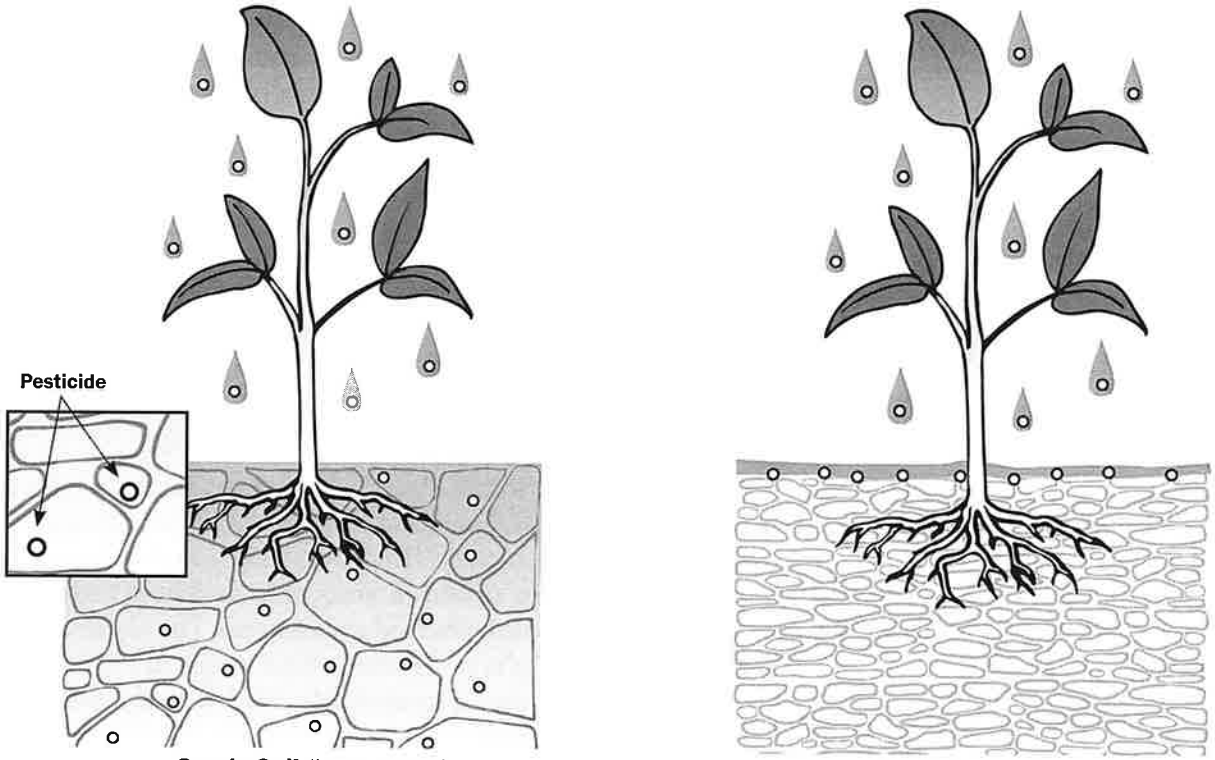
Soil permeability measures how fast water can move downward in a particular soil. You must manage the more permeable soils carefully to keep pesticides from reaching groundwater. Sandy soils are more permeable than clay and silt soils.

Soil organic matter influences how much water the soil can hold before the water begins to leach. Soils with more organic matter can slow down or stop the movement of pesticides. Soils in which plants are growing are more likely to prevent pesticide movement than bare soils.

Geology

The distance from the soil surface to the water table is the measure of how deep the groundwater is in a given place. If the groundwater is within a few feet of the soil surface, pesticides are more likely to reach it than if it is farther down. In humid areas, the water table may be only a few feet below the soil surface. In arid (dry) areas, the water table may lie several hundred feet below the surface. The depth to the water table does not stay the same over the course of a year. It varies according to:

- The amount of rain, snow, and irrigation water added to the soil.
- The amount of evaporation and plant uptake.
- Whether the ground is frozen.
- How much groundwater is withdrawn by pumping.



Sandy Soil vs. Clay Soil

The Natural Resources Conservation Service can provide you with valuable information on the geology of an area. It can also estimate the chance of groundwater contamination at your site.

Generally, the water table is closest to the soil surface in spring and fall. The water table often moves downward during the summer when evaporation and plant uptake are high. At this time, large amounts of groundwater are in use for irrigation and other hot-weather needs. The water table also moves downward in winter if surface water cannot penetrate the frozen soil to recharge the groundwater.

The permeability of geological layers between the soil and groundwater is also important. If surface water can move down quickly, pesticides are more likely to reach groundwater. Gravel deposits are highly permeable. They allow water and any pesticides present to move rapidly downward to groundwater. Regions with limestone deposits are prone to groundwater contamination. This is because water can move rapidly to the groundwater through caverns or "streams" with little filtration or chemical breakdown. On the other hand, layers of clay are almost impermeable. They may prevent most of the water and any pesticides within from reaching the groundwater.

Sinkholes are avenues to groundwater. A sinkhole forms when groundwater dissolves the minerals in limestone rock and soil over time. Underground caverns eventually appear. If the soil and rock that make up the cavern roof collapse, a sinkhole appears above ground. Surface water often flows into sinkholes and disappears quickly, flowing into groundwater. Do not apply a pesticide in an area that drains into a sinkhole. If you do, even a moderate rain or irrigation may carry the pesticide directly to the groundwater. Maintaining buffers around waterways and sinkholes is a good way to prevent contamination.

The Certified Applicator's Role

Some pesticides or certain uses of some pesticides are classified as restricted use because of groundwater concerns. As a certified applicator, you must handle all pesticides safely at or near use sites where groundwater contamination is likely. Take extra care when using techniques that are likely to cause groundwater contamination. These include chemigation and soil injection.

Typical pesticide labeling statements that alert you to concerns about groundwater contamination include:

This chemical has been identified in limited groundwater sampling. It may leach through the soil to groundwater, especially where soils are coarse and groundwater is near the surface.

This product readily decomposes into harmless residues under most use conditions. However, a combination of permeable and acidic soil conditions, moderate to heavy irrigation and/or rainfall, use of 20 or more pounds per acre, and soil temperature below 50□F (10□C) at application time tends to reduce degradation and promote movement of residues to groundwater. If the above describes your local use conditions and groundwater in your area is used for drinking, do not use this product without first contacting [registrant's name and telephone number].

Protecting the Chesapeake Bay: A Special Concern

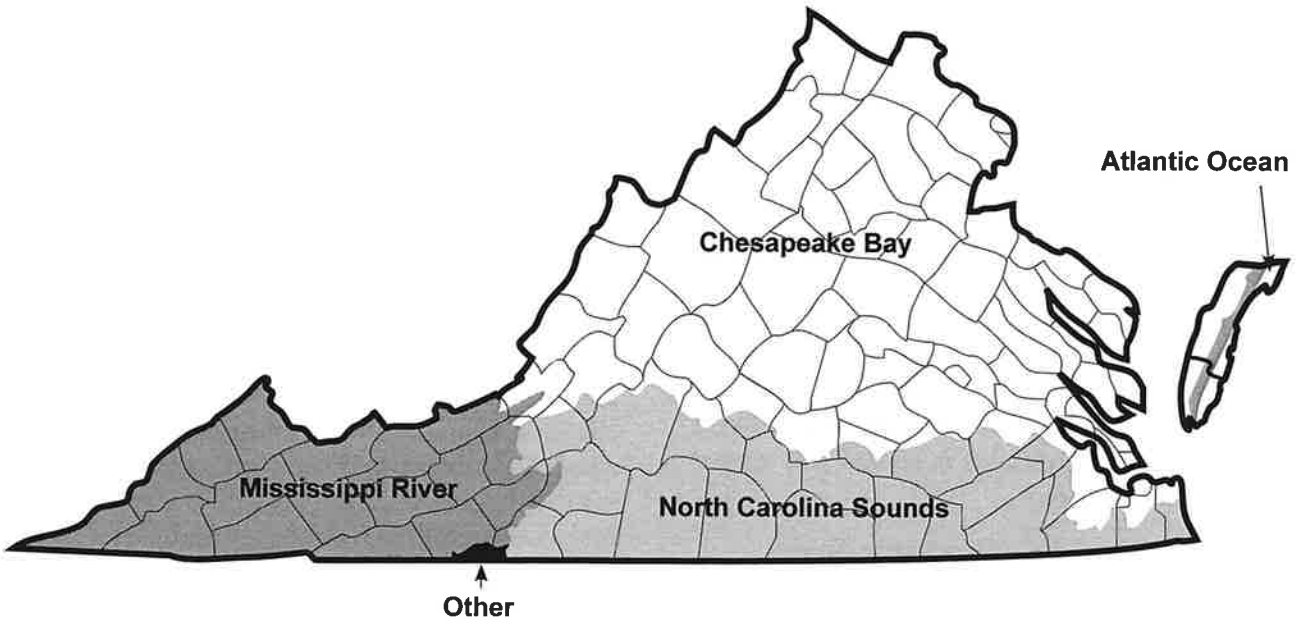
The Chesapeake Bay is a national treasure that played a large part in the settlement and history of our country. Great Native American civilizations and European settlers alike depended on its abundant resources for survival. It is the largest estuary in North America. Virginia is one of just six states with watersheds that drain into the Chesapeake Bay. A **watershed** is the land on which water drains into one particular waterway. Land practices within a watershed determine the quality of water that flows through it. Virginia has a number of major watersheds.

The fertile land along the Chesapeake Bay and Virginia's rivers, such as the James, Potomac, and Rappahannock, has been cultivated for centuries. The introduction of chemical fertilizers and pesticides to farming practices increased crop production. However, it also gave rise to many chemical pollutants entering the bay. As Virginia's population has grown over time, many farms have yielded to cities, housing developments, and golf courses. Pollution of all types has increased. In response, Virginia and its neighboring states are working together to solve the pollution problems of the Chesapeake Bay and restore it to its original abundance. Pesticide handlers who live and work within the Chesapeake Bay watershed of Virginia can help protect the bay and the environment. The best way to do this is to follow all labeling statements and safety requirements.

As noted elsewhere in this unit, EPA considers environmental risk when deciding if a pesticide can be used (registered) in the United States. Decades ago, the agency banned many pesticides that had been registered and, in some cases, widely used – but were later proven to pose an unacceptable environmental risk. Nevertheless, some of these still persist in our environment. The organochlorine insecticides (ex. dichloro-diphenyl-trichloroethane, or DDT) are examples. They accumulated in sediment (particles of soil washed into rivers and the bay) and in food chains (ex. the minnow eats the eelgrass, the bass eats the minnow, the osprey eats the bass). Some predators at the top of aquatic food chains, such as ospreys and bald eagles, faced extinction. Had humans not taken action soon after recognizing the harmful environmental effects of organochlorines, these creatures would have been lost.

The Environmental Protection Agency continues to use sound science when registering – and recalling – pesticides. As we learn more about our environment and the properties of the materials we produce and use, however, we may find that a chemical or practice we thought was safe is not. The best ways to minimize environmental risk due to pesticides are:

- Use them only when or as needed.
- Follow all label directions.



Major Watersheds of Virginia

Harmful Effects on Surfaces

Pesticides or pesticide residues can mar surfaces. Wood, carpeting, and paint may become discolored by contact with certain pesticides. Other surfaces may be pitted or marked. Some pesticides can even corrode or obstruct electronic systems or metal. Carefully read the product label to learn whether a pesticide is likely to damage a surface in your treatment area. Sometimes a pesticide will leave a visible deposit or residue on the treated surface. This may be unacceptable to your client.

Typical pesticide labeling statements that alert you to concerns about damage to surfaces include:

Do not apply to carpeting, linoleum, or other porous floor coverings, as discoloration may result.

Do not spray on plastic, painted, or varnished surfaces.

May cause pitting of automobile and other vehicle paint.

Do not spray directly into any electronic equipment or into outlets and switches, or any other location where the pesticide may foul or short circuit contacts and circuits.

A visible deposit may occur on some dark surfaces.

Harmful Effects on Nontarget Plants and Animals

Pesticides may harm nontarget organisms in two ways:

1. They may cause direct injury by contacting the organism (during an application).
2. They may cause indirect injury by leaving a residue (after the application).

Harmful Effects from Direct Contact

Even tiny amounts of some pesticides may harm some nontarget organisms or destroy their source of food. Poorly timed applications can kill bees and other pollinators that are active in or near the target site. Birds are especially vulnerable because their main sources of food may be the target insect and/or plant pests.

Applying pesticides by aircraft over large areas (such as in mosquito, biting fly, and forest pest control) is especially challenging. Be very careful to avoid poisoning nontarget plants and animals in or near the target site. Choose pesticides that are specific to the target pest if possible. For example, species-specific hormones that disrupt mating do not affect other nontarget species.

Drift from the target site may injure wildlife, livestock, pets, sensitive plants, and people. For example, herbicide drift can damage sensitive crops, forests, or ornamental plantings. Insecticide drift can kill beneficial insects and predators near the target site.

Pesticide runoff may cause fish kills and harm other aquatic animals and plants in

Typical pesticide labeling statements that alert you to concerns about harming nontarget organisms include:

Phytotoxic. Do not spray on plants.

Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.

Extremely toxic to aquatic organisms. Do not contaminate water by cleaning equipment or disposing of wastes.

This product is toxic to fish, shrimp, crab, birds, and other wildlife. Keep out of lakes, streams, ponds, tidal marshes, and estuaries. Shrimp and crab may be killed at application rates. Do not apply where these are important resources.

ponds, streams, and lakes. Careless tank filling or draining as well as rinsing or discarding used containers along or in waterways can also injure aquatic life.

Read the warnings and directions on the pesticide labeling carefully to avoid injuring nontarget organisms during a pesticide application.

Harmful Effects from Residues

A **residue** is the part of a pesticide that remains in the environment after an application or a spill. Pesticides start to break down into harmless components after they are released. The breakdown time can range from less than a day to several years. The rate of pesticide breakdown or persistence depends mostly on the chemical structure of the active ingredient.

Environmental conditions at the release site may also affect the breakdown rate. These include:

- Surface type, chemical composition, and pH.
- Surface moisture.
- Presence of microorganisms (ex. bacteria and nematodes).
- Temperature.
- Exposure to direct sunlight.

Persistent pesticides leave residues that remain for long periods without breaking down. These pesticides are sometimes desirable because they provide long-term pest control. They may also reduce the need for repeated applications. However, persistence can create problems. Some persistent pesticides can harm sensitive plants or animals, including humans, over time. This happens when these products are applied to or spilled onto soil, plants, lumber, and other surfaces, or into water. When using persistent pesticides, consider whether their continued presence in the environment is likely to cause harm.

Typical pesticide labeling statements that tell you a particular pesticide product is likely to be persistent include:

Can remain in the soil for 34 months or more and cause injury to certain crops other than those listed as acceptable on the label.

Provides season-long control in one application.

This product can remain phytotoxic for a year or more.

Pesticides can **accumulate** or build up in the bodies of animals or in the soil. If an applicator uses the same mixing/loading or equipment-cleaning site without limiting or cleaning up spills, persistent pesticides may accumulate in the soil. This can harm plants, animals, and objects that contact the soil. When pesticides accumulate in the soil, it is also more likely that they will move offsite and contaminate waterways.

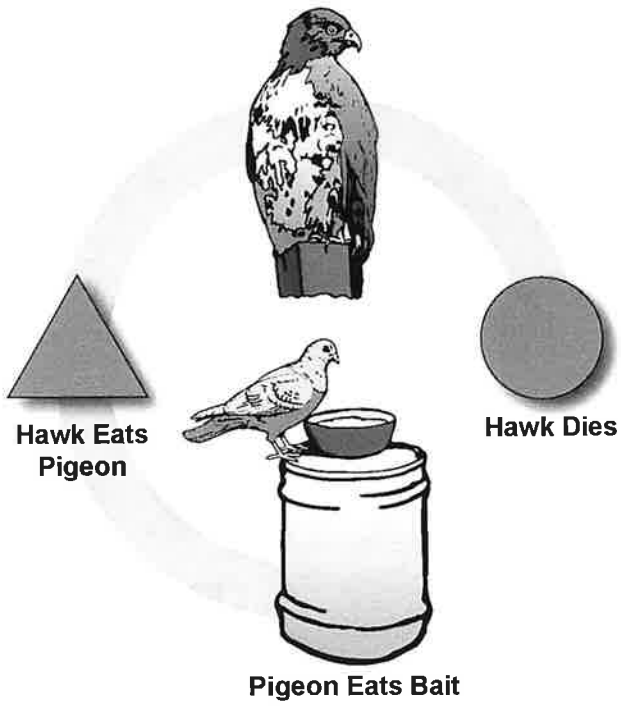
Sometimes animals feed on plants or other animals that have pesticide residues on or in them. **Secondary poisoning** is a special concern for predatory birds and mammals that feed on carcasses of target animals killed by pesticides. For example, bald eagles, which often scavenge for fish, will eat dead fish poisoned by a pesticide spill.

Typical pesticide labeling statements that alert you to concerns about secondary poisoning include:

Toxic to fish, birds, and wildlife. This product can pose a secondary hazard to birds of prey and mammals.

Do not use fish as food or feed within three days of application.

Animals feeding on treated areas may be killed and pose a hazard to hawks and other birds of prey. Bury or otherwise dispose of dead animals to prevent poisoning of other wildlife.



How Secondary Poisoning Occurs

Protecting Endangered Species

An **endangered species** is a plant or animal that is in danger of becoming extinct. There are two classifications: "endangered species" and "threatened species." In this manual, we use "endangered species" to refer to both classifications. Scientists believe that certain pesticides may threaten the survival of some of America's endangered species.

A federal law called the Endangered Species Act requires EPA to protect endangered species from harm. One goal of EPA's Endangered Species Protection Program (ESPP) is to remove or reduce the risk of pesticide harm. Reaching this goal requires some limitations on pesticide use. Usually, these limits apply only in the currently occupied habitat or range of each endangered species. However, they may also apply to places that endangered species had earlier lived in, abandoned, and are now reentering.

EPA created an information system called "endangered species protection bulletins" to inform pesticide users about use restrictions put in place to protect endangered species. These bulletins set forth pesticide use limitations for specific geographic areas for a given month. It is the pesticide applicator's responsibility to get a current bulletin and determine if there are any restrictions in the intended application site during the month he or she plans to apply the pesticide. Applicators must check on use limitations no more than six months ahead of an application. To find the bulletins online, look up the area by the county, state, and month of application at the following website: *www.epa.gov/espp/bulletins.htm* or call 1-800-447-3813.

NOTE: A product with ESPP restrictions will instruct its users to check for bulletins. Bulletin-referenced restrictions are enforceable, as they are a part of the pesticide product label.

Habitats of Endangered Species

A **habitat** (sometimes called "critical habitat") is the place where an animal or plant lives. It is the land, water, and air space that an endangered species needs for survival. Such areas include breeding sites; sources of food, cover, and shelter; and surrounding territory that allows normal population growth and behavior. The U.S. Fish and Wildlife Service (FWS) is responsible for identifying the current habitat or range of each endangered species. Pesticide use limitations and restriction zones are based on these habitats. For aquatic species, the restricted habitat often will include an additional zone around the body of water. The purpose of this zone is to keep any drift, runoff, or leachate (material obtained by leaching) in the watershed from reaching the water.

The Fish and Wildlife Service tries to accurately identify endangered species' habitats so that pesticide use limitations occur only where necessary. For this reason, use restric-

tions may apply to one property but not to a similar property nearby.

One example of critical habitat is the Clinch River in Southwest Virginia. Many species of freshwater mussels live in this river and nowhere else in the world. Most aquatic animals are very sensitive to pesticides and other forms of pollution. They are good indicators of water quality. Be aware of any endangered species in your area, whether on land, in the water, or in the air.

Importance of Protecting Endangered Species

Hundreds of animals and thousands of plants are considered endangered or threatened species under the Endangered Species Act. Some of these are well-known success stories, such as the now-recovered bald eagle. Others, such as the Roanoke logperch, are little-known creatures that are familiar only to trained naturalists.

Familiar or not, it is important to protect all endangered species. The well-being of the human race depends on maintaining biological diversity throughout the world. **Biological diversity** is the variety and differences among living things as well as the complex ways they interact. No one can predict which species may be vital to the future of humankind. Any species might be the key to stopping a global epidemic or surviving a major climate change.

Limitations on Pesticide Use

Read all pesticide labeling carefully to see whether using that product requires you to take any special steps to protect endangered species. The label may direct you to another source for details about what to do. When limitations do apply, they will usually affect only certain products and specific places. Use of a particular pesticide is usually limited in a certain place when:

- The site is designated as the current habitat of an endangered species.

Apply pesticides carefully to avoid harming nontarget organisms.

- The endangered species that uses the site might be harmed from the use of the pesticide in or near its habitat.

The Certified Applicator's Role

Pesticides can harm living organisms, including endangered species, in the following ways:

1. Pesticides can kill endangered plants and animals directly.
2. Pesticides in the habitat of the endangered organisms can disrupt or destroy their sources of food and shelter.
3. Pesticide application, drift, runoff, and leachate can contaminate water that endangered organisms drink or live in.
4. Some pesticides can build up to harmful 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 of pes-

Know the Law

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

The Endangered Species Protection Program (ESPP) limits pesticide use in the currently occupied habitat of each endangered species. Endangered species protection bulletins inform applicators of specific endangered species in their areas. Applicators must check use limitations before applying a pesticide.

FWS has the authority to designate land and freshwater species as endangered or threatened and to identify their current habitat or range. The National Marine Fisheries Service has the same authority for marine species.

FWS has the authority to prosecute persons, including pesticide users, who harm endangered or threatened species. In addition, EPA enforcement personnel have the authority to ensure that pesticide users observe labeling restrictions.

If in doubt about whether endangered species will be affected by a pesticide application, contact the regional U.S. Fish and Wildlife Service office (ask for the endangered specialist) or the Virginia Department of Game and Inland Fisheries.

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

Under the Endangered Species Act, it is a federal offense to use any pesticide in a manner that kills a member of an endangered species. Before making applications, users must determine that endangered species are not located in or immediately adjacent to the site to be treated. If in doubt whether endangered species may be affected, users should contact the regional U.S. Fish and Wildlife Service office (ask for the endangered species specialist) or the Virginia Department of Game and Inland Fisheries.

This product may have effects on endangered species. When using this product, you must follow the measures contained in the endangered species protection bulletin for the area in which you are applying the product. To obtain bulletins, consult www.epa.gov/espp, or call 1-800-447-3813 no sooner than six months before using this product. You must use the bulletin valid for the month and year in which you will apply the product.

Endangered Species Restrictions: For Aerial Application – Do not use within 100 yards of aquatic habitats. For Ground Application – Do not use within 20 yards of aquatic habitats.

Test Your Knowledge

Q. What is the environment?

A. Everything that surrounds us – indoors and outdoors – including natural elements, manmade objects, people, and other living organisms.

Q. What is the Environmental Protection Agency (EPA)? What is one part of its mission with regard to regulating pesticides?

A. The Environmental Protection Agency (EPA) protects people and natural resources. EPA studies the environmental effects of each pesticide as part of the pesticide registration or registration renewal process.

Q. What are sensitive areas? List examples of sensitive areas that need extra protection from pesticides.

A. Sites or living things within an environment that are vulnerable to pesticide injury. Examples include:

1. Places where pesticides might get into groundwater or surface water.
2. Areas near homes, schools, playgrounds, hospitals, and other places where people are present.
3. Places where there are animals – endangered species, bees, other wildlife, livestock, and pets.
4. Places where crops, ornamental plants, or other sensitive plants are growing.
5. Areas where food or feed is processed, stored, or served.

Q. Define "point source" and "nonpoint source" pesticide pollution. Give an example of each.

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

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

A.

1. Mismanaging wash water and spills produced at equipment cleanup sites.
2. Improperly disposing of containers, rinsate, and excess pesticides.
3. Failing to correctly clean up leaks and spills at pesticide storage sites.
4. Spilling pesticides while mixing or loading pesticides into application equipment.

Q. What factors should you consider if you accidentally or intentionally release a pesticide into the environment?

A.

1. Sensitive areas at or near the use site.
2. Weather or site conditions.
3. Factors in your application or handling methods that may affect the risk of environmental contamination.

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

A. 1. In air, through wind or air currents generated by ventilation systems.

2. In water, through runoff or leaching.

3. On or in objects, soil particles, plants, animals, or humans that travel or are moved offsite.

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

A. 1. By sticking to shoes or clothing, animal fur, or blowing dust – anything that moves away from the use site.

2. By remaining on treated surfaces, such as food or feed products, when they are taken from the use site and sold.

Q. How do illegal pesticide residues often occur?

A. 1. Too much pesticide is applied to the crop or animal.

2. The days-to-harvest, days-to-grazing, or days-to-slaughter directions on the pesticide labeling are ignored.

3. Pesticides move offsite and contaminate plants or animals nearby.

4. A pesticide is applied off-label, to a site not permitted by label directions.

Q. Which formulation factors influence whether a pesticide will drift (move offsite in the air)?

A. 1. The weight and density of dry particle applied.

2. Whether adjuvants were used in liquid spray mixtures.

3. Whether the pesticide tends to form vapors.

Q. How can volatility contribute to drift?

A. In vapor form, a pesticide can move great distances and injure sensitive plants and animals. Volatility may also contribute to illegal residues that may spoil neighboring food crops.

Q. What application factors influence pesticide drift?

A. 1. Droplet or particle size.

2. Height and direction of release.

Both are determined by applicator decisions: equipment selection, setup, and operation.

Q. What weather factors may contribute to drift?

A. 1. Strong winds or wind gusts.

2. Low relative humidity.

3. High temperatures.

4. Temperature inversions.

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

A. 1. Too much liquid is applied, leaked, or spilled onto a surface.

2. Too much rainwater, irrigation water, or other water gets onto a surface.

Q. What is the difference between runoff and leaching? How might each cause a pesticide to move offsite?

A. "Runoff" is the movement of water across the treated surface. This may cause a pesticide within the water to move away from the treated area. "Leaching" is the movement of water downward from the surface. This may cause a pesticide within the water to move through the soil and reach the groundwater.

Q. Explain how the solubility, adsorption, and persistence of a pesticide affect its ability to move offsite in water.

A. 1. **Solubility** – Some pesticides dissolve easily in water and are more likely to move in solution into water systems.

2. **Adsorption** – Some pesticides become tightly attached to soil particles. However, they will move with eroded soil. If eroded soil is deposited in water, adsorbed pesticides may then move into the water.

3. **Persistence** – Some pesticides break down slowly and remain in the environment for a long time. They are more likely to move offsite.

Q. Why should pesticide handlers in the Chesapeake Bay watershed be especially cautious of environmental contamination?

A. The Chesapeake Bay is a valuable resource for Virginia. Several contaminants, including fertilizers and pesticides, seriously threaten its water quality.

Q. What is groundwater? Why is it important to people and animals?

A. Water located beneath the earth's surface, usually in rock and soil. Aquifers are underground reservoirs holding groundwater. Groundwater usually moves very slowly through irregular spaces within the bedrock or seeps between soil particles. Groundwater is an important resource for private and public uses such as household wells, irrigation, and industry.

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

A. 1. Do not use more pesticide than the labeling directs.

2. Avoid application methods that present special risks.

3. Keep pesticides from back-siphoning into your water source.

4. Place pesticide storage facilities at least 100 feet from wells, springs, sinkholes, and other sites that directly link to groundwater.

5. Place mixing/loading and equipment-cleaning sites at least 100 feet from surface water or from direct links to groundwater (or take precautions to protect those sites).

6. Correctly dispose of unused pesticides, pesticide containers, and equipment and container rinse water.

Q. What types of soil slow the movement of pesticides into groundwater? What types permit rapid movement?

A. Fine- or smooth-textured soils containing more organic matter slow the downward movement of water containing pesticides. Coarse, sandy soils generally allow water to carry pesticides more rapidly downward.

Q. What geologic factors affect the movement of pesticides into groundwater? Briefly explain.

A. 1. **Distance from the soil surface to groundwater** – The closer groundwater is to the soil surface, the more likely pesticides are to reach it. This distance may vary over the course of a year.

2. **Permeability of soil and geological layers** – Sand, gravel, and limestone are highly permeable and allow pesticides to move rapidly downward. Clay, on the other hand, is much less permeable and may prevent pesticides from reaching groundwater.

3. **The presence or absence of sinkholes** – Sinkholes are pathways or conduits into caverns that allow surface water and pesticides to disappear quickly, flowing into groundwater.

Q. How can you protect your water source from contamination?

A. 1. Keep an air gap between water pipes or hoses and the pesticide mixture in your spray tank.

2. Use a check valve, antisiphoning device, or backflow preventer to prevent back-siphoning.

3. Do not place mixing/loading sites where a spill, leak, or overflow could allow pesticides to enter the water system.

Q. In what ways can some pesticides damage surfaces?

A. Surfaces may become discolored, pitted or marked, corroded or obstructed, or have a visible deposit.

Q. Pesticides may harm nontarget organisms by direct contact (during application or through drift or runoff). How else may a pesticide cause harm?

A. By pesticide residues. These remnants stay in the environment for some time after an application or spill. They can be residues that remain in soil or on surfaces, or they may be residues that build up (accumulate) in the bodies of animals. Pesticide accumulation can harm animals that contain residues and sometimes other animals that feed on them.

Q. What is secondary poisoning?

A. When a predator or scavenger ingests pesticide by eating an animal killed by a pesticide. Secondary poisoning may cause sickness or death.

Q. What is an endangered or threatened species?

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

Q. How can pesticides harm endangered species?

A. 1. By killing them directly.

2. By disrupting or destroying sources of food and shelter.

3. By contaminating water that endangered organisms drink or live in.

4. By building up to dangerous levels in endangered predators that feed on plants or animals exposed to pesticides.

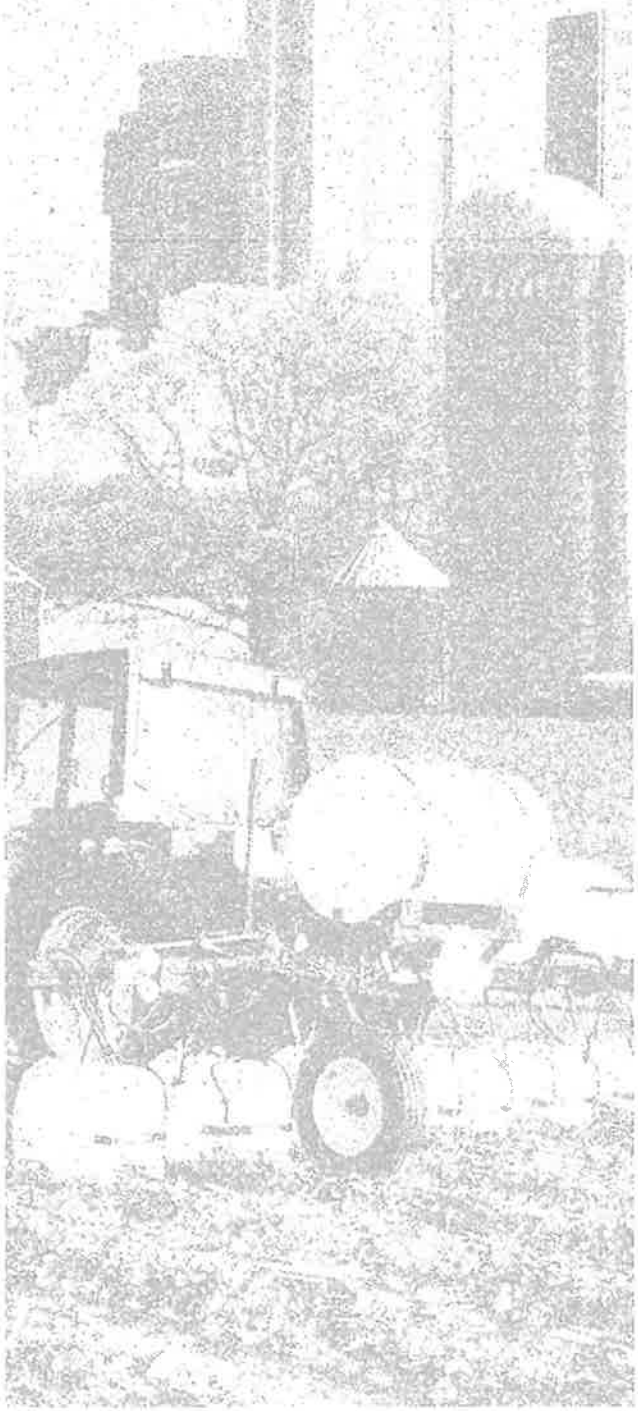
Q. What are endangered species protection bulletins? Why are they important?

A. Information provided by EPA to inform pesticide users about use restrictions put in place to protect endangered species. Pesticide applicators must determine whether their target areas are subject to pesticide restrictions at the time they plan to apply the pesticide. Endangered Species Protection Program (ESPP) bulletins are enforceable parts of the pesticide labels that reference them.

Q. What is biological diversity? Why is it important?

A. The variety and differences among living things as well as the complex ways they interact. The well-being of the human race depends on maintaining biological diversity throughout the world. No one can predict which species may be vital to the future of humankind.

Unit 6. Harmful Effects and Emergency Response



Learning Objectives

After studying this unit, you should be able to:

- Explain the relationship between hazard, exposure, and toxicity.
- List and discuss the four routes of human exposure to pesticides.
- Discuss the main causes of oral, inhalation, ocular, and dermal exposures.
- Explain how safety systems can reduce pesticide exposure.
- Distinguish between acute and chronic toxicity.
- Distinguish between acute and delayed effects.
- Name and describe the three main types of harmful effects that pesticides can cause in humans.
- Describe how to avoid harmful effects from pesticides.
- List some signs and symptoms of pesticide poisoning and pesticide injury (external irritants).
- Describe recommended first aid for pesticide exposures.
- Describe some of the signs and symptoms of heat stress.
- Explain how to avoid heat stress by altering workplace conditions.
- State how to administer first aid for heat

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Acute Effects – Illnesses or injuries that appear soon (within 24 hours) after exposure to a pesticide or combination of pesticides.

Acute Toxicity – The measure of harm caused by a single pesticide exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity.

Allergic Effects – Harmful effects, such as skin rash or asthma, that some people develop when exposed to a substance that does not cause the same reaction in others. An allergy causes a hypersensitivity to a specific substance, often called the allergen.

Chronic Effects – Illnesses or injuries that appear a long time (usually several years) after exposure to a pesticide. Often, chronic effects are due to repeated exposures.

Chronic Toxicity – The measure of harm caused by repeated, prolonged exposure to small amounts of pesticide.

Delayed Effects – Illnesses or injuries that appear more than 24 hours after exposure to a pesticide or combination of pesticides.

Delayed Systemic Effects – Illnesses or injuries to a system in the body that appear more than 24 hours after exposure to a pesticide or combination of pesticides.

Terms to Know cont.

Developmental Effects – Injuries to or illnesses of a fetus in the womb of a woman who has been exposed to a pesticide.

Exposed/Exposure – Contacting or touching (or subjected to contact with) a pesticide; getting a pesticide on a surface, or in or on an organism. Exposures may be oral, inhalation, dermal, or ocular.

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

Hazard – The risk of harmful effects from pesticides.

Heat Stress – A potentially life-threatening illness that occurs when the body is subjected to more heat than it can adjust to.

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

Occupational Safety and Health Administration (OSHA) – The federal agency responsible for regulating and enforcing labor laws, including the safe use of hazardous chemicals in the workplace (as outlined in the Hazard Communication Standard [HCS]).

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Precautionary Statement – Pesticide labeling statement that warns of possible hazards from use of the pesticide product and that may indicate specific ways to avoid the hazards.

Reproductive Effects – Injuries to the reproductive systems of exposed men or women.

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

Solvent – A liquid that will dissolve a substance and form a true solution. Common solvents include water, acetone, refined oil, and alcohol.

Toxicity – The measure of a pesticide's ability to cause acute, delayed, or allergic effects.

Pesticides and People

Most pesticides are designed to harm or kill pests. However, insects, rodents, and humans are all animals, and their nervous, circulatory, and respiratory systems are similar in some ways. For this reason, certain pesticides that harm pests can also harm people. Fortunately, people can usually avoid harmful effects by avoiding pesticide **exposure**.

Pesticides may harm humans in two ways: by poisoning or by injury. Pesticide poisoning is caused by pesticides that damage internal organs or other body systems. Pesticide injury is usually caused by pesticides that are external irritants.

Pesticides that are chemically similar to one another cause the same type of harmful effects in people. These effects may be mild or severe, depending on the pesticide involved and the amount of exposure. But the pattern of illness or injury caused by each chemical group is often the same. Some pesticide chemical families can cause both external irritation and internal poisoning. Note that some materials used to formulate pesticides (ex. petroleum products and organic **solvents**) are also harmful.

Some pesticides are highly toxic to humans: only a few drops in the mouth or on the skin can do great harm. Other pesticides are less toxic but can still cause harm with enough exposure. Remember this equation:

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 a given situation. Other risk factors include the physical and chemical characteristics of the product, the method (route) of exposure, and individual handler characteristics.

Hazard is the main concern for a **pesticide handler** because it reflects the likelihood of harm resulting from working with a pesticide. The best way to reduce hazards when using a pesticide is to understand what you are using and how to use it safety. *Read the label carefully and follow all instructions.*

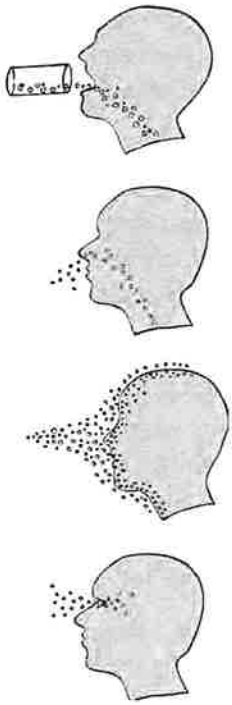
Exposure

Pesticide exposure occurs when a pesticide contacts a surface or an organism. For humans, it means getting pesticides in or on the body. The harmful effect of a pesticide exposure depends on how much pesticide is involved, its toxicity, and how long it remains there.

Types of Exposures

Pesticides contact your body in four main ways:

1. Oral exposure (swallowing a pesticide).
2. Inhalation exposure (inhaling a pesticide).
3. Ocular exposure (getting a pesticide in your eyes).
4. Dermal exposure (getting a pesticide on your skin).



Pesticide Exposure Routes (from top): Oral, Inhalation, Dermal, Ocular

Avoiding Exposure

Avoiding and reducing pesticide exposures will reduce the harmful effects from pesticides. To minimize exposures:

- Work carefully to avoid accidents.
- Use safety systems, such as closed systems and enclosed cabs. These are discussed in more detail later in this unit.

- Choose products and packaging that are easy to handle.
- Wear appropriate **personal protective equipment (PPE)**. Wash exposed areas often, and keep your PPE clean and in good operating condition.

In most pesticide-handling situations, the skin is most likely to be exposed. Evidence indicates that about 97% of all body exposure that happens during pesticide application is by skin contact. There is one exception: inhalation is a greater hazard than skin contact while working in a poorly ventilated, confined space and using a fumigant or similar pesticide. These products are highly toxic when inhaled.

Eyes are also sensitive to pesticides and can absorb large amounts of chemical. Some pesticide products are corrosive and can cause severe eye damage, including blindness. Proper eye protection is essential.

Swallowing or ingesting pesticides is most common among children. Proper pesticide storage will prevent most accidental oral exposures. Keep pesticides in their original, labeled containers. Clearly mark all secondary pesticide containers and measuring cups to prevent their use for any other purpose. Never store pesticides in unlabeled containers, especially food or beverage containers.

The amount of pesticide that is 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 (ECs), oil-based liquid pesticides, and oil-based diluents (ex. xylene) are generally absorbed most readily. Water-based pesticides and dilutions (ex. wettable and **soluble** powders and dry flowables) are usually absorbed less readily than oil-based liquid formulations but more readily than dry formulations. Dusts, granules, and other dry **formulations** are absorbed the least readily.
- 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.

Causes of Exposure

One of the best ways to prevent pesticide exposures is to avoid situations and practices where exposures commonly occur.

Oral exposures are often 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.

Inhalation exposures are often caused by:

- Handling pesticides in confined or poorly ventilated areas.
- Breathing vapors from fumigants and other highly toxic pesticides.
- Breathing vapors, dust, or mist while handling pesticides without appropriate PPE.
- Inhaling vapors immediately after a pesticide is applied (ex. from drift or from reentering the area too soon).
- Using an inadequate or poorly fitting respirator.

Ocular exposures are often caused by:

- Splashing pesticides in the eyes.
- Applying pesticides in windy weather without eye protection.

- Rubbing eyes or forehead with contaminated gloves or hands.
- Handling dust, granule, or powder formulations without eye protection.

Dermal exposures are often caused by:

- Not washing hands after handling pesticides or their containers.
- Splashing or spraying pesticides on skin.
- Wearing pesticide-contaminated clothing (including boots and gloves).
- Applying pesticides in windy weather or above your head.
- Exposure to spray or dust drift.
- Wearing inadequate PPE while handling pesticides.
- Touching pesticide-treated surfaces.

Safety Systems

One way to reduce pesticide exposure is to use safety systems. Closed mixing and loading systems, enclosed application systems, and pesticide containment systems are excellent investments for pesticide handlers who work with large quantities of pesticides or pesticides that are very hazardous to humans or to the environment. In some cases, pesticide product labels may require the use of specific engineering controls when handling certain pesticides or when using pesticides in or near sensitive areas. Pesticide containment systems (ex. collection trays and pads) are discussed in Unit 11.

Closed Mixing and Loading Systems

Closed mixing and loading systems are designed to prevent pesticides from contacting 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 impacting human health. In addition, some states may require use of closed mixing and loading systems for pesticides with high **acute toxicity**.

There are several types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment. Another uses water-soluble packaging.

Mechanical Systems

Typical statements on the labeling of such products include:

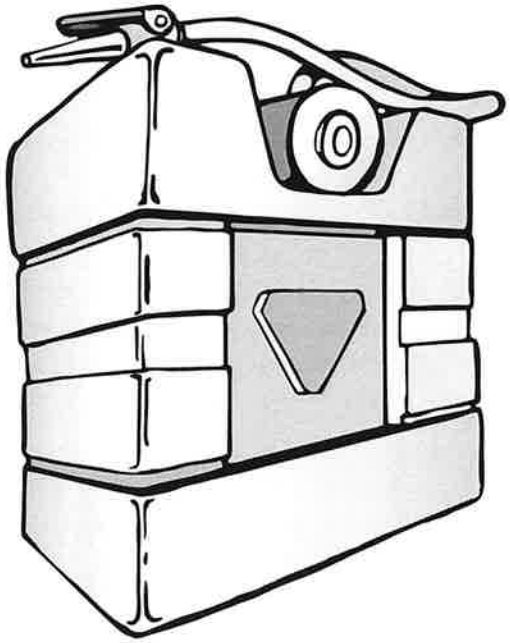
- *Must be transferred and mixed using closed-system equipment. Do not use open mixing vats or tanks, or open pouring.*
- *Must be transferred into the spray tank through the use of a mechanical transferring device.*

Mechanical systems often consist of a series of interconnected equipment parts that allow for the safe removal of a pesticide from its original container. You can rinse the empty container, then transfer the pesticide and rinse water (rinsate) to the application equipment with minimal exposure risk.

Closed mixing and loading systems are often custom-made with parts from several commercial sources. Because pesticide container openings vary in shape and size, no single closed system works with all containers. The mechanical systems now available remove the pesticide concentrate from the original container, either by gravity or by suction.

Minibulk Containers

Minibulk containers work well with mechanical loading systems. These containers or tanks range widely in size and are adapted to or designed as closed systems. The pesticide handler can attach the minibulk tanks to the sprayer without being exposed to the pesti-



Minibulk Tank

cide. Normally, pump and drive units deliver the product. A meter allows accurate measuring from the minibulk tank to the sprayer. These meters need frequent calibration to be accurate.

Minibulk containers are increasingly popular, partly because they reduce pesticide waste. You may return these tanks to the dealer for refilling or for claiming a deposit. This eliminates the need to triple rinse or pressure rinse many small containers. It also cuts down on plastic waste.

Gravity Systems

Gravity systems are sometimes called "punch and drain" systems. 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 rinsate also drains into the mixing tank. You then remove the rinsed container for disposal. Gravity systems are available for use with both liquid and dry concentrates.

A drawback of this system is that you must use the entire container. You cannot use part of the pesticide in a container and store the remainder.

Suction Systems

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 rinsate is added to the mixing tank.

To allow the use of only a portion of the pesticide in the container, the system must have a way to measure the amount of pesticide suctioned into the mixing tank. It also must allow the probe to remain in the container until all the pesticide is used and until the container and probe are rinsed. Some probes have a breakaway head that allows the head to stay and the probe to be withdrawn and reused.

Some suction systems do not allow you to reseal partly emptied containers. Moreover, highly viscous pesticides (those that pour like molasses) are difficult to move by suction.

Water-Soluble Packaging

Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or package. The pesticide package is placed unopened into the mixing tank. The package dissolves in water or liquid fertilizer.

One drawback 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. Another is the high risk of splashing as containers are added to the tank. Additionally, water-soluble bags are often unavailable for small-volume applications.

Lastly, water-soluble bags are designed to treat a specific area size (ex. one bag per 10 acres). You cannot cut the bag in half and treat 5 acres (using the example above).

Advantages and Disadvantages of Closed Systems

Advantages:

- Increased handler safety.
- Less need for personal protective equipment.
- Fewer spills.
- More accurate measurement.
- More cost-effective by reducing over- and underdosing.

Disadvantages:

- Some are expensive or scarce.
- May be cumbersome.
- Some are not appropriate for certain pesticides and/or handling activities.

Personal Protective Equipment Requirements

The PPE requirements for many pesticides may be different if you use a closed mixing and loading system:

- You may be able to wear a long-sleeved shirt, long-legged pants, shoes, and socks instead of chemical-resistant PPE if the pesticide labeling so states.
- If the closed system is for mixing or loading concentrated pesticides, you may be required to wear a chemical-resistant apron and chemical-resistant gloves.
- If the system operates under pressure, you may be required to wear protective eyewear.

If you use a closed system and follow label directions for PPE, you should keep a set of the label-required PPE at the mixing and loading site for those who do not use a closed system. Then you will be prepared in case the closed system equipment fails or there is an accidental spill.

- Always read and follow the label.

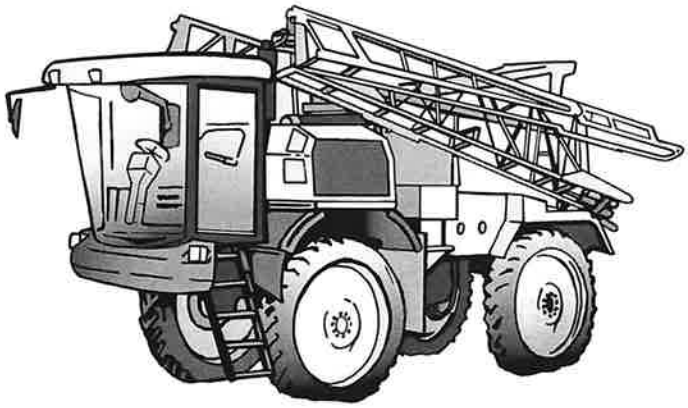
Enclosed Application Systems

An enclosed application system is a cab or cockpit that surrounds the occupants. It may prevent pesticide exposure as long as doors, hatches, and windows remain closed during the application.

Even though you are inside a cab, you must wear all PPE specified on the label. Enclosed cabs are a supplement to PPE – not a replacement for it. It is especially important to wear suitable PPE when getting in and out of the cab in the treated area. Outside surfaces of the cab are likely to be contaminated.

Enclosed application systems include:

- Enclosed cab – provides skin and eye protection.
- Enclosed cab with an air-filtering ventilation system – protects against inhalation of dusts and mists, and protects skin and eyes.
- Enclosed cab with a vapor-removing ventilation system – provides inhalation protection plus skin and eye protection.



An enclosed cab may help prevent pesticide exposure.

- Enclosed cockpit – provides skin, eye, and inhalation protection.

If the Environmental Protection Agency (EPA) has not approved the cab's ventilation system, the PPE requirement for respiratory protection would remain the same – in or out of the cab.

Toxicity

Toxicity is a measure of the ability of a pesticide to cause harmful effects. It is measured for both short-term (acute) and long-term (chronic) exposure. The toxicity of a pesticide product depends on the type and amount of:

- Active ingredient(s).
- Inert ingredients (ex. carrier or solvent ingredients).

To lower toxicity, reduce the amount of pesticide (if possible) and choose the least toxic product available.

There are two types of toxicity: acute and chronic.

Acute Toxicity

Acute toxicity is the measure of harm caused by a single pesticide exposure. Harmful effects may be systemic, contact, or both. A common method used to measure acute toxicity is LD_{50}. "LD" means lethal dose. LD_{50} is the dose, based on weight, that will kill 50% of a population of test animals. The higher the LD_{50} value, the less acutely toxic the chemical. This value is usually expressed as milligrams/kilogram (mg/kg) of body weight. A chemical with an oral LD_{50} of 5,000 mg/kg requires about 0.1 ounce of the chemical per pound of body weight to reach the LD_{50} value. For a 150-pound person, this would be about 12 ounces. For a child weighing 50 pounds, it would be 4 ounces.

Another common measure of acute toxicity is LC_{50}. "LC" means lethal concentration, and it measures the amount of pesticide in air or water.

These toxicity studies help determine which pesticides are classified as poisons. The signal words on a label (ex. DANGER—POISON) indicate the acute toxicity of a product, as shown in Table 6-1. See "Signal Words and Symbols" in Unit 3 for more information.

Toxicity studies help estimate the risk that a pesticide may cause harmful effects in humans. However, some people react more or less severely than others. Be alert to your body's reaction to the pesticides you are handling.

Chronic Toxicity

Chronic toxicity is the measure of harm caused by repeated, prolonged exposure to small amounts of pesticide. Chronic toxicity is determined by exposing laboratory animals to an active ingredient for about two years. **Chronic effects** from human exposure to certain pesticides are discussed below.

Harmful Effects

Pesticides can cause three types of harmful effects: acute, delayed, and allergic.

Acute Effects

Acute effects are illnesses or injuries that appear soon (within 24 hours) after exposure to a pesticide. Studying a pesticide's relative capability of causing acute effects has been the main way to assess and compare how toxic pesticides are. Acute effects can be measured more accurately than **delayed effects**. Moreover, they are more easily diagnosed than effects that do not appear until long after the exposure. Acute effects usually are obvious and often are reversible with appropriate, prompt medical care.

Pesticides cause four types of acute effects:

1. Oral (ingestion).
2. Inhalation (respiratory).

Table 6-1. Toxicity categories

Signal word & symbol	Toxicity level & class	LD_{50} oral (mg/kg)	LD_{50} dermal (mg/kg)	LC_{50} inhalation (mg/l)	Contact injury concern	Toxicity concern
Danger—Poison/Peligro skull & cross-bones	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2	Signal word based on oral, dermal, or inhalation toxicity	Very low dose could kill a person (a few drops to a teaspoon)
Danger/Peligro	Highly toxic, Hazard Class I				Corrosive: permanent or severe skin, eye, or respiratory damage	Based on the corrosive or irritant properties of the product
Warning/Aviso	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2	Moderate skin, eye, or respiratory damage	Small to medium dose could cause death, illness, or skin, eye, or respiratory damage (1 teaspoon to 1 ounce)
Caution	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20	Mild skin, eye, or respiratory irritation	Medium to large dose could cause death, illness, or skin, eye, or respiratory damage (1 ounce to 1 pint or pound)
Caution or no signal word	Hazard Class IV	> 5,000	> 20,000	> 20	Slight concern for skin, eye, or respiratory injury	Slight to none (more than 1 pint or pound)

Source: National Pesticide Applicator Certification Core Manual, p. 77.

3. Dermal (skin).

4. Ocular (eye).

All of these effects are harmful in various ways.

Acute Oral Effects

Some pesticides can severely burn your mouth, throat, and stomach. Other swallowed pesticides will not burn your digestive system but will be absorbed and carried in your bloodstream. For some pesticides, swallowing even a few drops from a splash or wiping your mouth with a contaminated glove can make you very ill or prevent you from eating and drinking normally.

Acute Inhalation Effects

Some pesticides can burn your entire respiratory system, making it difficult to breathe. Other inhaled pesticides may not injure your respiratory system but travel quickly in your blood throughout your body.

Acute Dermal and Skin Irritation Effects

Contact with some pesticides will harm your skin. These 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 move throughout your system.

Acute Ocular Effects

Some pesticides that get into your eyes can cause blindness (temporary or permanent) or severe irritation. Other pesticides may bypass your eyes and enter your body. These pesticides can travel throughout your body.

Delayed Effects

Delayed effects are illnesses or injuries that appear more than 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 applies only to certain types of delayed effects.

Delayed effects may be caused by:

- Repeated exposures to a pesticide, a pesticide group, or a combination of pesticides over a long period.
- A single exposure to a pesticide (or combination of pesticides) that causes a harmful reaction that does not appear 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 insecticides inhibit (suppress) a chemical called cholinesterase 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 low cholinesterase-inhibiting properties can trigger severe illness. A blood cholinesterase test can measure the effects of exposure to organophosphate and carbamate insecticides.

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 done little harm. Some organophosphate pesticides have this effect when they are used together.

In some cases, a single exposure to a pesticide (or combination of pesticides) could harm a person over time. For example, large exposures to paraquat, an herbicide, may cause severe or fatal lung injury that does not appear for three to 14 days after the first exposure. Paraquat slowly accumulates in the lungs and destroys lung cells.

Some kinds of harmful effects may occur only under certain circumstances. These effects can occur after the first exposure, but the likelihood is small. Continuous or frequent exposures over a long period make it more likely that all the necessary factors will exist. Some genetic changes that result in the development of cancer or other diseases are in this category.

There are three types of delayed effects:

1. Chronic.

2. Developmental and reproductive.

3. 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 may result from pesticides' chronic toxicity include:

- Production of tumors (oncogenic).

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.

- *The use of this product may be hazardous to your health. This product contains an ingredient which has been determined to cause tumors in laboratory animals.*

- Production of malignancy or cancer (carcinogenic).

- Changes in the genes or chromosomes (mutagenic).

Developmental and Reproductive Effects

Developmental effects are injuries to or illnesses of a fetus in the womb of a woman who has been exposed to a pesticide. These effects include:

- Birth defects (teratogenic effect).

- Illness or death (miscarriage or stillbirth) of a fetus (fetotoxic effect).

Reproductive effects are injuries 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. However, they may not be apparent for some time after the exposure. For example, a birth defect may be apparent only after the birth of a child, which may be several months after the exposure. Other developmental or reproductive effects appear to result from repeated exposures to a pesticide or combination of pesticides over 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

Delayed systemic effects are illnesses or injuries to a system in the body that appear more than 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, tremor, 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

It is sometimes hard to identify the cause of a delayed effect. One reason is the time delay between the exposure and the observable effect. Another is that many other types of exposures may have occurred during the delay. Although some pesticides may cause delayed effects in laboratory animals, further studies are necessary 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, EPA will determine what steps are appropriate to reduce or eliminate the risk. Such actions include:

- Removing the pesticide from use.
- Requiring label warning statements about the possible effects.
- Requiring specific PPE or safety systems during pesticide handling.
- 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 EPA have not yet determined the delayed effects of too much exposure to individual pesticides or combinations of pesticides. 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 experience when exposed to substances that do not cause the same reaction in others. These effects are expressed as a hypersensitivity to a specific substance, often called the allergen. 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 (second or subsequent) 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. Some species of turfgrass, for example, cause a severe skin rash in relatively few people.

Types of Allergic Effects

Some people become sensitized to certain pesticides. After being exposed once or a few

times without effect, they develop a severe, allergy-like response on later exposures. These allergic effects include:

- Systemic reactions, 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 a particular product. However, certain people seem to be more chemically sensitive than others. They 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 an allergic reaction should contact a physician.*
- *May be a skin sensitizer.*
- *The active ingredient may cause skin sensitization reactions in certain individuals.*

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. These individuals, however, may be able to work in situations where those pesticides are present by reducing their exposure to them.

Signs and Symptoms of Harmful Effects

There are two kinds of clues to pesticide-related illness or injury: symptoms and signs. Symptoms are feelings that only the victim can notice, such as cramps or headache. Signs, like vomiting or fainting, are visible to others. Be aware of:

- What your own symptoms might mean.
- What signs of poisoning or injury to look for in your coworkers and others who may have been exposed.

Many of the signs of pesticide poisoning are similar to those of other illnesses. If you have been working with pesticides and then develop suspicious symptoms, call your physician or poison control center. Only a physician can diagnose pesticide poisoning injuries.

External irritants may cause:

- Redness, blisters, rash, and/or burns on skin.
- Swelling, a stinging sensation, and/or burns in eyes, nose, mouth, and throat.

Pesticide poisoning may cause:

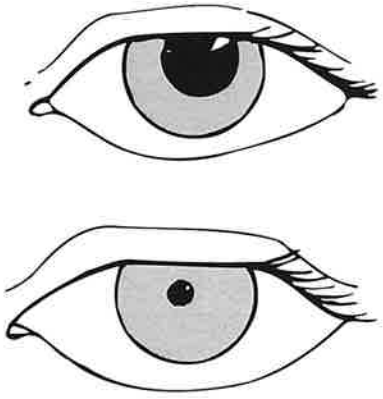
- Nausea, vomiting, diarrhea, and/or stomach cramps.
- Headache, dizziness, weakness, and/or confusion.
- Excessive sweating, chills, and/or thirst.
- Chest pains.
- Difficulty breathing.
- Muscle cramps or aches all over the body.

Telltale Signs

Poisoning by some pesticide chemical families produces distinctive signs that help others diagnose the cause of the poisoning.

Organophosphate and n-methyl carbamate poisoning, for example, are often identified by the presence of very small (pinpoint) pupils in the victim's eyes. Poisoning by pesticides containing arsenic or phosphorus is often detected by a garlic odor on the victim's breath. Anticoagulant-type rodenticides may cause bloody noses and bleeding gums. Certain herbicides can cause vomiting, headaches, and confusion.

Ask your physician or poison control center to obtain the latest edition of the EPA publication **Recognition and Management of Pesticide Poisonings**. It is available through EPA or from the U.S. Government Printing Office. Many physicians do not readily recognize and treat pesticide poisonings or injury because they rarely see such cases.



The eyes of some poisoning victims have tiny pupils.

Responding to a Pesticide Emergency

Get medical advice quickly if you or any of your coworkers have unusual or unexplained symptoms that appear within 24 hours of a pesticide exposure. Do not let yourself or anyone else become dangerously ill before calling for help or going to a hospital. It is better to be too cautious than too late. Take the pesticide container (or the labeling and the Safety Data Sheet [SDS]) to the physician. Do not carry the container in the passenger space of the vehicle.

First Aid for Pesticide Poisoning or Injury

The first response to pesticide emergencies is to stop the source of pesticide exposure as quickly as possible. First aid is the initial effort to help a victim while medical help is on the way. If you are alone with the victim, make sure he or she is breathing and is away from the pesticide before you call for emergency help. Administer cardiopulmonary resuscitation (CPR) chest compressions if the victim is not breathing and you cannot detect a pulse. Do not become exposed to the pesticide yourself while you are trying to help. Make sure you are wearing the right PPE before helping someone in an enclosed area.

In an emergency, look at the pesticide labeling. If it gives specific first aid instructions, follow them carefully. Call the National Poison Control Center (800-222-1222), the National Pesticide Information Center (800-858-7378), or 911. If labeling instructions are not available, follow the general guidelines below for first aid.

Pesticide on the Skin

- Drench skin and clothing with plenty of water. Any source of relatively clean water will do. If possible, immerse the person in a pond, creek, or other body of water. As a last resort, even water from a trough, ditch, or irrigation system could help dilute the pesticide.
- Remove PPE and contaminated clothing.
- Wash skin and hair thoroughly with a mild liquid detergent and water. A shower is the best way to completely and thoroughly cleanse the entire body surface.
- Dry the victim and wrap in a blanket or any clean clothing at hand. Do not allow him or her to become chilled or overheated.
- If the skin is burned or otherwise injured, cover immediately with a loose, clean, dry, soft cloth or bandage.

Administer first aid to victims of a pesticide poisoning or injury.

- Do not apply ointments, greases, powders, or other drugs when providing first aid treatment for burns or injured skin.

Pesticide in the Eye

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

Inhaled Pesticide

- Carry the victim to fresh air immediately.
- If other people are in or near the area, warn them of the danger.
- Loosen tight clothing on the victim that would constrict breathing.
- Keep the victim warm and quiet.
- Administer CPR (chest compressions) if breathing has stopped and you cannot detect a pulse. If there is a pulse, begin rescue breathing (artificial respiration).

Pesticide in Mouth or Swallowed

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

Do not induce vomiting:

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

Activated charcoal is another first aid treatment for swallowed pesticide. It acts as a magnet to adsorb many chemicals. Give the patient 2 to 4 tablespoons of pharmaceutical-grade activated charcoal dissolved in at least 8 ounces of water.

Heat Stress

Heat stress is the illness that occurs when the body is subjected to more heat than it can handle. In this manual, the term "heat stress" refers to both heat stroke and heat exhaustion. Heat stroke is a life-threatening condition. Heat exhaustion is less serious but can lead to heat stroke.

Heat stress is not caused by exposure to pesticides, but it may affect pesticide handlers who are working in hot conditions. Personal protective equipment worn while

handling pesticides can increase the risk of heat stress by limiting the body's ability to cool down. If you are under a physician's care, consult your physician before working in hot or humid conditions.

Avoid Heat Stress

Several factors work together to cause heat stress. Before you begin a pesticide-handling task, consider the following factors:

- Environmental conditions (temperature, humidity, air movement, and sunlight).
- Workload.
- Personal protective equipment.
- Water intake.
- Work schedule.

Environmental Conditions and Workload

High temperatures, high humidity, and direct sunlight increase the likelihood of heat stress. 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. Lifting or carrying heavy containers or equipment also increases the likelihood of overheating.

- Use fans and ventilation systems, and provide shade whenever possible. A work area or vehicle sometimes can be shaded by a tarp or canopy, or provided with fans.
- Allow time to adjust to the heat factors and workload. People accustomed to working in the heat are less likely to suffer from heat stress. To adjust to hot work environments, do short periods of light work in the heat for several days in a row. Gradually increase the work period and the workload over the next several days.
- Schedule frequent breaks when the risk of heat stress is high.

Personal Protective Equipment

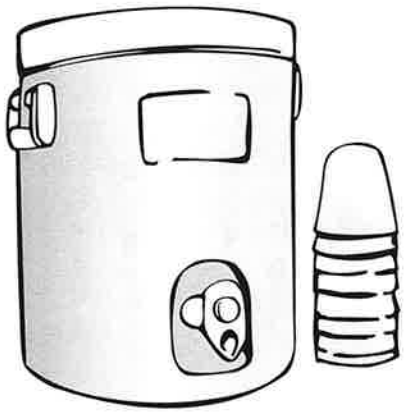
Pesticide-handling tasks often require you to wear extra layers of clothing or chemical-resistant suits and other protective equipment. This equipment keeps pesticides from getting on the skin. However, it also interferes with the natural body cooling that happens when sweat evaporates from the skin. You can get overheated very quickly when you are wearing personal protective equipment.

- Choose PPE designed to be as cool as possible or to provide a cooling effect (ex. a powered air-purifying respirator or back-vented coveralls). For more information on PPE, see Unit 7.
- Use awnings, fans, air conditioners, and cooling vests.

Water Intake

Evaporation of sweat from the skin helps to cool the body and maintain a constant core temperature. When it gets overheated, 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, heavy workload, or direct sunlight, a loss of as much as 1 gallon of water per hour is possible.

- Be sure to drink plenty of water or sports drinks during heat stress conditions. Do not rely on a feeling of thirst to tell you



Drink plenty of water to prevent heat stress.

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.

Work Schedule

Taking the above steps will prevent most heat stress problems. But you must be ready for times when, despite your best efforts, you or your coworkers 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.
- Plan your day – Try to schedule tasks requiring the heaviest workload or the most PPE during the coolest part of the workday.
- Stop work – Under extremely hot conditions when you cannot use cooling devices, you may need to stop work until conditions improve.

Signs and Symptoms of Heat Stress

Mild forms of heat stress (heat exhaustion) 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 (heat stroke) is a serious illness. Unless victims cool down quickly, they can die. Heat stroke is fatal to more than 10% of its victims, including 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. Take immediate action to cool down if you suspect you may be suffering from even mild heat stress. Signs and symptoms include:

- Fatigue (exhaustion or 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, or quarrelsome or irrational attitude).

Heat Cramps

Heat cramps are another type of heat stress. These are painful muscle spasms in the legs, arms, or stomach caused by loss of body salt through heavy sweating. To relieve cramps, have the victim drink lightly salted water or sports drinks. Stretching or kneading the muscles may temporarily relieve the cramps. However, if you suspect that stomach cramps are due to pesticide exposure, get medical help right away.

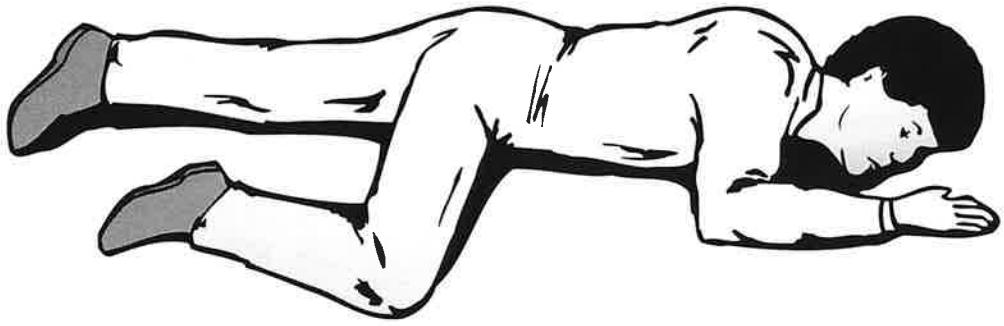
First Aid for Heat Stress

It is not always easy to tell the difference between heat stress illness and pesticide poisoning. The signs and symptoms are similar. Do not waste time trying to decide what is causing the illness. Get medical help.

To administer first aid for heat stress:

- Get the victim into a shaded or cool area.
- Cool victim as rapidly as possible by sponging or splashing the skin – especially face, neck, hands, and forearms – with cool water. When possible, immerse in cool water.
- Carefully remove all PPE and any other clothing that may be making the victim hot.

- Have the victim, if conscious, drink as much cool water as possible.
- Keep the victim quiet until help arrives.



Severe heat stress (heat stroke) is a medical emergency. Brain damage or death may result if treatment is delayed.

Know the Law

The Hazard Communication Standard (HCS), a regulation under the Occupational Safety and Health Act, requires employers to provide protections to workers who may be exposed to hazardous chemicals under normal operating conditions or in foreseeable emergencies. This regulation outlines the safe use of hazardous chemicals in the workplace, as enforced by the **Occupational Safety and Health Administration** (OSHA).

The HCS, which is administered by the U.S. Department of Labor, requires employers to:

- Make a list of the hazardous chemicals in the workplace.
- Obtain an SDS for all hazardous substances on the list.
- Ensure that all containers of hazardous materials are labeled at all times.
- Train all workers about the hazardous materials in their workplace.
- Keep a file with information (including the SDS) about the hazardous chemicals and make it available to workers.

The Occupational Safety and Health Act, administered by the U.S. Department of Labor, contains some requirements that could affect you if you or one of your employees is involved in a pesticide-related injury or illness:

- Employers must keep records of all work-related deaths, injuries, and illnesses and make periodic reports. Minor injuries needing only first aid treatment need not be reported. You must keep a record of any injury involving medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job.
- OSHA will investigate employee complaints related to exposure to hazardous materials such as pesticides.

Know the Law (cont.)

The Worker Protection Standard (WPS) is an EPA regulation. It requires growers who employ agricultural workers and pesticide handlers to take steps to protect them from pesticide exposures. The goal of WPS is to reduce the risks of pesticide poisonings and injuries. Specifically, WPS regulates pesticide use on agricultural establishments where plant production occurs.

Labels of pesticides used in agricultural plant production, nursery/greenhouse operations, and forestry note some of the WPS requirements. Protective clothing and equipment requirements, restricted-entry intervals (REIs), and instructions for notifying employees about treated areas are included on the labels of agricultural use products. However, growers must comply with all of the requirements of the WPS, as referenced by the label, including:

- Display of pesticide safety information, pesticide application information, and hazard information (WPS safety poster, location of medical facilities, and a list of recent pesticide applications) at a central location.
- Pesticide safety training for both field workers and noncertified pesticide handlers.
- Information exchange between the employers of agricultural workers (growers) and employers of commercial (for-hire) pesticide handlers.
- Restrictions during application, including application exclusion zones.
- Decontamination sites.
- Emergency assistance, including transport to medical care and providing information to medical personnel or employees.
- Notice of applications when the REI for the treated area is greater than 48 hours.
- Compliance with REIs.
- Protection for early-entry workers, including training and instruction, decontamination sites, and clean, well-maintained PPE. Records of notifications provided to early-entry workers must be kept for two years.
- Monitoring of handlers who are using certain highly toxic pesticides.
- Specific instructions to handlers, including label information and safe operation of application equipment.
- Equipment safety, including inspection and maintenance.
- Providing PPE (clean and maintained in good condition) for pesticide handlers and field workers, and preventing heat stress or illness.
- Observing specific application restrictions in nurseries and greenhouses.

Farm owners and immediate family members must comply with some – but not all – WPS requirements. Custom (commercial) applicators are also exempt from some WPS provisions.

For more information, consult EPA's WPS manual, **How To Comply With the 2015 Revised Worker Protection Standard For Agricultural Pesticides: What Owners and Employers Need To Know.**

Test Your Knowledge

Q. Explain the terms "hazard," "toxicity," and "exposure." How do 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 (acute, delayed, or allergic). Exposure occurs when a pesticide contacts a surface or an organism. For a person, it means getting pesticides in or on the body. HAZARD = TOXICITY x EXPOSURE.

Q. What are the four routes of pesticide exposure?

A. 1. Oral (swallowing a pesticide).

2. Inhalation (inhaling a pesticide).

3. Ocular (getting a pesticide in your eyes).

4. Dermal (getting a pesticide on your skin).

Q. How can you avoid harmful effects from pesticides?

A. By avoiding and reducing pesticide exposures. You can minimize exposures by working carefully, using safety systems (ex. closed systems and enclosed cabs), choosing easy-to-handle products and packaging, wearing appropriate personal protective equipment (PPE), washing exposed areas often, and keeping your PPE clean and in good operating condition.

Q. Which type of exposure is most likely for pesticide handlers?

A. Dermal (skin).

Q. Name several ways to prevent accidental ingestion of a pesticide.

A. Store pesticides properly. Keep pesticides in their original, labeled containers. Clearly mark all secondary pesticide containers and measuring cups to prevent their use for any other purpose. Never store pesticides in unlabeled containers, especially food or beverage containers.

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. The area of the body exposed.

3. The condition of the skin exposed.

Q. Two pesticide applicators are applying a highly toxic pesticide in a confined area. Neither is using a respirator. What kind of exposure are they risking?

A. Inhalation.

Q. While applying a granular formulation, an applicator removes his face shield to rub his eyes. What kind of exposure is he risking?

A. Ocular.

Q. What are closed mixing and loading systems?

A. Devices to prevent pesticides from contacting handlers or other persons during mixing and loading. The labeling of some pesticides requires the use of a closed mixing and loading system when handling the product.

Q. What are minibulk containers? What are their advantages?

A. Tanks that are adapted to or designed as closed mixing and loading systems. Minibulks attach to the sprayer without exposing the pesticide handler to the pesticide. These containers reduce both pesticide and plastic waste. They may be returned to the dealer for refilling or for claiming a deposit.

Q. Describe water-soluble packaging. What are its drawbacks?

A. Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or package. The pesticide package is placed unopened into the mixing tank. The package dissolves in water or liquid fertilizer.

One drawback is the risk of accidental release of the concentrate during shipping or storage. Another is the risk of splashing as containers are added to the tank. Additionally, water-soluble bags are designed to treat a specific area size – you cannot increase or decrease their quantity.

Q. What are enclosed application systems?

A. Enclosures (such as cabs or cockpits) that surround the occupants. These enclosures may prevent pesticide exposure as long as doors, hatches, and windows remain closed during the application.

Q. True or false: Working inside an enclosed cab allows you to wear less PPE than the label specifies.

A. False. Even though you are inside a cab, you must wear <u>all</u> PPE specified on the label. Enclosed cabs are a supplement to PPE – not a replacement for it.

Q. What is the difference between acute and chronic toxicity? Briefly discuss.

A. Acute toxicity is the measure of harm caused by a single pesticide exposure. Harmful effects may be systemic, contact, or both. Acute toxicity is determined by using lethal dose (LD_{50}) or lethal concentration (LC_{50}) values. These measures help identify which pesticides are classified as poisons.

Chronic toxicity is the measure of harm caused by repeated, prolonged exposure to small amounts of pesticide. Chronic toxicity is determined by exposing laboratory animals to an active ingredient for about two years.

Q. Which pesticide is more toxic: one with an LD_{50} value of 50 mg/kg or one with an LD_{50} value of 5,000 mg/kg? Why?

A. The pesticide with an LD_{50} value of 50 mg/kg. A very low dose of this substance (a few drops to a teaspoon) could kill a person. The pesticide with an LD_{50} value of 5,000 mg/kg is much less toxic – a medium-to-large dose of the substance (an ounce to a pint or a pound) is necessary to kill or harm someone. The higher the LD_{50} value, the less acutely toxic the chemical.

Q. If a pesticide has the signal words DANGER—POISON with a skull and crossbones symbol on its label, how toxic is it to people?

A. It is extremely toxic – a very low dose (a few drops to 1 teaspoon) could kill a person.

Q. Distinguish between acute, delayed, and allergic effects.

A. Acute effects are illnesses or injuries that appear soon (within 24 hours) after exposure to a pesticide. Delayed effects are illnesses or injuries that appear more than 24 hours after exposure to a pesticide or combination of pesticides. Allergic effects are harmful effects that some people experience when exposed

to substances that do not cause the same reaction in others. These effects are expressed as a hypersensitivity to a specific substance, often called the allergen.

Q. A pesticide applicator accidentally splashed some pesticide on her arm. A few hours later, her skin began to blister and change color. What type of effect did she experience?

A. Acute dermal.

Q. A pesticide handler was exposed to small amounts of a carbamate insecticide several times over a six-week period. What harmful effect might result?

A. A reduction of the body's cholinesterase levels. This may harm the central nervous system.

Q. Name three types of delayed effects. Which type relates to the viability of a fetus?

A. 1. Chronic.

2. Developmental and reproductive.

3. Systemic.

Developmental effects have to do with how pesticide exposure affects the health of a fetus.

Q. What are delayed systemic effects? Give at least two examples.

A. Illnesses or injuries to a system in the body that appear more than 24 hours after exposure to a pesticide or combination of pesticides. Examples include disorders of the blood, nervous system, brain, skin, lungs, liver, and kidneys.

Q. Describe how a person may become sensitized to a pesticide.

A. After being exposed to the pesticide a few times without effect, a person might develop a severe allergy-like response upon later exposures. This sensitization process could result in asthma; rash, blisters, or sores; itchy, watery eyes; or even shock.

Q. Name four signs or symptoms of pesticide poisoning and two signs or symptoms of external irritation effects from pesticides.

A. Pesticide poisoning: nausea, vomiting, diarrhea, and/or stomach cramps; headache, dizziness, weakness, and/or confusion; excessive sweating, chills, and/or thirst; chest pains; difficulty breathing; muscle cramps or body aches.

External irritants: redness, blisters, rash, and/or burns on skin; swelling; a stinging sensation; burns in eyes, nose, mouth, and throat.

Q. What steps should you take in a pesticide emergency?

A. Stop the source of pesticide exposure as quickly as possible. Make sure the victim is breathing and is away from the pesticide. Administer cardiopulmonary resuscitation (CPR) chest compressions if the victim is not breathing and you cannot detect a pulse. Call the National Poison Control Center or 911 for help. Look at the pesticide labeling and follow any first aid instructions.

Q. Describe basic first aid procedures for pesticide poisoning or injury.

A. Pesticide on the skin: Drench skin and clothing with plenty of water, removing PPE and contaminated clothing. Wash skin and hair thoroughly with a mild liquid detergent. Dry the victim and wrap in a blanket or clean clothing. Cover any burns with a loosely fitting bandage.

Pesticide in the eye: Rinse the eye for at least 15 minutes. Do not use chemicals or drugs in the rinse water. Use an eyewash dispenser, if available.

Inhaled pesticide: Carry the victim to fresh air immediately. Loosen any tight clothing, and keep the victim warm and quiet.

Swallowed pesticide: Rinse the mouth, then give the victim a large amount of water to drink. Do not induce vomiting unless the labeling instructs you to do so. Give the victim pharmaceutical-grade activated charcoal dissolved in water to adsorb harmful chemicals.

Q. What is heat stress?

A. The illness that occurs when the body is subjected to more heat than it can cope with. In this manual, the term "heat stress" refers to both heat stroke and heat exhaustion.

Q. What five factors should you consider to avoid heat stress?

A. Environmental conditions (temperature, humidity, air movement, and sunlight); workload; personal protective equipment; water intake; and work schedule.

Q. What steps could you take to avoid heat stress?

A. 1. Use fans and ventilation systems; provide shade whenever possible.

2. Allow time to adjust to the heat factors and workload.

3. Schedule frequent breaks, and assign the most difficult tasks during the coolest part of the day.

4. Choose PPE designed to be as cool as possible.

5. Drink plenty of water or sports drinks.

Q. What are some common signs and symptoms of heat stress?

A. Fatigue (exhaustion or 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; and altered behavior (confusion, slurred speech, or quarrelsome or irrational behavior).

Q. If you are not sure whether a person is suffering from heat stress or pesticide poisoning, what should you do?

A. Get medical help right away. In the meantime, get the person to a cooler place away from pesticides. Remove PPE or other clothing that could be contaminating the skin or making the person hot. Clean and cool the skin with water, and give the person plenty of water to drink. Keep the victim quiet.

Unit 7. Personal Protective Equipment

Learning Objectives

After studying this unit, you should be able to:

- Define personal protective equipment (PPE) and explain its importance to pesticide handlers.
- Explain the legal responsibility to follow all PPE requirements on pesticide labeling.
- Identify the minimum PPE required for a particular pesticide application.
- Define the term "chemical resistant."
- Describe the signs that tell you a material is not chemically resistant to a certain pesticide.
- List and describe what PPE to use to protect your skin from pesticide exposure.
- Explain when and how to wear gloves and footwear.
- Describe how to protect your head, neck, and eyes from pesticides.
- State the importance of protecting your respiratory tract while handling pesticides.
- Distinguish among and describe air-purifying respirators and atmosphere-supplying respirators.
- Describe how to choose the proper respirator for a job based on National Institute for Occupational Safety and Health (NIOSH) designations.
- Explain how to perform fit tests and fit checks on air-purifying respirators.
- Name some pesticide application tasks that may require extra PPE.
- State how to clean, maintain, and store PPE according to manufacturers' recommendations.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Active Ingredient (a.i.) – A chemical in a pesticide product that affects or controls the target pest.

Air-Purifying Respirator – A type of personal protective equipment that removes particulates and toxic vapors. It traps and removes contaminants from the surrounding atmosphere using a cartridge, canister, or particulate filter.

Air-Supplying Respirator – A type of personal protective equipment that provides breathing air from a source independent of the surrounding atmosphere.

Canister Respirator – A type of personal protective equipment that has a cylindrical container (canister) filled with gas- and vapor-removing material. The canister is either connected directly to the facepiece or worn on a harness and connected to the facepiece by a flexible hose. Canister respirators are often called gas masks.

Cartridge Respirator – A type of personal protective equipment that contains gas- and vapor-removing material. Cartridge respirators may be either one-piece units with cartridges permanently attached to the facepiece, or two-piece units with removable cartridges.

Chemical Resistant – Able to prevent movement of a pesticide through material during the period of use.

Terms to Know (cont.)

Concentrates – Pesticides that have a relatively high percentage of active ingredient.

Exposed/Exposure – Contacting or touching (or subjected to contact with) a pesticide; getting a pesticide on a surface, or in or on an organism. Exposures may be oral, inhalation, dermal, or ocular.

Filtering Facepiece Respirator (FFR) – A disposable air-purifying device that protects the user by filtering particles (particulates) from the air. The filter is an integral part of the facepiece. There are seven classes of filters for NIOSH-approved FFRs currently available. FFRs are one type of particulate-filtering respirator.

Fit Check – An on-the-spot test to make sure a respirator is working correctly and is positioned properly on the face.

Fit Test – A procedure to evaluate the fit of a respirator on an individual. This may be a qualitative or a quantitative test.

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

Fumigant – A pesticide that is or forms a toxic vapor or gas when applied.

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

N, R, and P Series – Filters classified by NIOSH based on oil degradation resistance. N-series filters are not oil resistant, R-series filters have limited oil resistance (typically eight hours of use), and P-series filters have indefinite oil resistance (oil proof). The filter efficiency level for each classification may be 95%, 99%, or 99.97%.

National Institute for Occupational Safety and Health – The federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH tests and sets standards for respiratory-protection devices such as filtering facepiece respirators and cartridge respirators, as well as other personal protective equipment.

Particulate-Filtering Respirator – A disposable air-purifying device that protects the user by filtering dusts, mists, powders, and particles from the air.

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Prefilter – An accessory item placed in front of an approved filter that removes coarse particles from the air. Prefilters do not meet NIOSH requirements for particulate filters. Respirators with prefilters must still meet these requirements.

Release – To discharge pesticide from its container or the equipment or system used to apply it. Release can be intentional (as in an application) or accidental (as in a spill or leak).

Residue – An amount of pesticide that remains in the environment (ex. on a plant, an animal, or in the soil) after an application or a spill.

Respirator – A device that protects the respiratory tract from irritating and poisonous gases, fumes, smoke, and dust. Some respirators have equipment that supplies oxygen or clean air.

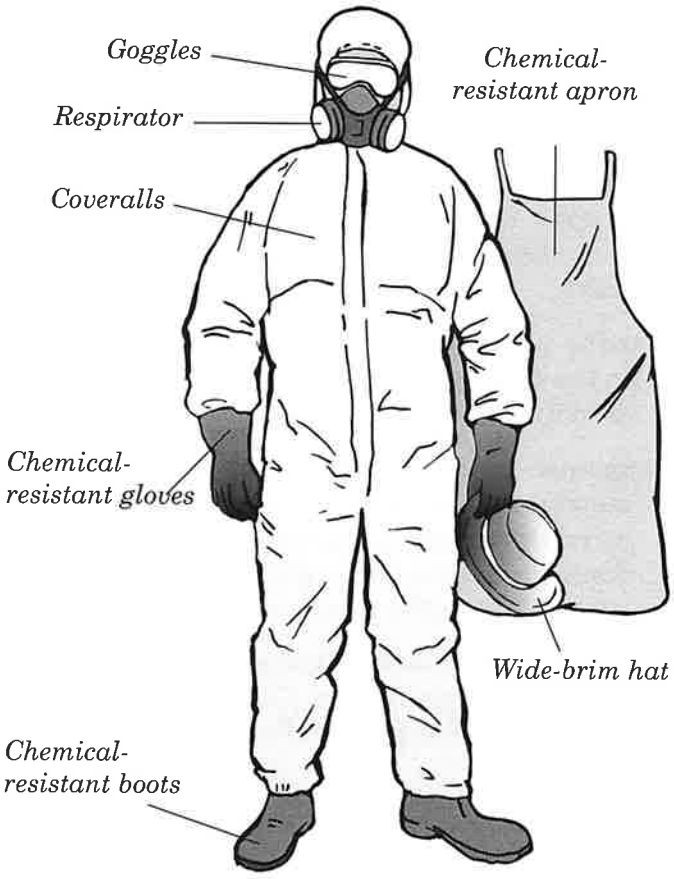
Solvent – A liquid that will dissolve a substance and form a true solution. Common solvents include water, acetone, refined oil, and alcohol.

Water-Based Products – Pesticides or other chemicals that use water as the only diluent or carrier.

What Is Personal Protective Equipment?

Pesticides can be harmful to humans. To prevent or reduce **exposure** to pesticides, you need to wear **personal protective equipment (PPE).** PPE refers to clothing and devices worn to protect the human body from contact with pesticides or pesticide **residues**. Personal protective equipment includes coveralls or protective suits, footwear, gloves, aprons, **respirators**, eyewear, and hoods or hats. Wearing PPE can greatly reduce the chance of pesticide exposure – and, hence, pesticide poisoning. Remember, though, that PPE reduces exposure but may not eliminate it.

*All **pesticide handlers** and early-entry agricultural workers are legally required to follow all PPE instructions on the product **labeling**.* Pesticide labeling lists the *minimum* PPE you must wear while handling a pesticide. Sometimes the labeling lists different requirements for different activities. For example, you may need more PPE for mixing and loading than for application. PPE offers varying levels of protection. Some items simply keep dry or spray material off the skin. Others offer better protection against **water-based products.** Some protect you from chemicals in a concentrated pesticide product. PPE must be comfortable enough that people will wear it and use it properly.



Personal Protective Equipment

This unit describes some common types of PPE used to protect people from pesticide exposure. Read the label, analyze the task ahead, and use your common sense to choose the right personal protective equipment for each job.

Chemical-Resistant Clothing

Some pesticide labeling requires you to wear chemical-resistant personal protective equipment. "**Chemical resistant**" means that no measurable amount of the pesticide can go through the material during the period of use. Some PPE is water-resistant only. Water-resistant PPE will keep a small amount of fine spray particles or small liquid splashes from penetrating the clothing and reaching the skin. Waterproof material keeps water-soluble substances out. However, it may not keep out oil **solvent**-based products. Waterproof materials include items made of plastic or rubber.

Some materials are also chemical-resistant. The chemical resistance of a material indicates how strongly it resists chemical penetration by pesticide products during use. Read the PPE packaging carefully to determine whether the protective item is chemical-resistant, waterproof, or water-resistant.

Choosing Chemical-Resistant Materials

When deciding which protective equipment to use, follow these general guidelines. Cotton, leather, and other absorbent materials are not chemical-resistant, even to dry **formulations**. Powders and dusts sometimes move through cotton and other woven materials as quickly

as liquid formulations. Do not use a hat that has a cloth or leather sweatband, and do not use cloth or cloth-lined gloves, footwear, and aprons. Cloth and leather are difficult or impossible to clean after a pesticide contaminates them. Items made of these materials are too expensive to replace after each use.

Gloves, boots, aprons, suits, and hoods come in a variety of chemical-resistant materials.

Generally, the best choices are:

- Plastics, such as polyvinyl chloride (PVC).
- Synthetic rubber, such as butyl, nitrile, neoprene, or viton rubber.
- Nonwoven fabrics coated with plastic or another barrier material.

Barrier-laminate materials are resistant to most pesticides. However, many pesticide handlers consider gloves made of these materials uncomfortable to wear and hard to use while doing many tasks.

Solvents

The ability of a given material to protect someone from a pesticide product depends largely on the type of solvent used to formulate the product. Common solvents are xylene, acetone, and alcohol. When xylene is in a formulation, the ingredient statement on the front panel of the pesticide label must list it.

Watch for signs that the material is not chemically resistant to the pesticide you are using. Sometimes it is easy to see when plastic or rubber is not resistant to a pesticide. The material may:

- Change color.
- Become soft or spongy.
- Swell or bubble up.
- Dissolve or become like jelly.
- Crack or get holes.
- Become stiff or brittle.

If any of these changes occur, discard the item and choose another type of material.

The pesticide labeling will often tell you what materials are resistant to the pesticide product. Other helpful sources include Virginia Cooperative Extension, pesticide distributors, and PPE manufacturers.

Length of Exposure

Different materials that are resistant to a particular pesticide do not necessarily protect you for the same amount of time. Some materials restrict pesticide entry for a long time. Others will allow the pesticide to penetrate the PPE more quickly. Thin materials, such as disposable plastic gloves, shoe covers, or aprons, may provide enough protection for short-term tasks (a few minutes' duration). Longer jobs usually require heavier material.

Chemical resistance is often stated as exposure time. For example, neoprene is resistant to acetone for 30 minutes or less. If you wear neoprene gloves while handling pesticides containing an acetone solvent, change the gloves at least every 30 minutes. Otherwise, the pesticide and the acetone might penetrate the gloves and get onto your hands.

Protect Your Skin

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

Work Clothes

Ordinary shirts, pants, shoes, and other work clothes usually are not considered PPE. However, pesticide labels often require pesticide handlers to wear specific items of clothing during certain activities. Any time you handle pesticides, wear – at a minimum – a long-sleeved shirt, long pants, shoes, and socks. The shirt and pants should be made of a sturdy woven cotton material, free of holes and tears. Fasten the shirt collar completely to protect the lower part of your neck. Sometimes, the labeling requires you to wear a coverall, a chemical-resistant suit, or a chemical-resistant apron over your work clothes.

Coveralls

For the best protection, choose coveralls with flaps over the zippers, elastic at the wrists and ankles, and seams that are bound and sealed. Coveralls should be made of sturdy material such as cotton (high thread count and tight weave), polyester, a cotton-synthetic blend (at least 50% cotton), or a nonwoven fabric. When wearing a coverall, close the opening securely so the entire body (except the feet, hands, neck, and head) is covered. If you wear a two-piece coverall, do not tuck it in at the waist. Allow the shirt to extend well below the waist of the pants and fit loosely around the hips.

Wear a coverall over a long-sleeved shirt, long pants, and socks when handling pesticides that are highly or moderately toxic by dermal exposure or are skin irritants.

Several factors determine how well a coverall protects you. First, it needs to fit loosely. Each layer of clothing and air between the pesticide and your skin provides added protection. If the coverall fits too tightly, there will not be a layer of air between it and your skin. Any pesticide that gets through the coverall will directly contact your skin.

The design and structure of the coveralls also affect how well they protect you. Well-designed coveralls have tightly constructed, sealed seams and snug, overlapping closures that do not allow gaps or unfasten readily. This type of construction makes it harder for pesticides to get through these areas and onto your inner clothing or your skin. Some coveralls are water-resistant and disposable.

Chemical-Resistant Suit

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

Chemical-Resistant Suit

If you believe a large amount of pesticide may be deposited on your clothing over an extended period, consider wearing a chemical-resistant suit even if the product label does not require it. Under those circumstances, even pesticides that are applied dry (such as dusts or granules) can go through ordinary fabric and harm you.

Chemical-resistant suits made of rubber or plastic are often called rain suits. They are 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 air-conditioned environments, heat stress becomes a major concern. Take extra precautions to avoid heat stress by drinking plenty of water and taking frequent rest breaks.

Chemical-Resistant Apron

An apron protects you from splashes, spills, and billowing dust. It also protects your coveralls or other clothing. Consider wearing a bib-top apron made of butyl, nitrile, or foil-laminate material whenever you handle pesticide **concentrates**. The product label may require you to wear a chemical-resistant apron when mixing and loading a pesticide or cleaning application equipment.

Chemical-Resistant Apron

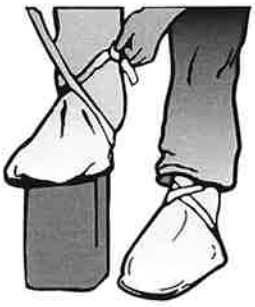
Choose an apron that extends from your neck to at least your knees. Some aprons have attached sleeves and gloves. This style of apron protects your arms and hands and the front of your body. It eliminates the potential gap where the sleeve and glove or sleeve and apron meet.

An apron is cooler than a chemical-resistant suit and is easy to remove. However, it can be a safety hazard when you are working around equipment with moving parts. If an apron could get caught in machinery or get in your way, wear a chemical-resistant suit instead.

Gloves and Footwear

Pesticide handlers are most likely to get pesticides on their hands and forearms. Studies have shown that wearing chemical-resistant gloves can reduce pesticide exposure to hands by 99%. As a result, most product labels will require the use of waterproof or chemical-resistant gloves while handling and mixing pesticides. Wear gloves any time you may get pesticides on your hands except when handling certain **fumigants** (see below).

Pesticide handlers also often get pesticides on their feet. Leather or canvas/cloth shoes absorb pesticides easily and cannot be decontaminated. Cover them with overshoes or use waterproof or chemical-resistant footwear when handling pesticide concentrates, making applications, or if pesticide residues may get on your footwear.



Wear chemical-resistant footwear to protect your feet.

Some product labels require you to wear waterproof or chemical-resistant footwear. This could mean shoe covers or boots. If a pesticide is likely to get on your lower legs or feet, wear chemical-resistant boots that extend at least halfway up to your knee. Wearing waterproof boots is especially important if you enter or walk through treated areas before the spray has dried (ex. pesticide applications made to lawns).

Some pesticide labels may require specific types of gloves and footwear – or prohibit their use. For example, the labeling on some fumigants will tell you to wear loose-fitting clothes and "breathable" footwear such as canvas or other fabric. Do not wear gloves or footwear when handling the fumigant methyl bromide. They can trap the fumigant gas near the skin, which can cause burns or lead to poisoning through skin absorption. Other fumigants (ex. aluminum phosphide and magnesium phosphide) require you to wear gloves made of cotton or a similar material when handling the product. Read the label.

Wear Gloves and Footwear Correctly

Be sure to choose gloves and footwear suitable for the pesticide you are handling. Always start out with new or freshly cleaned gloves and footwear. Do not grab a pair just because they are handy. They may not be the right style or made of the right material for the job.

If pesticide gets inside your gloves or footwear, take them off right away. Wash your hands or feet, and put on clean protective equipment. Keep several pairs of gloves

and footwear on hand. Change to a clean set whenever you suspect the inside has become contaminated. Clean or discard contaminated PPE.

Contamination often occurs when applicators remove their gloves to adjust their equipment or PPE, open a pesticide container, or wipe their faces – then replace the gloves over their contaminated hands. If you must remove your gloves while handling pesticides, wash the gloves thoroughly before taking them off. Then wash your hands thoroughly and dry them before you touch anything. Put the gloves on again when you return to work. Another common mistake is putting on footwear with contaminated hands. This may transfer the pesticide from your hands to your socks and feet.

Be careful not to allow pesticides to run down your sleeves into your gloves. For jobs in which your arms are mostly lowered, place sleeves outside the gloves. Use gloves that go up over your wrist and at least halfway to your elbow. For jobs in which your arms are mostly raised, leave your gloves outside your sleeves. Fold the cuffs of your gloves up 1 or 2 inches toward your fingers to catch the pesticide before it runs down your arm.

For some jobs, you will be working some of the time with your arms raised and some of the time with them lowered. In these cases, close the glove cuff tightly outside the sleeve and put heavy-duty tape or an elastic band around the end of the glove where it meets the sleeve. Some gloves have a way to tighten the cuff to your sleeve so the pesticide cannot run down into the glove.

Wear chemical-resistant gloves to protect your hands.

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

Hats

For overhead exposure or exposure to many airborne particles, wear something to protect your head and neck. Chemical-resistant hoods or wide-brimmed, unlined hats are good choices. Plastic safari hats with plastic sweatbands are cooler in hot weather. More flexible hats and hoods are also available in chemical-resistant materials. Hats must not contain absorbent material, such as cotton, leather, or straw. Many chemical-resistant jackets or coveralls come with attached, protective hoods.

Protect Your Eyes

Eyes are very sensitive to the chemicals in some pesticide formulations, especially concentrates. The moist membranes in your eyes readily absorb pesticides. Some product labels require handlers to wear protective eyewear. Chemical splash-proof goggles, a face shield, or safety glasses with shields at both the brow and sides are examples of protective eyewear. Some labels specify a particular type of eye protection. Contact lens wearers should consult an eye doctor or other physician before using pesticides.

Shielded safety glasses and full-face shields are good choices in many handling situations because they are comfortable, do not cause fogging or sweating, and give excellent eye protection. Face shields cupped inward toward your throat give better protection from splashes than straight face shields. Wear goggles that fit tightly against your face if you will be:

- In an open cab during an air-blast application.

- Applying mists, fogs, or aerosols indoors.
- In any other situation where you will be enveloped in a spray, mist, or dust.

Select goggles made of polycarbonate with protected air baffles to avoid fogging. You can wear either goggles or shielded safety glasses with a half-face respirator. Full-face respirators have their own face shields. Additional eye protection is not required.

Protect your eyes with proper safety glasses.

Eyewash Dispenser

Under the agricultural Worker Protection Standard, if the label requires goggles for eye protection, pesticide handlers must have an eyewash dispenser available at all times. They are recommended at all mixing/loading sites. Eyewashes can be portable or set in a fixed location (ex. an eyewash station in a greenhouse). If a pesticide gets past your goggles, you do not have time to look for clean water to flush your eyes. Carrying an eyewash dispenser with you is best. This is because some corrosive and irritant products can cause injury within seconds.

Protect Your Respiratory Tract

The respiratory tract consists of the lungs and other parts of the breathing system. It is much more absorbent than the skin. Even if a pesticide label does not require it, consider wearing a respirator:

- If you are handling a product for which the label states, "Do not breathe vapors or spray mist," or "Harmful or fatal if inhaled."
- If you will be exposed to any pesticide that could be inhaled.

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

The federal Occupational Safety and Health Administration (OSHA) has issued regulations for a respiratory-protection program. This program contains eight elements, mandatory for all respirator users:

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

Respirators

A respirator is a safety device that covers at least the mouth and nose. Respirators protect you from breathing pesticide-contaminated air. Various pesticide formulations require different types of respirators. The product label states whether you must use a respirator and, if so, which type.

There are two main types of respirators:

1. Atmosphere-supplying respirators, which provide clean, uncontaminated air from an air tank or an offsite location.

2. **Air-purifying respirators**, which remove contaminants from the surrounding air using a cartridge, canister, or particulate filter.

Atmosphere-Supplying Respirators

Use atmosphere-supplying (also called air-supplying) respirators when required to do so by the product label. Use these devices when the oxygen supply is low or when fumigating in enclosed areas. Such areas might include greenhouses or other buildings, railcars, ship holds, and grain bins.

When the oxygen supply is low, you must use a self-contained breathing apparatus (SCBA) or an airline respirator with an escape cylinder.

Fumigant gases are extremely toxic to people, and PPE requirements are more stringent than for other types of pesticides. Use great caution and wear appropriate personal protective equipment whenever you handle fumigants. Wear the respirator listed on the fumigant labeling during any handling activity. This includes removing tarps or other coverings, and when exposure to the gas is likely.

There are two types of atmosphere-supplying equipment: SCBA and airline (also called supplied-air) respirators.

Self-Contained Breathing Apparatus

Self-contained breathing apparatus consists of a full-face mask attached to a compressed cylinder of air that is carried by the worker. The cylinder of compressed air supplies air to a two-stage regulator. The regulator reduces the pressure and delivers breathable air to the facepiece. An SCBA provides complete respiratory protection against toxic gases, vapors, particulates, and oxygen deficiency.

If you carry your air supply, you do not need to be connected to a stationary source of breathable air. This gives you the mobility of a canister mask and does not restrict movement. One person can carry enough air for up to 60 minutes. However, use time depends on the size and health of the applicator and the amount of strenuous work he or she is doing. The more strenuous the work, the more quickly air is consumed.

Self-Contained Breathing Apparatus (SCBA)

Airline Respirators

Airline respirators have a facepiece that delivers air through an air hose connected to a compressor, blower, or compressed air tank. The air supply is not designed to be carried by the user and may be located outside the treatment area. Supplied-air respirators are lightweight and provide long, continuous use. They are relatively inexpensive. However, the applicator is at the mercy of the hose, which limits movement and may be crushed or kinked.

Air-Purifying Respirators

Air-purifying respirators remove particles as well as toxic gases and vapors. They use filters, sorbents, and catalysts to trap and remove contaminants from the air. When you breathe in, you draw air from outside the respirator, through air-purifying filters, and into the mask. The filtering material absorbs impurities as the air passes through.

Air-purifying respirators will not protect you from fumigants in all situations, from extremely high concentrations of gases or vapors, or when the oxygen supply is less than 19.5% by volume. However, in most situations requiring the use of respiratory protective equipment, an air-purifying respirator is sufficient.

Functions of Air-Purifying Respirators

Air-purifying respirators remove contaminants from the air by:

- Filtering dusts, mists, and particles.
- Removing gases and vapors.

Wear a **filtering facepiece respirator (FFR)** if required by the pesticide labeling or if you will be exposed to pesticide dusts, powders, mists, or sprays in your breathing zone. Wear a respirator that also removes gases and vapors if required by the product label or if you will be exposed to gases or vapors in your breathing zone. If any oil is present, you must use only R- or P-class FFRs (see "Selecting and Using Respirators" below). Always use the label-required respirator for optimum respiratory protection and to comply with the law.

Air-Delivery Systems

Air-purifying respirators may be either powered or nonpowered.

Powered, Air-Purifying Respirators

Powered, air-purifying respirators (PAPRs) use a blower to move the contaminated air through one or more purifying filters. Do not confuse PAPRs with atmosphere-supplying respirators – PAPRs do not supply breathable air from an outside source. These respirators are available as lightweight backpacks. They may also be mounted on or in application equipment powered by the vehicle's electrical systems.

Some PAPRs have tight-fitting facepieces; others have loose-fitting hoods or helmets. PAPRs may also have another type of hood called a loose-fitting facepiece. Loose-fitting respirators constantly pump air through one or more cartridges or canisters into a head covering that resembles a helmet or hood. The positive outward pressure caused by the steady outflow of air keeps contaminants out of the headpiece. The purified air circulates over the user's head, face, and neck and provides some cooling.

Not all PAPRs move air at the same rate. **The National Institute for Occupational Safety and Health (NIOSH)** requires tight-fitting PAPRs to have a minimum airflow rate of 4 cubic feet per minute (cfm). Loose-fitting PAPRs must have an airflow rate of at least 6 cfm.

Because loose-fitting respirators do not have to form a seal, people with facial hair can use them safely. They do not require extra lungpower and are not nearly as tiring or as hot as face-sealing respirators.

Loose-fitting respirators are a good choice:

- To avoid the need for **fit tests** and **fit checks**.
- For pesticide exposure lasting several hours.
- If heat stress is a concern.

See "Fit Testing Respirators" below for more information about fit tests and fit checks.

Nonpowered, Air-Purifying Respirators

Nonpowered respirators can be either half-face or full-face devices. They place a filtration unit between your nose and mouth and the contaminated air source. Filtering facepiece respirators and most cartridge and **canister respirators** are examples of nonpowered, air-purifying respirators.

Cartridges for gases and vapors are approved for specific contaminants. Particulate-removing filters will work, regardless of the exact composition of the aerosol. Combination chemical- and particulate-removing cartridges are also available. When handling some pesticides, an organic vapor (OV) cartridge is required. Many pesticide labels require using respirators with OV cartridges without specifying any other type of cartridge. Therefore, all **cartridge respirators** used for protection against pesticides must be fitted with cartridges that are approved for organic vapors. (Filters are also usually required.) The parts of a typical nonpowered, air-purifying cartridge respirator are:

- One or more air-purifying cartridges.

- A facepiece with exhalation and inhalation valves.
- Adapters to mount the cartridges or filters.
- A head harness.

A **prefilter** – together with a NIOSH-approved filter – may also be included as an accessory item.

If you have respiratory problems, a licensed healthcare professional must clear you before you wear ANY respirator.

Half-Face Respirator

Full-Face Respirator

Styles of Air-Purifying Respirators

There are three basic styles of air-purifying respirators: particulate filtering, cartridge, and canister.

Particulate-Filtering Respirator

Particulate-filtering respirators offer protection from small, airborne particles. Filtering facepiece respirators are one type. Particulate-filtering respirators cover the nose and mouth to filter out dusts, mists, powders, and particles. Dispose of them after each use or according to the manufacturer's instructions.

Cartridge Respirator

Cartridges contain gas- and vapor-removing material. Many pesticide labels specify a NIOSH-approved, combination OV/particulate-filtering respirator with any R or P filter that has these approval number prefixes: TC-84A and TC-14G for nonpowered, air-purifying respirators, or TC-23C and TC-14G for PAPRs.

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 may be cleaned and reused.

Canister Respirator

A canister contains both gas- and vapor-removing material. Canisters contain more air-purifying material than cartridges. They last longer and may give better protection when the concentration of gas or vapor in the air is high. They are also heavier and more uncomfortable to wear than cartridge respirators.

Canister-type respirators are often called gas masks. The canister is usually connected directly to the facepiece or worn on a harness and connected to the facepiece by a flexible hose. The facepiece and other parts are designed to be cleaned and reused. You can replace the canisters when necessary.

Selecting and Using Respirators

The National Institute for Occupational Safety and Health is the federal agency responsible for testing and certifying respirators used by pesticide handlers. Approval numbers beginning with the letters "TC" (testing and certification) are assigned to all respirators reviewed by the agency. Pesticide product labels often specify the type of respirator required by listing its TC schedule number (see below). In addition, filters are classified based on oil degradation resistance and filter efficiency. The classification levels for oil degradation resistance are N (not oil resistant), R (limited oil resistance), and P (oil proof).

Canister-Style Respirator

This is known as the **N, R, and P series**. The filter efficiency for each classification level may be 95%, 99%, or 99.97%.

Another designation, HE (high efficiency), is used for PAPRs. HE filter efficiency is equal to or greater than 99.97%. Numerical codes are not used with HE filters.

Below is a list of several types of respirators and their TC schedule number designations:

- TC-84A – nonpowered, particulate-filtering respirators (N, R, P, or HE filters). Also includes combination cartridges for gas/vapor and particulates.
- TC-21C – powered, air-purifying, particulate-filtering respirators only (100 series filters).
- TC-23C – powered, air-purifying, chemical cartridge respirators with or without particulate filters.
- TC-14G – gas masks with canisters.
- TC-19C – supplied-air respirators.
- TC-13F – self-contained breathing apparatus.

The complete NIOSH approval number has this format: TC + schedule number (ex. 84A) + serial number for each make and model.

The product formulation, toxicity, and type of application influence the type of respirator you need. Manufacturers use criteria approved by the Environmental Protection Agency (EPA) to assign PPE respirator requirements on labels (see Table 7-1). When a pesticide label requires a respirator, wear a NIOSH-approved one that matches the specifications given on the product label. Remember, no one respirator will protect you from every pesticide or formulation that you may use.

If the label recommends a NIOSH/MSHA (Mine Safety and Health Administration) respirator, it is referring to an older classification system. In this system, TC-21C designated dust/mist mask respirators. The correct designation is now TC-84A, and the name has changed to particulate-filtering respirators. (MSHA only approves respirators used in mine rescue or other mine emergencies.) Be sure to use the right respirator for your pesticide.

Table 7-1. Label examples based on EPA respiratory-protection criteria

EPA criteria	Label statement for respiratory protection
Solid pesticides with Toxicity Class II, III, or IV	Use a NIOSH-approved respirator with any N, R, P, or HE filter with approval code TC-84A or TC-21C.
Liquid pesticides, Toxicity Class I	Use a NIOSH-approved respirator with a combination OV/particulate-filtering cartridge or canister with any R, P, or HE filter with approval code TC-84A, TC-14G, or TC-23C.
Gas applied in enclosed area	Use an air-supplying respirator with NIOSH TC-19C, or use a self-contained breathing apparatus with NIOSH TC-13F.

Source: National Pesticide Applicator Certification Core Manual, p. 96.

Particulate-Filtering Respirator

Look for a respirator held in place by two straps. One-strap styles do not keep the respirator adequately sealed against the face.

When you wear a respirator with a particulate-removing filter, you will have trouble breathing as more dusts, mists, and other particles become trapped in the filter material. When breathing becomes too difficult, replace the filter. Always check the user's instructions for specific requirements. Eight hours of use is usually the limit. During continual use, you may need to change filters twice a day – more often in dusty or dirty conditions. Do not use a filtering facepiece respirator if the pesticide will completely soak the mask. Replace the mask if it gets soaked or loses its shape.

NIOSH no longer uses the term "dust/mist respirators," and the term "prefilter" is no longer used for NIOSH-approved products. NIOSH has replaced the dust/mist classification with N, P, R, or HE types of particulate-removing respirator (minimum efficiencies of 95%, 99%, or 99.97%). Some pesticide labels call out a NIOSH-approved N95 respirator, for example. This refers to a respirator with an N95 filter. Some call out N95, R95, or P95.

Some labels still call for use of a NIOSH-approved dust/mist respirator. Very few of these older respirators are still available. It may be preferable to choose another product with a label you can more easily comply with.

Gas- and Vapor-Removing Devices

Gas- and vapor-removing devices (cartridge and canister respirators) are rated by NIOSH for the types of gases and vapors they will remove. Pesticide handlers must use one of the following:

- A cartridge approved for organic vapors plus a filter.
- A canister approved for organic vapors (NIOSH code TC-14G) plus a filter.

In both cases, the pesticide label will designate the filter's level of protection.

Gas- and vapor-removing materials gradually lose their ability to hold more gases and vapors. The useful life of respirators can vary greatly depending on:

- Concentration of gas or vapor in the air.
- Amount of absorbent material they contain.
- Breathing rate of the wearer.
- Temperature and humidity.
- Length of storage time before use and between uses.

A noticeable odor, taste, irritation, or dizziness means you are no longer being protected. Refer to the end-of-service-life indicator or other instructions (ex. cartridge service-life prediction software) to tell you when to replace the cartridge or canister.

Fit Testing Respirators

Respirators fit wearers in one of two ways: most seal tightly to the face; others are loose-fitting. See "Air-Delivery Systems" above for more information on loose-fitting respirators.

Respirators that seal must fit your face tightly. They must be fit tested to their users. For a firm and comfortable fit of your face mask, adjust the headbands in this order:

1. Make sure the straps lie flat against your head.
2. Tighten the lower or neck straps.
3. Tighten the head cradle straps.
4. Place both hands on the headband or head cradle and position it on the crown of the head.
5. Repeat steps 1 and 2.

6. Tighten the forehead or front strap a few notches.

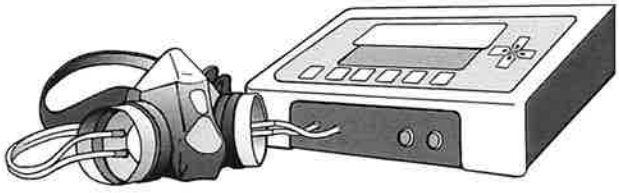
The mask should feel comfortable, while forming a tight seal against your face. OSHA requires that respirators fit properly and that you test their facepiece-to-face seal.

Fit Tests

The fit test is a method used to select the right size respirator for each user. OSHA's respiratory-protection standard requires a fit test before using a respirator for the first time, when using a different respirator facepiece, and at least once a year thereafter. A fit test is also required for anyone whose physical condition has changed in a way that could affect the fit of a respirator (ex. facial scarring or cosmetic surgery). All employees using either a negative- or positive-pressure, tight-fitting, facepiece respirator must pass an appropriate fit test.

There are two types of fit tests: qualitative and quantitative. The qualitative fit test uses irritant smoke released in the air to detect leakage into the respirator. The test operator directs a stream of smoke from the smoke tube toward the face seal area, using a low-flow pump or a squeeze bulb. When cued, the wearer makes certain movements (breathe normally, breathe deeply, move the head, grimace, bend at the waist, and talk). He or she then reports any noticeable odor or taste agent that leaks into the mask.

The quantitative fit test uses a particle-counting instrument. This device measures respirator fit by comparing the dust concentration in the surrounding air with that inside the respirator. The ratio of these concentrations is called the fit factor. A modified filter cartridge (or a modified respirator facepiece) equipped with a sample port collects air from inside the respirator. With the sampler attached, the wearer makes the same movements as described for the qualitative fit test. During these movements, the particle-counting device measures any leakages.



Quantitative Fit Test

Qualitative Fit Test

Contact an industrial hygienist, your local Extension agent, or the equipment manufacturer to help decide which fit test to use for your respirator.

Fit Checks

The purpose of a fit check (also called a user seal check) is to make sure your respirator is positioned properly and forms a complete seal around your face. Do a fit check each time you put on your respirator *before* you enter the target area. Follow up from time to time while in the field.

The seal-checking process has two parts: a positive-pressure check (breathing out) and a negative-pressure check (breathing in). You must complete both parts each time. If you cannot pass both parts, your respirator is not working properly. Adjust it and try again.

Positive-Pressure Check

Cover the exhalation valve with your hand and exhale gently into the facepiece. If the facepiece remains inflated with no sign of leakage, the fit is good. If there is leakage, inspect the respirator. Reposition it, and try the test again. This method is the most widely used to check proper fit in the field.

Negative-Pressure Check

Close off the air inlet valves by covering the cartridges with your hands. (It may be difficult to get a good seal when trying to cover the inlet valves.) Inhale gently to collapse the facepiece slightly and hold your breath for 10 seconds. If the facepiece remains slightly collapsed with no sign of leakage, the respirator fits properly. If there is leakage, inspect the respirator. Reposition it and try the test again.

Positive-Pressure Fit Check

Negative-Pressure Fit Check

Additional Personal Protective Equipment

Some situations put you at greater risk of exposure to pesticides. Consider using additional protection for tasks such as the ones described below.

Carrying Application Equipment

When you carry application equipment (ex. hand-held sprayers or shake cans), you risk direct exposure to the pesticide. A dripping or partly clogged nozzle, an unfastened cap, a leaky hose, or a loose connection is likely to cause exposure. Consider wearing extra PPE to protect the area of your body that is in contact with the equipment.

If you are carrying the equipment in front, consider wearing a sleeved apron, an apron with built-in gloves and sleeves, or an apron plus long gloves to protect your front from leaks, drift, and splashes.

If you are carrying the equipment on your back (ex. backpack or trombone-style sprayers or dusters), consider wearing a cape to protect your back and shoulders from leaks.

Using a hand-held sprayer may directly expose you to pesticides.

If you are carrying only the nozzle, consider wearing long gloves with the cuffs taped or otherwise sealed to the coverall sleeve.

Entering the Path of the Released Pesticide

You may need to walk into the path of the pesticide you are releasing. Whenever possible, apply pesticides so that you are walking in an untreated area, away from where the pesticide is being **released.**

If you must walk into the path of the released pesticide, consider wearing either shin-high or knee-high boots or protective footwear with chemical-resistant pants. Spraying a thick coating of fabric starch or fabric stain protectant on the lower legs of your coveralls may provide a temporary barrier for low-toxicity pesticides.

When you apply pesticides from a vehicle, try to release the pesticide to the rear. You will be located in front of and above the area of release, moving away from it. Sometimes, however, you may have to walk or drive into the path of the pesticide being released.

Whether you are walking or riding, if the pesticide is not directed downward or if it remains suspended in the air long enough to expose the front of your body, consider wearing an apron or chemical-resistant suit. If the

pesticide mist or dust reaches as high as your face, consider a filtering facepiece respirator and eye protection.

Walking into a Just-Treated Area

Even when you apply a pesticide from a vehicle, you may need to walk into an area that you have just treated. For example, you may need to repair or adjust the equipment or check the pesticide dispersal. You may have to climb over a contaminated rig and walk through an area that was treated only moments before. Consider putting on additional PPE while you are out of the vehicle.

For short vegetation in the treated area covered with pesticide spray or dust, consider wearing either shin-high or knee-high boots or protective footwear with chemical-resistant pants. Again, it may be useful to apply spray starch or fabric stain protector to the pants legs.

For tall plants in the treated area, you may need to wear a chemical-resistant suit plus footwear. If it is too hot to wear the suit, try a cape or an apron.

If spray is dripping or dust is falling from overhead, wear a hood or wide-brimmed hat in addition to the body protection and footwear. A filtering facepiece respirator and protective eyewear may also be necessary.

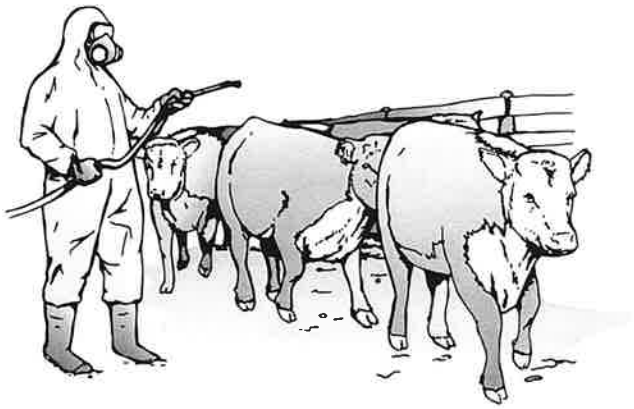
Making High-Exposure Applications

Certain types of pesticide applications are especially risky because they engulf you in pesticide fallout. These include:

- Mist-blower or air-blast applications.
- Aerosol and fog applications, especially indoors.
- Some applications using high-pressure sprayers and power dusters.
- Applications directed upward and overhead, such as to tree canopies or roof eaves.

When making these types of applications, large amounts of pesticide fallout may land on your skin and clothing. Unless you are in an enclosed cab, you cannot avoid this exposure.

Only a chemical-resistant suit with a hood, gloves, and footwear with sealed cuffs – plus a full-face or half-face respirator with sealed goggles – can fully protect you during high-exposure applications.



Protect yourself when making high-exposure applications by wearing extra PPE.

Applying Pesticides in Enclosed Spaces

It is sometimes necessary to apply pesticides (ex. fumigants) in enclosed spaces, such as:

- Warehouses, factories, homes, and other buildings.
- Railcar, ship, and truck cargo areas.
- Silos, elevators, and other grain storage areas.
- Greenhouses.

When you use pesticides in enclosed spaces, you increase the risk of inhalation exposure. You may need to use a respirator even if you would not need one for the same application outdoors.

Adjusting Pesticide-Coated Equipment

You may need to wear a protective apron while doing some types of equipment adjustments and repairs. Some soil fumigation labels may require you to wear a vapor-removing respirator – even outdoors – if you must adjust fumigation equipment.

Immersing Hands and Forearms

Some application techniques, such as animal-, plant-, or seed-dipping vats and spray-dip machines, require you to place your hands and forearms into the pesticide liquid or dust. Wear a sleeved apron for full front and arm protection as well as protective footwear. A face shield will protect against splashes or drifting dusts.

Applying in Air Currents

If you will be applying pesticides into or across wind or air currents, consider wearing extra PPE. Pesticide may blow onto you. You may need more body protection, protective eyewear, and a filtering facepiece respirator.

Applying Concentrates

Exposure to highly concentrated pesticides is also dangerous. Ultra-low-volume concentrates and fumigant formulations may be close to 100% active ingredient and are often highly toxic. Consider using extra PPE when applying concentrates.

Maintaining Personal Protective Equipment

When you finish a pesticide-handling activity, remove your personal protective equipment right away. Wash the outside of your gloves with detergent and water *before* you remove them. Consider washing the outside of other chemical-resistant items before you remove them also. This helps you avoid touching the contaminated part of the items while you are removing them and helps keep the inside surface clean. If any other clothes have pesticides on them, change them also. Decide whether to dispose of the items or clean and reuse them.

Disposables

Disposable PPE items cannot be cleaned and reused. Discard them when they become contaminated with pesticides. Place disposable PPE in a separate plastic bag or container before disposal. If possible, cut or tear them so they cannot be reused.

Discard contaminated, disposable PPE in a separate bag or disposable container.

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

Nonwoven (including coated, nonwoven) coveralls and hoods are usually discarded after use. Most should be worn for only one workday. The instructions with some coated, nonwoven suits and hoods, however, permit you to wear them more than once if each use period is short and not much pesticide gets on them. Pay close attention when reusing these items. Be ready to change them whenever you suspect that pesticides are penetrating the material or the inside surface is contaminated.

Filtering facepiece respirators, canisters, gas- and vapor-removing cartridges, and a few cartridge respirators are disposable. Be sure to replace these items often.

Reusables

Some PPE items, such as rubber and plastic suits, gloves, boots, aprons, capes, and headgear, can be cleaned and reused several times. However, do not make the mistake of continuing to use these items when they are no longer protecting you.

Wash reusable PPE items thoroughly between uses. Never wash contaminated gloves, boots, respirators, or other equipment in streams, ponds, or other bodies of water. Before you put them on, inspect the reused items carefully for signs of wear or abrasion. Check for rips and leaks by using the rinse water to form a "balloon" (i.e., filling the PPE item with water) and/or by holding the items up to the light. Even tiny holes or thin places can allow large quantities of pesticides to penetrate the material and reach your skin. Discard any PPE that shows signs of wear.

Even if you can see no signs of wear, replace reusable, chemical-resistant items regularly. The ability of a chemical-resistant material to resist the pesticide decreases each time an item is worn. Additionally, pesticide that contacts chemical-resistant PPE may gradually permeate the barrier. A good rule of thumb is to throw out gloves worn for about five to seven workdays. Extra-heavy-duty gloves, such as those made of butyl or nitrile rubber, may last as long as 10 to 14 days.

Glove replacement is crucial because adequate hand protection greatly reduces a pesticide handler's exposure risk. The cost of frequently replacing gloves is a wise investment. Footwear, aprons, headgear, and protective suits may last longer than gloves. This is because they generally receive less exposure to the pesticides and less abrasion from rough surfaces. Replace them regularly and at any sign of wear.

Most protective eyewear and respirator bodies, facepieces, and helmets can be cleaned and reused. Good-quality items can last many years if they are maintained correctly.

Launder fabric coveralls and work clothing after each day's use. However, do not try to wash clothing made of cotton (ex. denim or canvas), polyester, or cotton blends if these items are drenched or saturated with concentrated pesticides labeled with the signal words DANGER—POISON, DANGER, or WARNING. If possible, discard any such contaminated clothing or footwear at a household hazardous waste collection site. (Cut the items up first to prevent reuse.)

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

Washing Personal Protective Equipment

Always wash pesticide-soiled items separately from the family laundry. Otherwise, pesticide residues may contaminate the family laundry and cause harm.

Be sure that the people who clean and maintain your PPE and other work clothes know that touching pesticide-contaminated items can be dangerous. Instruct them to:

- Wear chemical-resistant gloves and an apron.
- Work in a well-ventilated area if possible.
- Avoid inhaling steam from the washer or dryer.

Washing Procedure

Follow the manufacturer's instructions for cleaning chemical-resistant items. If an item is

Wash pesticide-contaminated items apart from the family laundry.

washable but there are no detailed laundering instructions, use the guidelines below ("Procedure for Washing Contaminated PPE"). Some chemical-resistant items are not flat (ex. gloves, footwear, and coveralls). Wash these twice – once to thoroughly clean the outside of the item and again after turning it inside out. You can wash some chemical-resistant items (ex. heavy-duty boots and rigid hats or helmets) by hand using hot water and a heavy-duty, liquid detergent. These items should be dried and aired as directed below.

Follow the steps in the gray box to wash nonchemical-resistant items (ex. cotton, cotton/polyester, and other absorbent materials) and most chemical-resistant items.

Drying Procedure

Hang the items outside to dry if possible. It is best to let them hang for at least 24 hours in an area with plenty of light and air movement. Even after thorough washing, some items still may contain residues. When the items are exposed to clean air and sunlight, most residues move to the surface of the fabric, evaporate, and break down. You may wish to buy two or more sets of PPE so you can let one set air while you wear the other set. Do not hang items in enclosed living spaces: pesticide residues may evaporate and expose people or animals in the area.

If you cannot hang fabric items to dry, use a clothes dryer (vented outside). Be sure to clean the lint filter.

Procedure for Washing Contaminated PPE

1. Wash only a few items at a time so there is plenty of agitation and water for dilution.

2. Pretreat, using a heavy-duty, liquid detergent or other pretreating product.

3. Wash in a washing machine, using a heavy-duty, liquid detergent and hot water for the wash cycle. Set your washer to the longest wash cycle and two rinse cycles.

4. Use two entire machine cycles to wash items that are lightly to moderately contaminated. (If PPE is saturated or heavily contaminated, bundle it in a labeled plastic bag. Cut up the items to prevent reuse. If possible, dispose of the bag at a household hazardous waste collection site.)

5. Run the washer through at least one more entire cycle without clothing, using detergent and hot water, to clean the machine before washing any other laundry.

Maintaining Eyewear and Respirators

Wash goggles, face shields, shielded safety glasses, respirator bodies, and facepieces after each day's use. Wash them thoroughly with detergent and hot water (less than 110□F). Remove any contaminants (such as residual pesticides) under running water with a soft brush. Sanitize them by soaking for at least two minutes in a mixture of 2 tablespoons of chlorine bleach and 1 gallon of hot water. Rinse thoroughly to remove the detergent and bleach. After rinsing, dry the items thoroughly or hang them in a clean area to dry.

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

Store respirators and eyewear in an area protected from dust, sunlight, extreme temperatures, excessive moisture, and pesticides or other chemicals. A sturdy plastic bag with a zip closure works well for storage.

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

If you remove your respirator between handling activities:

- Wipe the respirator body and facepiece with a clean cloth. Use disposable wipe pads to sanitize and freshen facepieces.
- Replace caps (if available) over cartridges, canisters, and filters.
- Seal the respirator in a sturdy, airtight container (ex. a plastic bag with a zip closure). If you do not seal the respirator immediately after each use, the disposable parts will need replacement more often. This is because cartridges and canisters continue to collect impurities as long as they are exposed to air. Remove contaminated filters *before* placing the canisters and cartridges in a resealable plastic bag to avoid contaminating the canisters and cartridges.

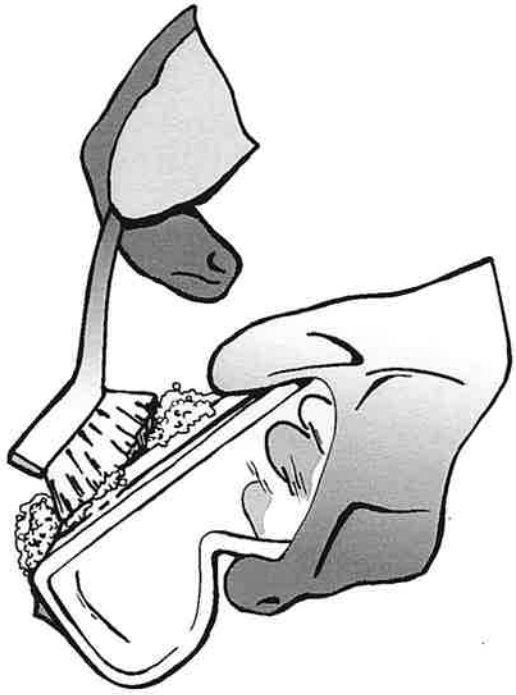
At the end of any workday after wearing a reusable respirator, follow these steps:

1. Remove the filter. Most filters should be discarded.
2. Take off the cartridges or canisters. Discard them or, if they are still usable, replace their caps and seal them in an airtight container (ex. a plastic bag with a zip closure).
3. Clean and store the respirator as directed above.

Discard disposable respirators according to manufacturer's instructions. Do not try to clean them.

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

Remember that PPE has limitations – you are never completely protected even with the best equipment. Use caution and common sense to prevent pesticide exposure.



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

Test Your Knowledge

Q. Briefly define personal protective equipment (PPE).

A. Clothing and devices worn to protect the human body from contact with pesticides or pesticide residues. PPE includes coveralls or protective suits, footwear, gloves, aprons, respirators, eyewear, and hoods or hats.

Q. By law, how much personal protective equipment must you wear for a given pesticide-handling situation?

A. At least the PPE listed on the labeling for each handling task. You may wear additional PPE if desired.

Q. Define the term "chemical resistant."

A. Able to prevent movement of a pesticide through material during the period of use.

Q. Which materials are most likely to be chemical-resistant?

A.
1. Plastics, such as polyvinyl chloride (PVC).
2. Synthetic rubber, such as butyl, nitrile, neoprene, or viton rubber.
3. Nonwoven fabrics coated with plastic or another barrier material.
4. Barrier-laminate materials.

Q. How can you tell when a material is NOT chemically resistant to a pesticide?

A. 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.

Q. What factors determine how well coveralls will protect your body?

A.
1. Loose fit – provides a layer of air between the coverall and the skin or inner clothing.
2. Worn over another layer of clothing – each layer adds a protective layer of air as well as a layer of fabric.
3. Tightly constructed, with sealed seams and snug, overlapping closures – will not gap or readily become unfastened.
4. Made of sturdy material with flaps over the zippers and elastic at the wrists and ankles – makes it hard for pesticides to get through the coveralls.

Q. Under what circumstances might you wear a chemical-resistant suit?

A. First, if the product label requires it. Even if the label does not require it, you might choose to wear a chemical-resistant suit if it is likely that a lot of pesticide may be deposited on your clothing over an extended period.

Q. What is the purpose of a chemical-resistant apron? When should you wear one?

A. To protect a pesticide handler from splashes, spills, and billowing dust. You may need to wear a bib-top apron when handling pesticide concentrates, mixing and loading a pesticide, or cleaning application equipment.

Q. When should you wear chemical-resistant gloves? Why are gloves so important to a pesticide handler?

A. Generally, any time you may get pesticides on your hands. The hands are the most

likely route of exposure for a pesticide handler. (Note, however, that some fumigant labels instruct you to *not* wear gloves.)

Q. If you need to remove your gloves while handling pesticides, what steps should you take to avoid contaminating the inside of your gloves?

A. 1. Wash gloves thoroughly before taking them off.

2. Wash hands thoroughly and dry them before putting the gloves on again.

Q. How could pesticides get on your skin even when you are wearing gloves and protective footwear?

A. Your gloves and footwear may not be resistant to the chemical you are handling. Other possibilities: they may be worn incorrectly, be in poor condition, have been cleaned inadequately, or not replaced soon enough.

Q. When should you wear PPE to protect your head and neck? What type of headgear should you use?

A. For overhead exposure or exposure to many airborne particles. Chemical-resistant hoods or wide-brimmed, unlined hats are best. Plastic safari hats are cooler in hot weather.

Q. When the pesticide labeling requires protective eyewear, what should you wear?

A. Chemical splash-proof goggles, a face shield, or safety glasses with brow and side shields. Shielded safety glasses and full-face shields are comfortable and give excellent eye protection.

Q. Why must pesticide handlers wear PPE to protect their respiratory tracts while on the job?

A. The respiratory tract (lungs and other parts of the breathing system) is much more absorbent than the skin. Inhaling just a few breaths of some pesticides (especially fumigants) can be harmful or fatal.

Q. What is a respirator? Name and briefly describe the two main types.

A. A safety device that covers at least the mouth and nose. Respirators protect you from breathing pesticide-contaminated air. The two main types are:

1. Atmosphere (air)-supplying respirators, which provide clean, uncontaminated air from an air tank or an offsite location.

2. Air-purifying respirators, which remove contaminants from the surrounding air using a cartridge, canister, or particulate filter.

Q. Name the two types of atmosphere-supplying respirators. When would you most likely use them?

A. Self-contained breathing apparatus (SCBA) and airline (supplied-air) respirators. Use these devices when the oxygen supply is low or when fumigating in enclosed areas (ex. greenhouses or other buildings, railcars, ship holds, and grain bins). You must use an atmosphere-supplying respirator if required to do so by the product label.

Q. How do air-purifying respirators work?

A. These respirators remove particles as well as toxic gases and vapors. They use filters, sorbents, and catalysts to trap and remove contaminants from the air. When you breathe in, you draw air from outside the respirator, through air-purifying filters, and into the mask. The filtering material absorbs impurities as the air passes through.

Q. How do air-purifying respirators remove contaminants from the air?

A. By filtering dusts, mists, and particles, and by removing gases and vapors.

Q. What are loose-fitting respirators? What are their advantages?

A. A type of powered, air-purifying respirator (PAPR). Unlike face-sealing respirators, loose-fitting respirators do not fit tightly. They constantly pump air through a cartridge or canister into a loose-fitting head covering that resembles a helmet or hood. Loose-fitting respirators have several advantages:

1. People with facial hair can wear them.
2. They do not require extra lungpower and are less tiring.
3. They are cooler and less likely to contribute to heat stress.
4. They do not require fit tests and fit checks.
5. They are a good choice for pesticide exposure lasting several hours.

Q. What are the three basic styles of nonpowered, air-purifying respirators?

A. Particulate filtering, cartridge, and canister.

Q. True or false: People with respiratory problems can wear a loose-fitting respirator without getting a medical evaluation.

A. False. If you have breathing problems, a licensed healthcare professional must clear you before you wear ANY respirator.

Q. What are filtering facepiece respirators?

A. Disposable masks that cover the nose and mouth to filter out dusts, mists, powders, and sprays (particulates). FFRs will not remove gases or vapors.

Q. Which type of air-purifying respirator – cartridge or canister – would be a better choice in an area with a high concentration of gas or vapor? Why?

A. A canister respirator. Canisters contain more air-purifying material than cartridges. They last longer and may give better protection in higher-risk situations.

Q. How would you go about choosing a respirator for a particular job?

A. Check the pesticide product label. It often specifies the type of respirator required by listing its TC schedule number. In addition, filters are classified based on oil degradation resistance and filter efficiency. Classification levels are: N (not oil resistant), R (limited oil resistance), P (oil proof), and HE (high efficiency). The filter efficiency for each classification level may be 95%, 99%, or 99.97%.

Q. You will be working in an environment that will expose you to organic vapors. What type of respirator would you choose?

A. Either a cartridge approved for organic vapors plus a filter, or a canister approved for organic vapors (NIOSH code TC-14G) plus a filter. In both cases, the filter's protection level is designated on the pesticide label.

Q. What is a fit test? A fit check?

A. A fit test is a method used to choose the right size respirator for a particular user. OSHA requires a fit test before using a respirator for the first time, when using a different respirator facepiece, and at least once a year thereafter. Anyone using either a negative- or positive-pressure, tight-fitting, facepiece respirator must pass an appropriate fit test.

A fit check (user seal check) is a test to make sure the respirator is positioned properly and forms a complete seal around the face. It has two parts: a positive-pressure check (breathing out) and a negative-pressure check (breathing in). Do a fit check each time you put on your respirator – *before* you enter the target area.

Q. Describe the two types of fit tests.

A. Qualitative: Uses irritant smoke released in the air to detect leakage into the respirator. The test operator directs a stream of smoke from the smoke tube toward the face seal area, using a low-flow pump or a squeeze bulb. When cued, the wearer makes certain movements. He or she then reports any noticeable odor or taste agent that leaks into the mask.

Quantitative: Uses a particle-counting instrument. This instrument measures respirator fit by comparing the dust concentration in the surrounding air with that inside the respirator. While wearing a sample port, the wearer makes the same movements as described for the qualitative fit test. During these movements, the particle-counting device measures any leakages.

Q. Name at least four types of pesticide application that might require extra PPE (more than that specified on the product label).

A. 1. Carrying application equipment (in front or on your back).

2. Entering the path of the released pesticide.

3. Walking into a just-treated area.

4. Using high-exposure application methods where the pesticide may engulf you.

5. Applying pesticides in enclosed spaces.

6. Adjusting pesticide-coated equipment.

7. Immersing hands and forearms in pesticides.

8. Applying into or across air currents.

9. Applying concentrated pesticides.

Q. Name several PPE items that are considered disposable (discarded after one use).

A. 1. Inexpensive gloves, footwear, and aprons made of thin vinyl, latex, or polyethylene.

2. Nonwoven coveralls and hoods.

3. Filtering facepiece respirators, canisters, gas- and vapor-removing cartridges, and a few cartridge respirators.

Q. If your chemical-resistant gloves are reusable, how often should you routinely replace them? When should you immediately replace chemical-resistant items?

A. For most reusable gloves, after five to seven workdays. (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.

Q. What should you do with a coverall that has highly toxic pesticide concentrate spilled on it?

A. If possible, dispose of it at a household hazardous waste collection site. It cannot be adequately cleaned. (Cut it up to prevent reuse.)

Q. What instructions should you give the people who will be washing your pesticide-contaminated clothing?

A. 1. Wear chemical-resistant gloves and an apron.

2. Work in a well-ventilated area if possible.

3. Do not inhale steam from the washer or dryer.

Q. List the steps to follow when washing pesticide-contaminated PPE.

A. 1. Wash only a few items at a time so there is plenty of agitation and water for dilution.

2. Pretreat, using a heavy-duty, liquid detergent or other pretreating product.

3. Wash in a washing machine, using a heavy-duty, liquid detergent and hot water for the wash cycle. Set your washer to the longest wash cycle and two rinse cycles.

4. Use two entire machine cycles to wash items that are lightly to moderately contaminated. (If PPE is saturated or heavily contaminated, bundle it in a labeled plastic bag. Cut up items to prevent reuse. If possible, dispose of the bag at a household hazardous waste collection site.)

5. Run the washer through at least one more entire cycle without clothing, using detergent and hot water, to clean the machine before washing any other laundry.

Q. What should you do with your respirator between handling tasks?

A. Wipe the respirator body and facepiece with a clean cloth. Use disposable wipe pads to sanitize and freshen facepieces. If possible, replace caps over cartridges, canisters, and filters. Seal the respirator in a clean, airtight container, such as a sturdy plastic bag with a zip closure.

Q. What should you do when you are finished using your respirator for the day?

A. 1. Remove the filter. Most filters should be discarded.

2. Take off the cartridges or canisters. Discard them or, if still usable, replace their caps and seal them in an airtight container (ex. a resealable plastic bag).

3. Wash the respirator body, facepiece, and any reusable filters. Soak them for at least two minutes in a mixture of 2 tablespoons of chlorine bleach and 1 gallon of hot water (less than 110□F). Rinse thoroughly. Dry thoroughly or hang them in a clean area to dry.

4. Store the respirator and any reusable cartridges, canisters, and filters in an airtight container in a place where they are protected from dust, sunlight, extreme temperatures, excessive moisture, and pesticides or other chemicals.

5. If the respirator is disposable, discard it according to manufacturer's instructions.

Q. How do you know when to replace the particulate filter in a filtering facepiece respirator?

A. When breathing becomes difficult. Eight hours of use is usually the limit. Check the user's instructions for specific requirements.

Q. How do you know when to replace gas- and vapor-removing devices?

A. Replace them immediately if you smell, taste, or feel irritation from pesticide vapors or gases. Refer to the end-of-service-life indicator or other instructions (ex. cartridge service-life prediction software).

Unit 8. Pesticide-Handling Decisions

Learning Objectives

After studying this unit, you should be able to:

- State what personal safety considerations to check whenever you or those you supervise will be handling pesticides.
- Cite some consequences of using pesticides incorrectly.
- List factors to consider when choosing a formulation.
- Name conditions at the application site that may influence your application procedures.
- Name some best practices for pesticide applicators.
- Explain how pesticide labeling statements can alert you to special application considerations.
- Recognize the benefits of scheduling pesticide applications after normal business or work hours.
- List some important tasks following the application.
- Describe personal cleanup after pesticide handling.
- List some benefits of recordkeeping.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Adjuvant – A substance added to a pesticide formulation or tank mix to increase its effectiveness or safety (ex. emulsifier or wetting agent).

Agitation – The process of stirring or mixing.

Chemical Resistant – Able to prevent movement of a pesticide through material during the period of use.

Concentrates – Pesticides that have a relatively high percentage of active ingredient.

Decontaminate/Decontamination – To remove (or the removal of) pesticide from exposed surfaces or organisms to prevent further harm or damage.

Diluent – Any substance used to dilute a pesticide (for liquid formulations, usually water).

Dilute – To make less concentrated.

Drift – The movement of pesticides away from the release site in air.

Exposed/Exposure – Contacting or touching (or subjected to contact with) a pesticide; getting a pesticide on a surface, or in or on an organism. Exposures may be oral, inhalation, dermal, or ocular.

Terms to Know cont.

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

Fumigant – A pesticide that is or forms a toxic vapor or gas when applied.

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

Leaching – The movement of pesticide in water or another liquid downward through soil or other planting medium.

Nonporous – Having no openings or pores to allow liquid to be absorbed or pass through (ex. surfaces).

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

Organic Matter – Materials and debris in the soil that began as living plants or animals.

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Porous – Having tiny openings that allow liquid to be absorbed or to pass through. Porous surfaces may absorb pesticides readily.

Residue – An amount of pesticide that remains in the environment (ex. on a plant, an animal, or in the soil) after an application or a spill.

Runoff – The movement of pesticide away from the release site in water or another liquid flowing laterally across the surface.

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

Personal Safety Considerations

Before handling any pesticides, you need to make some important decisions. First, decide how to ensure the safety of yourself, others, and the environment. Reading the **labeling,** avoiding **exposure** to pesticides, using the proper **personal protective equipment** (PPE), and checking your application equipment are crucial. You must also avoid accidental pesticide contamination, provide all **pesticide handlers** with specific instructions, be prepared for emergencies, and keep animals and unauthorized people out of the treatment area.

Make safety a top priority every time you handle pesticides or supervise another pesticide handler. By making a few simple safety decisions, you can prevent many pesticide accidents and reduce the severity of others. Ask yourself the basic safety questions below.

Have I Read the Labeling?

Always read the applicable sections of the pesticide labeling before you open a pesticide container or handle any pesticide. Pesticide labeling contains precautions and instructions that you must follow in order to use the product safely and appropriately. The labeling may contain very specific information that concerns the task you plan to do. For example, it may list temperature or wind restrictions. It may also include postapplication requirements, such as restricted-entry interval details. Be sure you understand everything you need to know about the pesticide product before you handle it. See Unit 3 for more information about pesticide labels and labeling.

Read the pesticide label first.

How Can I Avoid Exposure to Pesticides?

The key to personal safety when handling pesticides is to avoid exposure to them. Always keep your clothing, food, drinks, and personal items away from where pesticides are stored or handled. If these items become contaminated, they could poison or injure you. See Unit 6 for more information on reducing pesticide exposure.

When you take a break, wash your gloves on the outside, remove them, and wash your hands and face thoroughly. Then you can safely chew gum, eat, drink, or smoke.

Avoid getting pesticide on yourself when you use the toilet. Take the time to wash your hands thoroughly before using the toilet. Additionally, be careful not to contaminate yourself from pesticides that may be on the outside of your clothing.

Do not tear paper or cardboard containers to open them. Use a sharp knife or scissors. Clean the knife or scissors afterward, and do not use them for other purposes. Open pesticide containers only when they are sitting on a flat, stable surface. If they lean at an angle or are in an unstable position, they can easily spill over or leak out when the seal is broken. To prevent spills, close containers tightly after each use. Wear suitable PPE when handling pesticide containers.

When pouring any pesticide from its container, keep the container and pesticide below face level. This will avoid a splash or spill and keep dust from getting on your face or into

your eyes and mouth. If there is a wind outdoors or a strong air current indoors, stand so the pesticide cannot blow back on you. Try to find another place to mix or load. When transferring wettable powders, dusts, or other dry **formulations,** avoid spilling or inhaling dusts.

If you are siphoning the pesticide from the container to the tank, never use your mouth to get the siphon started. You could easily get a mouthful of pesticide.

Be careful in all exposure situations:

- Protect yourself during mixing, loading, and application; during spill cleanup; and when repairing or maintaining equipment.
- Use great care when transporting, storing, or disposing of pesticide containers – especially those that are open or have pesticides on their outer surface.
- Use PPE when necessary to keep pesticides from getting on your skin and in your mouth, eyes, or lungs.

What Personal Protective Equipment Do I Need?

Decide what personal protective equipment you and your crew will need. You must use *at least* what the labeling requires. However, you may decide that you need additional equipment. Make sure that all PPE is clean and in good operating condition.

Be sure that you know how to use your protective equipment correctly:

- Put on and remove the equipment carefully so that you will not contact any pesticides that may be on the outside.
- Do not "cheat" by taking off your gloves to make an equipment adjustment.
- Refrain from pulling your respirator away to scratch your face, wipe off sweat, or take a deep breath while working with the pesticide.
- Do not wipe your gloves on your clothing. This will contaminate your clothes and put you at greater risk of pesticide exposure.

See Unit 7 for more information about PPE.

Is My Application Equipment Ready and Safe?

Decide what application equipment you need for the task at hand. Check to make sure that you have all the necessary equipment and that it is clean and in good operating condition. Make sure that anyone who will use the equipment knows how to operate it safely and correctly.

How Can I Avoid Accidental Pesticide Contamination?

Consider the many ways in which you and your crew might contribute to accidental pesticide contamination. You may transfer pesticides to objects, people, and animals when you touch them with gloves that you wore while handling pesticides. When you sit in your car or on a chair while wearing your pesticide-handling outfit, you may leave pesticides behind. If you answer the telephone or use the toilet at work or at home, you may leave pesticides on surfaces there.

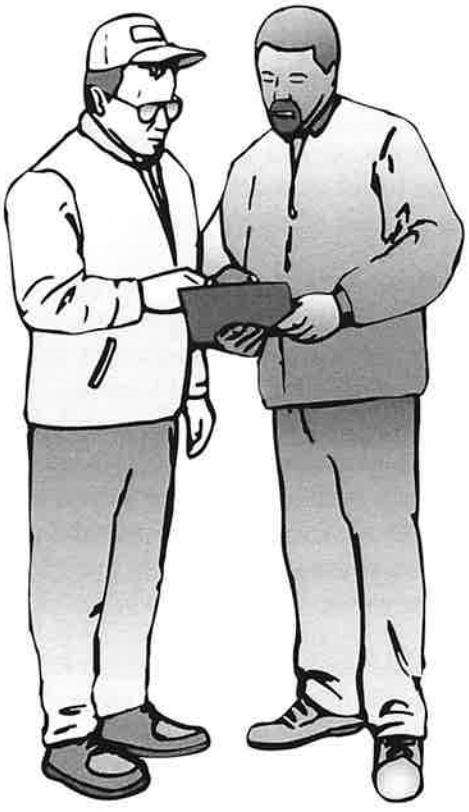
Any time you take home or wear home your work clothing, PPE, or other pesticide-contaminated items, the pesticides can rub off on carpeting, furniture, and laundry. Pesticides can also end up on pets and people who touch the contaminated materials. If you fail to clean up a spill – no matter how small – other people or animals may unknowingly get pesticide on themselves. These pesticides may harm whoever or whatever touches them.

To avoid accidental pesticide contamination, do not allow your PPE to contact furniture, other objects, people, or pets. Launder your work clothes separately as described in Unit 7. Clean up all spills immediately, following the procedures described in Unit 11.

Have I Instructed the Handlers I Supervise?

If you supervise other people who handle pesticides, be sure that they understand the personal and environmental hazards of pesticide use. They should know the routes of exposure and how to limit their exposure. They should also understand how to reduce the risk of heat stress and how to respond in an emergency. All pesticide handlers should know how to use the pesticide labeling and other informational resources to learn about the pesticide they are using.

Be sure to provide all pesticide handlers with specific instructions about the pesticides they will be using and the duties expected of them. It is your legal responsibility to make sure that those you supervise are well-informed and that they take all the precautions the pesticide labeling requires.



Inform all pesticide handlers of their duties and responsibilities.

Am I Prepared for Emergencies?

Before you begin any pesticide-handling task, be sure you are prepared to deal with emergencies such as spills, injuries, and poisonings. Your emergency supplies should include at least the following:

1. Personal **decontamination** equipment – Keep plenty of clean water, detergent, and paper towels nearby in a protected container to allow for fast decontamination in an emergency. Have an extra coverall-type garment nearby in case clothing becomes soaked or saturated with pesticide and must be removed.

2. First aid equipment – Keep a well-stocked first aid kit on hand. It should include a plastic eyewash dispenser that has a gentle flushing action. See Unit 6 for more information about first aid procedures.

3. Spill cleanup equipment – Keep a spill cleanup kit on hand at all times. The kit should contain all the items needed for prompt and complete spill cleanup. It should also include PPE to protect you while you are dealing with the spill. See Unit 11 for more information about spill cleanup procedures.

Know whom to call in a medical emergency. Be familiar with the signs and symptoms of poisoning caused by the pesticides you handle. In a poisoning emergency:

- Remove the victim from the exposure zone at once.
- Summon medical assistance quickly.
- Provide first aid.

Are People and Animals out of the Area?

Do not allow anyone but trained and equipped pesticide handlers to be present during *any* pesticide-handling task. Keep children, animals, and unauthorized people away from the application equipment. If they

are injured or poisoned, you are responsible. By law, you must make sure that no one is overexposed to pesticides that you and those you supervise are handling. Always inform workers, supervisors, and any others who may be near the application site which sites you plan to treat and how long they must stay out of those sites.

Preapplication Decisions

Every time you apply pesticides, you have two major responsibilities:

1. Protect yourself, others, and the environment.

2. Make sure that you apply the pesticide correctly.

Take the time to think carefully about every pesticide application before you begin. The decisions you make will determine whether you will use the pesticide safely and correctly. Be careful – wrong decisions can lead to incorrect and dangerous pesticide use. Here are some examples:

- Incorrect use can result in wasted material, failure to control the pest, and damage to the target site (the animal, plant, or place receiving the pesticide).

- Misused pesticides can cause immediate as well as long-term damage to humans, other living things, property, and other parts of the environment.

- Misused pesticides can result in fines as well as legal actions charging you with liability for damages.

- Pesticides are expensive, as are application operations (especially labor costs and fuel). Using pesticides incorrectly can be costly.

You must make important decisions about the application itself. This includes choosing the right pesticide, picking the best formulation, selecting appropriate application procedures, and scheduling the application.

Choosing a Pesticide

One of the first things to decide is which pesticide to use. Your knowledge of the situation may allow you to make that decision on your own. When in doubt, ask for help in choosing the safest and most effective pesticide for the job. Pesticide dealers, Virginia Cooperative Extension agents, trade associations, or other experts may be able to help you.

Choosing a Formulation

The pesticide you have chosen may be available in several formulations. Each type of formulation has different benefits and drawbacks. Decide which one best fits your needs and meets the special requirements of your application site. See Unit 4 for more information about pesticide formulations.

When choosing a formulation, consider the following factors:

- Application site.
- Equipment.
- Pesticide movement.
- Personal safety.
- **Target pest.**
- Surface characteristics.
- Cost.

Application Site

Some formulations are more likely than others to harm **nontarget** surfaces, plants, and animals in the application site. Emulsifiable **concentrates** (ECs), for example, tend to pit or stain some surfaces. They are also easily absorbed through the skin of some animals and may injure some plants. Dusts and powders often leave a visible **residue** that may be unacceptable. **Fumigant** formulations are very likely to injure or kill all plants or animals at the application site.

If you plan to broadcast pesticides over large areas (such as in mosquito, biting fly, and forestry pest control), choose the for-

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

- *Spray droplets will permanently damage automobile paint.*
- *Do not apply directly to carpet, as discoloration may occur.*
- *Repeated applications may cause the appearance of visible spray residues on foliage.*
- *Do not allow spray to contact ferns, hickory, and maples, as injury may result.*
- *Do not apply over areas containing exposed food crops.*
- *Beekeepers should be warned well in advance to remove hives a safe distance from areas to be treated.*

mulation with great care to avoid poisoning nontarget plants and animals.

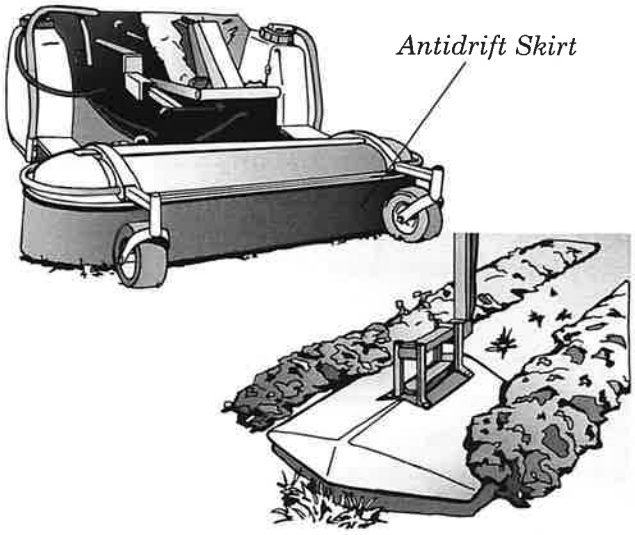
Equipment

The type of equipment that is designed to be used for or on the site, available, and in good working condition may limit your choice of formulation. Check to be sure you have all the equipment you need and that it is in good operating condition before you select a particular pesticide formulation.

Pesticide Movement

Consider whether **runoff** is likely to carry the pesticide away from the application site. Granules, pellets, dusts, and other dry formulations that do not require water as a **diluent** can reduce the risk of runoff.

Consider whether air currents are likely to carry the pesticide away from the application site as spray droplets, particles, or vapors. Check weather conditions to assess the risk of particle or vapor **drift.** Consult the label for temperature and/or wind restrictions or equipment configuration requirements.



Spray Shield

Choose a formulation or application method that minimizes drift. Avoid using dusts, high-pressure sprays, aerosols, and ultra-low-volume formulations outdoors if wind is a concern. A granular or pellet formulation or a low-pressure spray with coarse droplets would be a good choice. For other types of liquid formulations, consider using an **adjuvant** designed to reduce drift. See Unit 5 for more information on drift.

Personal Safety

Some pesticide formulations are more hazardous to people than others. ECs and ultra-low-volume concentrates often contain solvents that are hazardous themselves or that allow the pesticide to pass through the skin more quickly. Fumigants and aerosols are easily inhaled. Whenever you have a choice, select the formulation that is least hazardous to the people (or animals) who will be exposed.

Some adjuvants that you mix with your pesticide may increase your risk of exposure. Penetrants and emulsifiers may allow the pesticide to travel through the skin more quickly than usual. Stickers may increase your exposure by causing the pesticide to stick to PPE, other clothing, and skin. Spreaders and wetting agents may allow the pesticide to spread out more easily, contaminating larger areas of skin or PPE.

Target Pest

The type of formulation you select may depend on the pest you are trying to control. Sometimes you must cover an entire area with a pesticide to contact as many pests as possible. However, you can control other pests with baits or pesticides placed in a few locations, such as cracks and crevices, at the application site. Some products will only control pests present at the time of application.

Surface Characteristics

Certain pesticide formulations are better-suited for use on some types of surfaces than on others. Granules, for example, often provide good control on flat surfaces. They are less useful, however, on surfaces where they are likely to slide or fall off. On a **porous** surface, consider using a wettable powder or a dry flowable instead of an emulsifiable concentrate or oil-base pesticide. The wettable powder and dry flowable formulations will leave more pesticide remaining on the surface.

Cost

Pesticides that are sold as concentrates to be **diluted** by the end user are usually the least expensive and most convenient to buy and transport. However, these products often entail more risk during mixing and loading than pesticides that are already diluted when sold. It is important that the pesticide application be as economical as possible. Nonetheless, other factors may outweigh cost when choosing the most suitable pesticide formulation.

Choosing an Application Procedure

The conditions at the application site will influence some of the decisions you make about the application. Consider factors that affect:

- The effectiveness of the pesticide application.
- The possible effects on you and other applicators under your supervision.
- The expected impact on other people and the environment.

Some of these factors are described below.

Treated Spaces

Some fogging and aerosol applications occur in open areas outdoors. However, most such pesticide applications take place in an enclosed space. The space may be a building, hold, silo, or a smaller enclosure, such as a room or vault. Sometimes you must create the enclosed space by using tarpaulins, sheets of plastic, or other **chemical-resistant** coverings. Consider whether these treated spaces are sealed well enough to prevent the pesticide from escaping too quickly. If not, consider using a different application method or taking steps to improve the seal. You may need to tighten openings, cover air vents, or fasten the covering more securely at the base.

Soil Surfaces

If you are directing a pesticide application at a soil surface, consider the characteristics of the soil at the application site. **Organic matter** in soils may "tie up" pesticides, limiting their activity. Some pesticide labeling will allow you to use higher rates on soils with high organic matter. Soil texture also affects the way pesticides work. Soils with fine particles (silts

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

In soils over 10% organic matter, use the highest rate given.

Use the lowest rate for coarser-textured (light) soils or soils with lower organic matter.

Use a medium rate on medium-textured soils or soils containing more than 5% organic matter.

Use the highest rate for fine-textured (heavy) soils or soils containing more than 10% organic matter.

and clays) have the most surface area. The labeling may direct you to use higher rates for total coverage. Coarser soils (sands) have less surface area and may allow you to use lower rates.

Plant Surfaces

Pesticides tend to bounce or run off narrow, upright leaves. Broad, flat leaves often hold the pesticide longer. A thick wax and cuticle layer may prevent foliar sprays from entering the leaf. The waxy surface also tends to cause a foliar spray to bead up and run off the leaves.

A dense mat of leaf hairs may hold the pesticide droplets away from the leaf surface. This causes uneven distribution on the surface and allows less chemical to be absorbed into the plant. However, a thin mat of leaf hairs may allow more even distribution on the surface. This may cause the chemical to stay on the leaf surface longer than normal. As a result, the plant may absorb more chemical.

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

Add sticker-spreader when applying to smooth or waxy surfaces.

For best results on emerged weeds, add a surfactant and apply as a directed spray.

In difficult wetting situations, such as mature waxy foliage, use the higher rate.

Other Surfaces

Porous surfaces – such as wood, concrete, and fabric – may absorb pesticides (especially liquid or gas formulations) readily. If your objective is to saturate the material with pesticide, porous surfaces are helpful. However, if the pesticide must remain on the surface to be effective, porous surfaces may require more product to work well. Pesticides may bounce or run off **nonporous** surfaces, making even coverage less likely.

Applying pesticides so that they remain on upright and slanted surfaces is also difficult. Consider using adjuvants (ex. stickers) that help the pesticide cling to the treated surface.

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

Use the lower rate on nonporous surfaces and the higher rate on porous surfaces.

Activity on porous surfaces may be limited.

The cleanliness of the surface may also affect the efficacy of a pesticide application. An accumulation of organic matter on the soil surface may absorb many pesticides and reduce the amount available to control the target pest. For applications to surfaces other than soil, excess dust and dirt may prevent some of the pesticide from reaching the treated surface. Remove as much dust and dirt as you can from the application site before applying the pesticide.

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

Remove existing plant material from surface before application.

Application should be made to clean surfaces.

Before application, clean up waste materials, dust, dirt, and all other debris.

Surface Moisture

Pesticides often work best with moderate surface moisture. Too much moisture may keep the pesticide from adequately contacting the surface. Dryness may prevent the pesticide from spreading evenly over the surface and contacting the target pest.

A typical pesticide labeling statement that alerts you to this consideration is:

Most effective when good surface moisture conditions exist.

Temperature, Sunlight, and Humidity

Temperature may influence the effectiveness of some pesticide applications. Low temperature slows down or stops the activity of some pesticides. It also affects some pests by making them move about less, eat less, or change into another form. These pests may be less susceptible to some pesticide applications.

A typical pesticide labeling statement that alerts you to this consideration is:

Do not apply when temperatures are below 50°F.

High temperature and direct sunlight will also influence how well some pesticides work. They cause some pesticides left exposed on top of surfaces to break down before adequately controlling the pest.

A typical pesticide labeling statement that alerts you to this consideration is:

Do not apply when temperatures are above 95°F.

High temperature, especially combined with low humidity, increases the chance that some pesticides will vaporize. Once in vapor form, pesticides can drift from the original application site and settle onto nontarget areas. When you are applying pesticides that you know or suspect can vaporize easily, consider the environmental conditions at the application site.

Typical pesticide labeling statements that alert you to this consideration include:

At high air or surface temperatures, vapors from this product may injure susceptible plants.

When applied to properly prepared soil, the liquid is converted into a gaseous fumigant.

Do not breathe vapors or fumes.

These statements suggest that the pesticide is volatile and precautions are necessary to keep it from vaporizing and moving offsite. When applying the pesticide as a spray, consider reducing the risk of volatility by decreasing the pressure and increasing the droplet size. Avoid making applications when the temperature is high and the humidity is low.

Humidity is also an important factor in some pesticide applications. For example, herbicides often work best when weeds are growing fast – usually in high humidity and optimum temperature conditions. However, these same conditions may make nontarget plants more likely to suffer herbicide injury.

A typical pesticide labeling statement that alerts you to this consideration is:

Apply when conditions are favorable for weed growth.

Rain or Irrigation Water

Maximum/ Minimum Thermometer

Light Meter

In some situations, you must consider whether rain or other watering will occur during or soon after a pesticide application. Sometimes such watering is helpful. Some pesticides applied to porous surfaces, especially soil, must be carried by water. Thorough watering also is necessary to start pesticidal action after applying some granular pesticides. In other cases, you must apply certain protectant fungicides to plants during or just before an expected rain or watering.

In most cases, however, you should not make pesticide applications during or just

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

Apply just before a light rain or water lightly after application to wash chemical down to soil.

Begin applications when dew or rain occurs and disease threatens.

before rain or watering. This is because rain, irrigation water, or other moisture that wets the surface soon after a surface application may interfere with pest control. Water may wash off the pesticides or cause them to leach downward, away from the surface. For outdoor applications, check the forecast and make your own weather observations. For applications to plants, check for an irrigation or watering schedule.

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

Application may have to be repeated if rain occurs shortly after application.

Following application, and during rainfall events that cause runoff, this chemical may reach surface water bodies including streams, rivers, and reservoirs.

Avoid wash-off of sprayed foliage within 6 hours of application.

Air Movement

Air movement from wind or ventilation can greatly alter the effectiveness of a pesticide application. Too much wind can blow the pesticide off target and lead to poor control. The amount of air movement that is acceptable depends on the type of formulation and your application technique.

Typical pesticide labeling statements that alert you to these considerations are:

Do not apply when weather conditions favor drift from treated areas.

Do not apply with aerial equipment when wind speed is greater than 10 mph.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine droplets.

Sometimes you can use air movement to blow the pesticide into part of the target area (ex. swath displacement). You may be able to arrange for someone to turn off the ventilation system during indoor applications.

An anemometer measures wind speed.

Best Practices for Pesticide Applicators

Every time you apply a pesticide, follow these basic procedures to make sure that you are using the pesticide safely and effectively:

Adopt Safe Mixing and Loading Practices

Mixing, loading, and application are the main pesticide-handling tasks. They are also among the most hazardous. Never try to cut corners where safety is concerned. Do not assume that each job will be like every other. For example, even if you are familiar with a pesticide, take the time to read the labeling again each time you buy the product. Important directions may change; new information may have been added.

Use clean water to mix or dilute liquid concentrates. If you tank mix one pesticide

Use great care when mixing and loading pesticides.

with another, follow the instructions on the label. If there are no instructions, do compatibility testing as described in Unit 4.

Pesticide handlers are most often exposed to harmful amounts of pesticides when mixing or loading concentrated product. Handlers who mix and load concentrated pesticides with high acute toxicity run an especially high risk of accidental poisoning. By observing some simple precautions, you can reduce the risks involved in this part of your job.

Choose the pesticide mixing and loading area carefully. It should be safe and easy to work in. Additionally, the area should be outdoors or in a well-ventilated area away from unprotected people, animals, food, other pesticides, and other items that might be contaminated. Be very careful not to mix or load pesticides indoors unless lighting and ventilation are good.

Measure the Pesticide Carefully

Gather the necessary utensils to measure the pesticide you will use. You will need an assortment of glass or plastic containers to measure liquids. You will also need a scale and some pans or papers to measure and weigh dry pesticides. (Dry flowables and water-dispersible granules are sold with measuring devices for each specific formulation and batch.) Mark each utensil clearly so that you will not use it for other purposes. After each use, clean all utensils. Store them in a locked pesticide storage area. For more information on measuring pesticides, see Unit 10.

Calibrate Your Equipment

Many times, you must calibrate your application equipment before applying a pesticide. This means measuring the delivery rate and distribution of your equipment. To make corrections, adjust the application equipment so the desired amount of pesticide is applied uniformly to the target area. For more information on calibration, see Unit 9.

Inspect the Treatment Area

Before you begin your application, inspect the treatment area. Determine the exact location and boundaries of the area to be treated. Locate sensitive areas such as water wells and streams. Identify nontarget organisms (ex. honey bees) and any potential hazards. Come up with a plan to protect people working or living in or near the treatment area.

Deliver the Pesticide to the Target Site

Make sure that the pesticide is reaching the target surface or space. Depositing pesticide elsewhere is a waste of time and money and may harm nontarget areas.

Check the Delivery Rate

Check to be sure that you are applying the pesticide evenly and in the right amounts. There should be no puddles of liquid pesticide or mounds of dry pesticide in the application area. Be especially careful in areas where you turn or pause. Many types of application equipment will continue to release pesticide even when they are not moving.

When you have applied the pesticide to the first part of the treatment area or space, check to be sure that you have applied about the right proportion of pesticide. If you are

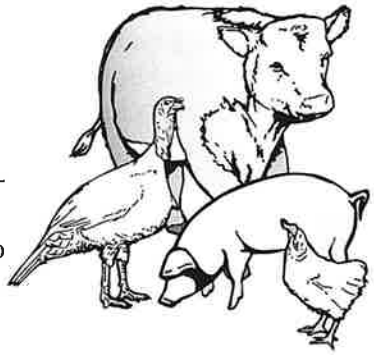
releasing too little, check the equipment openings for clogs or obstructions. If you are releasing too much, check for worn or stuck openings.

Check for Appearance

As you work, notice whether the released pesticide looks as it should. Applications of wettable powders usually have a whitish color. If the liquid is clear, check to be sure that you are agitating the mixture enough to keep the wettable powder mixed with the water. Granules and dusts should appear dry and should not form clumps. Emulsifiable concentrates usually look milky. If the pesticide does not look right, be sure that you have the right mixture and that it is still blended evenly.

Check the appearance of the target area where you have just released the pesticide. If the surface is changing colors or is stained unexpectedly, stop and make sure you are not harming the surface.

Avoid Nontarget Organisms



Keep livestock and other nontarget animals out of the application area.

Before you apply a pesticide, clear all unprotected people from the area. It is illegal to expose bystanders to a pesticide application – either directly or through drift. Also, remove any pets or livestock that are not undergoing treatment. Even when the pesticide application is a narrowly directed one (such as a crack and crevice treatment), keep people and animals out of the immediate area during the application.

Check the pesticide labeling to find out when people and nontarget animals can reenter the application area. The labeling of some pesticides restricts entry into treated areas for periods ranging from several hours to several days. Even if the labeling has no such instructions, do not allow anyone to enter the treated area at least until any dusts and mists have settled, sprays have dried, and vapors have dispersed. After indoor treatments, consider ventilating the area with fans, vents, or open windows before you let anyone return.

Avoid Nontarget Surfaces

When possible, remove any items that should not be contaminated with pesticides from the application site. Cover or protect any items that you cannot remove from the area and that are not needed during the application. Items that should be removed or covered include food and food utensils; bedding; toys; seed; pet or livestock feed, water, or supplies; and other items that could transfer pesticides to people, pets, or livestock.

Operate Equipment Safely

Turn off your equipment whenever you pause for any reason. Take special care to turn it off before making any adjustments or repairs. When you stop to take a break, to move to another site, or for repairs, depressurize any pressurized spray tanks. Turn off the main pressure valve on the tank and release any pressure remaining at the nozzles.

If you are applying pesticides at a distance from your equipment – at the end of a long hose, for example – be sure that unprotected people and pets stay away from the equipment. You may need to post a helper near it.

Check hoses, valves, nozzles, hoppers, and other equipment parts occasionally while you are working. If you notice a problem, stop right away and fix it. Do not use bare hands or your mouth to clear nozzles, hoses, or hopper openings. Carry a soft-bristle brush for such jobs. Never use this tool for any other purpose.

Scheduling Pesticide Applications

Each pesticide application involves a different set of conditions. Your responsibility is to assess these conditions. Then, you must decide when to apply the pesticide and whether to take any special precautions.

Sometimes you have no choice about when to schedule a pesticide application. In those cases, you must be careful to apply the pesticides safely under the existing conditions. If you do have some scheduling flexibility, consider working after normal business hours. This means during very early morning hours, in the evening, or even at night – both outdoors and indoors in greenhouses, malls, office buildings, and other nonresidential structures.

Applying pesticides after hours has several advantages:

- It is less likely that people other than pesticide handlers will be nearby.
- It is more likely to be cooler, reducing concerns about heat stress and pesticide vaporization.
- The wind is likely to be low, and indoor ventilation systems may be off or reduced.
- There will be no direct sun in outdoor and glass-roofed sites.

If you do choose to work after normal business hours, have another person check on you often. Work only where there is enough light to allow you to apply the pesticide correctly and accurately.

Postapplication Tasks

As soon as you finish the application, you should do a few important follow-up tasks:

- Take the time to clean up properly. Wash your pesticide equipment and then wash yourself. Return equipment to its designated place.
- Safely store or dispose of all remaining pesticide materials and other chemicals.
- Be sure that your worksite presents no hazards to people or to the environment.
- Never leave the site unattended until everything has been cleaned up and put away.
- While you can still remember the facts, make a record of what you have applied and the conditions at the application site. Later on, evaluate the efficacy of the application. Look for any unexpected results or problems.

Equipment Cleanup

Always clean your 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 area. When the job is done and the tank or hopper is empty, return the equipment to the designated equipment cleanup area. Do not wash equipment repeatedly in the same location unless you use a containment pad or tray or you can effectively decontaminate the area. Over time, pesticide residues may contaminate the flooring or soil in a frequently used area. This increases the chance of harming people and animals in the contaminated area. It also increases the likelihood of runoff or **leaching** into water systems. Avoid keeping pesticide-contaminated equipment in one place all the time. Pesticides may move off the outside of the equipment and onto the floor or soil.

Do not assign a worker to clean pesticide-contaminated equipment unless he or she is certified and knows the basic rules of pesticide safety. Remember that equipment cleaning presents as great a risk of pesticide exposure as many other pesticide-handling tasks. Moreover, all parts of the equipment are likely to have pesticides or pesticide residues on them. When you clean pesticide-contaminated equipment, wear the required PPE plus a chemical-resistant apron.

Benefits of Correct Cleaning

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 residue can damage equipment.

Liquid pesticides that remain in the equipment may quickly corrode it and clog or corrode the nozzle openings. They may cause the equipment to leak or the nozzles to release too little or too much pesticide when the equipment is in use. Some pesticides change if they are stored after being diluted. As a result, they may not be suitable for application later on.

Some liquid pesticides 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 liquids that cannot easily be remixed. Liquid pesticides that are allowed to dry in the equipment may be impossible to remove completely.

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 later, and they cannot be easily removed from the equipment.

Cleaning and Storing Procedures

After the equipment is empty, clean both the inside and outside thoroughly – including nozzles or hopper openings. Sometimes you may need to use the diluent within the pesticide mixture (ex. high-grade oil), special cleaning agents, or water under pressure. In other cases, ordinary water may be enough.

Collect the rinsate (the liquid that results from the washing process). If you cannot reuse or legally dispose of it, limit the amount of material you use. You will create less waste. See Unit 11 for more information on rinsates.

Use special care when washing any vehicles (ex. vans and trucks) used to transport unprotected workers or families. People have been poisoned by riding in vehicles used for pesticide application.

Before you store your sprayer at the end of the spray season, add 1 to 5 gallons of lightweight oil (depending on the size of the tank) before the final flushing. The oil leaves a protective coating on the inside of the tank, pump, and plumbing. Remove nozzles and screens, and store them in a can of light oil. Add a little oil and rotate the pump a few revolutions by hand. This will coat the interior surfaces and prevent corrosion. After cleaning and draining the equipment, store empty metal or plastic containers until they can be recycled or properly disposed of. Replace any worn-out or broken parts.

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

Do not store spray solution in tank overnight.

Clean application equipment thoroughly after use by flushing with water in a safe place.

Do not contaminate water by cleaning of equipment.

Dispose of rinsate by incorporation into area just treated or by other approved means.

Personal Cleanup

When you finish working with pesticides or pesticide-contaminated equipment, take time for personal cleanup. Wash the outside of your gloves first, before taking them off. Then carefully peel back your personal protective equipment to avoid getting pesticides on your skin. Remove any other clothing that has pesticide on it.

If you cannot take a shower right away, use a mild liquid detergent and warm water to wash your face, hands, forearms, and any other area that may have pesticides on it. As soon as you can – no later than the end of the workday – wash your entire body and hair thoroughly with a mild liquid detergent and plenty of warm water.

When you remove your PPE and work clothing, put them in a plastic box or bag until they can be laundered. Do not allow children or pets to play with these items. Do not wash work clothing and PPE in the same wash water with the family laundry.

Recordkeeping

Why Keep Records?

Keeping records of pesticide applications is essential. In many cases, it is a legal requirement. Records can establish proof of proper use. They also can provide you with useful information in response to claims of excess residues or damages.

Good records can save you money. They allow you to compare the results obtained from using different pesticides, formulations, and equipment. With accurate records, you can gauge how various site conditions affect your outcomes. In this way, you can improve your overall pest control practices and efficiency.

Records can help you reduce pesticide mistakes or misuse. If a pest is not properly controlled, if pesticide damage has occurred in the target area, or if a pesticide has drifted off target, you may be able to determine what went wrong. Records may help you pinpoint a particular pesticide, formulation, type of application equipment, or condition in the treatment area as the cause of the problem. You can then take steps to avoid this situation in the future.

Be sure to keep accurate records of your application.

Good records can help you reduce overstock and waste by buying only the amount of pesticides you will need. Some pesticides do not store well for long periods. In addition, disposing of excess pesticide can be very expensive.

Additional Information

Every record form should have a space for additional comments. Use this space to jot down information for your own use or to note anything unusual about the treatment. Record details about any scouting or monitoring. Make notes about weather conditions. Additionally, write down what other pest management methods are in use and how successful the overall pest management strategy is. This information will help you improve your pest management operations, either through better customer or worker relations or by saving money.

Required Records

Be sure you know what records you must keep, what data elements are required, and how long you must keep them. Many enforcement inspections look closely at recordkeeping because records are a clue to how an operation is being managed. Keep your records in a safe place where you can find them when needed. For more information about required recordkeeping, see "Recordkeeping" sections in Unit 1.

Test Your Knowledge

Q. What eight basic safety questions should you ask yourself whenever you or those you supervise will be handling pesticides?

A.

1. Have I read the labeling?
2. How can I avoid exposure to pesticides?
3. What personal protective equipment (PPE) do I need?
4. Is my application equipment ready and safe?
5. How can I avoid accidental pesticide contamination?
6. Have I instructed the handlers I supervise?
7. Am I prepared for emergencies?
8. Are people and animals out of the area?

Q. List at least six ways to avoid exposing yourself to pesticides.

A.

1. Keep clothing, food, drinks, chewing gum, tobacco products, and other belongings away from where pesticides are stored or handled.
2. Before taking a break, wash your gloves on the outside, remove them, and wash your hands and face thoroughly.
3. Avoid getting pesticide on yourself when you use the toilet.
4. Do not tear paper or cardboard containers to open them – use a sharp knife or scissors instead.
5. Open pesticide containers only when they are sitting on a flat, stable surface. Close containers tightly after each use.
6. When pouring a pesticide, keep the container and pesticide below face level.
7. If there is a wind outdoors or a strong air current indoors, stand so the pesticide cannot blow back on you. Or, find another place to mix or load.
8. When transferring wettable powders, dusts, or other dry formulations, avoid spilling or inhaling dusts.
9. Never use your mouth to siphon pesticide from the container to the tank.
10. Protect yourself during mixing, loading, and application; during spill cleanup; and when repairing or maintaining equipment.
11. Use great care when transporting, storing, or disposing of pesticide containers that are open or have pesticides on their outer surface.
12. Use PPE when necessary to keep pesticides from getting on your skin and in your mouth, eyes, or lungs.

Q. What are your two major responsibilities when applying pesticides?

A.

1. Protect yourself, others, and the environment.
2. Make sure that you apply the pesticide correctly.

Q. What legal responsibilities do you have as a pesticide handler and supervisor?

A.

1. Follow labeling instructions to the letter.
2. Provide all pesticide handlers you supervise with specific instructions about the pesticides they will be using and the duties expected of them.

3. Make sure no one is overexposed to pesticides that you or your workers are handling.

Q. Name several ways you could accidentally transfer pesticides to others.

A. 1. Touching objects, people, or animals with pesticide-contaminated gloves.

2. Sitting in your car or on a chair while wearing soiled PPE.

3. Using the telephone or the toilet at work or at home right after or during a pesticide application.

4. Taking pesticide-contaminated clothing or other items home. These items can transfer pesticides to carpeting, furniture, laundry items, pets, and people.

Q. What three steps should you take in a pesticide-poisoning emergency?

A. 1. Remove the victim from the exposure zone at once.

2. Summon medical assistance quickly.

3. Provide first aid.

Q. List some consequences of the incorrect or dangerous use of pesticides.

A. 1. Wasted material, failure to control the pest, and damage to the target site.

2. Both immediate and long-term harmful effects to humans, other living things, property, and other parts of the environment.

3. Fines as well as legal actions charging you with liability for damages.

4. High costs.

Q. Name several resource groups that will help you choose an appropriate pesticide.

A. Pesticide dealers, Virginia Cooperative Extension agents, and trade associations.

Q. Name at least four factors to consider when choosing a pesticide formulation.

A. 1. Application site – Will the formulation harm nontarget plants, animals, or surfaces in the proposed treatment area?

2. Application equipment – Is the equipment needed for the formulation available, in good working condition, and designed to be used for or on the site?

3. Pesticide movement – Does the formulation present a hazard of drift or runoff away from the application site?

4. Personal safety – Is the formulation unreasonably hazardous to applicators, workers, and other people and animals likely to be exposed?

5. Target pest – Is the formulation likely to control the target pest in its natural habitat?

6. Surface characteristics – Is the target surface suitable for that formulation?

7. Cost – Is the formulation cost-effective for the intended application?

Q. True or false: A drift-reducing adjuvant, such as a sticker, may also increase your risk of pesticide exposure.

A. True. Stickers may cause the pesticide to stick to PPE, other clothing, and skin.

Q. Name at least five application-site conditions that may influence your application procedures.

A. 1. Type of space to be treated (ex. outdoors, in a silo, or in a building).

2. Type of surface to be treated (ex. soil, plant, wood, concrete, or fabric).

3. Surface cleanliness (dirt and organic matter may interfere with the effectiveness of the pesticide).

4. Surface moisture (excessive wetness or dryness may prevent the pesticide from contacting the target pest).

5. Temperature, sunlight, and humidity (these factors may influence how well some pesticides work).

6. Rain or irrigation water (water may be helpful or harmful, depending on when it occurs).

7. Air movement (wind or ventilation can greatly alter the effectiveness of a pesticide application).

Q. How does temperature influence the effectiveness of a pesticide?

A. Low temperature slows down or stops the activity of some pesticides. High temperature increases the chance that certain pesticides will vaporize. It also may cause some pesticides left exposed on top of surfaces to break down prematurely.

Q. How might soil characteristics at an application site affect your application rates?

A. Some pesticide labeling will allow you to use higher rates on soils with high organic matter. Labeling may also direct you to use higher rates for soils with fine particles (silts and clays). Coarser soils (sands) have less surface area and may allow you to use lower rates.

Q. How might air movement affect your application?

A. Too much wind can blow the pesticide off target and lead to poor control. It may also result in off-target damage.

Q. What best management practices should you follow each time you apply a pesticide?

A. 1. Adopt safe mixing and loading practices – Choose the pesticide mixing and loading area carefully. It should be safe and easy to work in. Additionally, the area should be outdoors or in a well-ventilated, well-lit area away from unprotected people, animals, food, other pesticides, and other sensitive items.

2. Measure the pesticide carefully – Gather the necessary measuring utensils, marking each clearly. After each use, clean all utensils and store them in a secure area.

3. Calibrate your equipment – Measure the delivery rate and distribution of your application equipment before applying the pesticide. Make adjustments as necessary.

4. Inspect the treatment area – Locate sensitive areas and identify nontarget organisms. Learn the exact location and boundaries of the area to be treated. Come up with a plan to protect people working or living in or near the treatment area.

5. Deliver the pesticide to the target site – Make sure that the pesticide is reaching the intended surface or space.

6. Check the delivery rate – Ensure that you are applying the pesticide evenly and in the right amounts. Adjust as needed.

7. Check for appearance – Note the color and consistency of the pesticide you are releasing. Also, check the surface color of the target area.

8. Avoid nontarget organisms – Keep all bystanders, pets, and livestock out of the treatment area. Check the pesticide labeling for reentry instructions.

9. Avoid nontarget surfaces – Remove or protect any items that should not be contaminated with pesticides.

10. Operate equipment safely – Turn off your equipment whenever you pause for any reason. Fix any mechanical problems right away, using proper tools.

Q. Name several advantages to scheduling pesticide applications after normal business hours (very early morning, evening, or at night).

A. 1. It is less likely that people other than pesticide handlers will be nearby.

2. It is more likely to be cooler, reducing concerns about heat stress and pesticide vaporization.

3. The wind is likely to be low, and indoor ventilation systems may be off or reduced.

4. There will be no direct sun in outdoor and glass-roofed sites.

Q. When you have finished a pesticide application, what should you do right away?

A. 1. Wash your pesticide equipment and then wash yourself.

2. Return equipment to its designated place.

3. Safely store or dispose of all remaining pesticide materials and other chemicals.

4. Be sure that your worksite presents no hazards to people or the environment.

5. Make a record of what you have applied and the conditions at the application site.

Q. True or false: Cleaning pesticide-contaminated equipment presents a much smaller risk to the pesticide handler than actually applying pesticides.

A. False. Equipment cleaning presents as great a risk of pesticide exposure. All parts of the equipment are likely to have pesticides or pesticide residues on them.

Q. Why is it so important to remove all traces of liquid or dry pesticide from your equipment after an application?

A. Even small amounts of pesticide residue can damage equipment. Liquid pesticides corrode it, clog nozzle openings, and cause leaks. They may also settle out, form a clump at the bottom of tank, and/or be impossible to remove. Dry pesticides may become wet and are very difficult to remove from the equipment.

Q. Briefly describe how to prepare a sprayer for storage at the end of the season.

A. Add 1 to 5 gallons of lightweight oil (depending on the size of the tank) before the final flushing. Remove nozzles and screens, and store them in a can of light oil. Add a little oil and rotate the pump a few revolutions by hand. After cleaning and draining the equipment, store empty metal or plastic containers until they can be recycled or properly disposed of. Replace any worn-out or broken parts.

Q. When you have finished handling pesticides, what steps should you take for personal cleanup?

A. 1. Wash the outside of your gloves first, before taking them off.

2. Carefully peel back your PPE.

3. Remove any other clothing that has pesticide on it.

4. If you cannot take a shower right away, use a mild liquid detergent and warm water to wash your face, hands, forearms, and any other area that may have pesticides on it.

5. As soon as you can – no later than the end of the workday – wash your entire body and hair thoroughly with a mild liquid detergent and plenty of warm water.

6. Put your PPE and work clothing in a plastic box or bag until it can be laundered.

Q. Why should you keep records of pesticide applications?

A. 1. It is often a legal requirement.

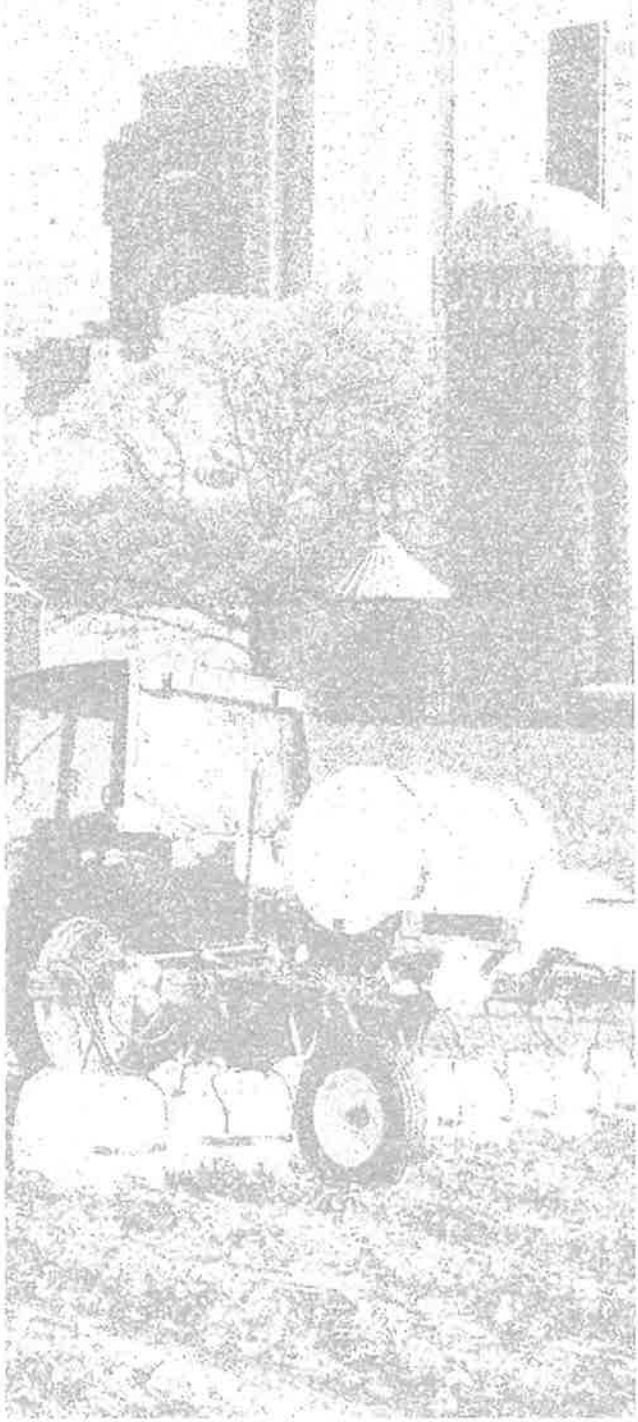
2. Records can establish proof of proper use. They can provide you with useful information in response to claims of excess residues or damages.

3. Good records can save you money by improving your pest control practices and efficiency.

4. Records can help you reduce pesticide mistakes or misuse. They can help you pinpoint the pesticide, formulation, type of application equipment, or condition in the treatment area as the possible cause of a problem.

5. Good records can help you reduce overstock and waste by buying only the amount of pesticides you will need.

Unit 9. Application Equipment, Calibration, and Methods



Learning Objectives

After studying this unit, you should be able to:

- Define calibration.
- Choose the right application equipment and pesticide formulation for a job.
- State the importance of using proper application techniques.
- Name and describe the basic types of sprayers and spreaders.
- Explain the importance of nozzles in a spraying system.
- Name the factors that affect application rate.
- Explain the importance of calibrating equipment and recalibrating when necessary.
- List and discuss specific steps in calibrating sprayers and spreaders.
- Calibrate a sprayer or spreader using a representative test area.
- Explain why it is important to distribute a pesticide properly, as directed by the label.
- Decide how to manage and reduce pesticide drift.
- Use ratio and proportion to determine how much product to apply.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Active Ingredient (a.i.) – A chemical in a pesticide product that affects or controls the target pest.

Application Rate – The amount of pesticide applied to a given area.

Band Application – Application of a pesticide to a long, narrow strip (ex. over or between crop rows).

Broadcast Application – Uniform application of a pesticide to a wide or large area.

Calibrate – To measure the delivery rate and distribution of application equipment; to adjust application equipment so the desired amount of pesticide is applied uniformly to a given area or space.

Calibration – The process of measuring and adjusting the amount of pesticide a piece of equipment applies to a target.

Carrier – The primary material used to allow a pesticide to be dispersed effectively. Examples include the talc in a dust formulation, water mixed with a wettable powder before a spray application, and air that disperses the pesticide in an air-blast application.

Terms to Know cont.

Concentrated – Having a high percentage of active ingredient.

Directed Application – Precise application to a specific area or site (ex. underleaf, fence-line, or guardrail spraying), often using specialized equipment.

Drift – The movement of pesticides away from the release site in air.

Drop Spreader – A type of granular applicator with an adjustable sliding gate that opens holes in the bottom of the hopper. Granules flow out by gravity feed.

Effective Swath Width – The span of spray or granules with enough pesticide to control the pest.

Flow Rate – Volume of material released per unit time; for example, the amount of fluid that passes through a nozzle's orifice in one minute.

Gallons per Acre (gpa) – The volume of liquid applied to an acre unit area.

Gallons per Minute (gpm) – The volume of liquid released by a spraying system or from a specific nozzle in one minute (60 seconds).

Orifice – A precisely sized opening in a spray nozzle, duster, or granular applicator through which the spray, dust, or granules flow.

Release – To discharge pesticide from its container or the equipment or system used to apply it. Release can be intentional (as in an application) or accidental (as in a spill or leak).

Rotary Spreader – A type of granular applicator that distributes granules to the front and sides of the spreader, usually with a spinning disk or fan.

Spot Treatment – An application to a small, localized area. In some cases, spot treatment involves treating individual pests, such as thistles in a pasture or a yellow jacket nest, while avoiding nontarget organisms.

Spray Volume – The amount of finished pesticide mixture to be applied per unit area.

Swath – The area treated by application equipment in one pass.

Swath Width – Side-to-side measurement of the band or strip of pesticide released by application equipment.

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

Introduction

As a pesticide applicator, one of your most important tasks is to make sure that you apply the correct amount of pesticide to the target. Always read and follow label directions. Be sure to use the right equipment and application method for the task. Applying either too little or too much can cause problems.

Underdosing is often expensive over time. If you apply too little pesticide, you may not control the pest. Sometimes you can legally repeat the entire application. However, doing so may be costly in time, money, pesticide, labor, and equipment. In other cases, a repeat application may not be possible because it would result in an overdose.

Overdosing is illegal and unsafe. Like underdosing, it is also expensive. This is true because an overapplication uses more product than necessary. Applying more than the label-directed amount to food, feed crops, or livestock may result in illegal residues. In addition, exceeding the label **application rate** may damage the surface you treated or injure the animal or plant you intended to protect. It may also harm people and the environment. Do not use any more than the amounts listed in the directions for use section of the pesticide label. Using more than the label directs will not do a better job of controlling pests. You may be fined for – and liable for damages caused by – exceeding the application rate.

One of your most important skills is calibration. **Calibration** is the process of measuring the amount of pesticide your equipment will uniformly apply to a target area. Calibration also involves adjusting the application rate as necessary to match label directions.

Section A: Application Methods and Equipment

Common Application Methods

The pesticide application method you select depends on a number of factors:

- Life cycle stage, nature, and habits of the target pest.
- Site characteristics.
- Mode of action of the pesticide **active ingredient**.
- Properties of the pesticide formulation.
- Suitability of the application equipment for the job.
- Cost and efficiency of alternative methods.

In many cases, one or more of these factors will influence your choice.

Some common application techniques include:

1. Band – Application of a pesticide in strips, such as between crop rows, instead of uniformly over an entire field.
2. Broadcast – Uniform application of a pesticide to a large area, such as an entire field, golf course fairway, or electric utility right-of-way.
3. Crack and crevice – Placement of small amounts of pesticide into less-accessible spaces in buildings, such as along baseboards and in cabinets; a type of **spot treatment**.
4. Foliar – Application of a pesticide to the leafy portions of a plant.
5. Soil – Application of a pesticide directly on or in the soil instead of on a growing plant.
6. Soil incorporation – Use of tillage, rainfall, or irrigation equipment to move the pesticide into the soil during or soon after application.
7. Soil injection – Application of a pesticide under pressure beneath the soil surface.
8. Space treatment – Application of a pesticide in an enclosed area.

9. Spot treatment – Application of a pesticide to small, distinct areas.

10. Tree injection – Application of pesticides under tree bark.

Application Equipment

The following section is of particular interest to private applicators and registered technicians. These applicators may not read the commercial category manuals that provide information on application equipment. For that reason, a short section on application equipment follows. It serves as a review for commercial applicators who use the kinds of equipment discussed. Private applicators and registered technicians will be tested on this content.

This section describes how to choose, use, and care for application equipment. You will use some equipment to treat field crops, nursery stock, common household pests, turf, and ornamental landscape plants. Other equipment may require special training. Such equipment is necessary for specialized pesticide applications, such as air-blast spraying, fumigation, aerial application, and chemigation.

Your equipment must be able to deliver the correct amount of pesticide to the intended target. Consider the formulation you wish to apply and the site you plan to treat. Read and follow the manufacturer's directions. Keep up with new application equipment technology. As an example, hooded boom sprayers, electrostatic sprayers, and devices that apply herbicides to cut or mowed surfaces are coming into increasing use.

To learn more about application equipment and its components (ex. nozzles, pumps, tanks, and hoses), contact your local Extension agent. Other resources include equipment manufacturer catalogs, technical bulletins, and websites.

Sprayers

Sprayers are the most common kind of pesticide application equipment. They range in size and complexity from simple, hand-held models to intricate machines weighing several tons. Sprayers deliver liquid spray mixtures (solutions or suspensions) to a target.

Sprayer Components

Most sprayers have these parts:

- Tank.
- Pump.
- Agitator.
- Hoses.
- Screens and filters.
- Pressure regulator.
- Boom or wand.
- Nozzles.

Sprayers use water or another liquid as a **carrier** and to dilute a pesticide. They have a tank to hold the finished spray mix. A pump moves the liquid through hoses and out of the spraying system. A pressure regulator matches the flow through the regulator to the demand placed upon the system. Many systems include an agitator, which keeps particles in suspension and evenly distributed. Screens and filters keep dirt and debris from clogging or damaging the nozzles and other parts. A wand is an extension that holds one or several nozzles. A boom does the same thing. Booms usually hold a number of nozzles. You can adjust the boom **release** height to ensure that the liquid is dispersed properly.

Nozzles

Nozzles are a vital part of a spraying system. The nozzle you select affects output, droplet formation and size, droplet distribution, and spray pattern. A complete nozzle assembly consists of the body, screen, cap, and nozzle or **orifice** plate. The nozzle is an atomizing device. It produces droplets that form the spray pattern. Nozzles are classified based on the spray pattern and droplet size(s) they produce. The size of the orifice (opening)

affects the droplet size and **flow rate**. Nozzles are made for many different spraying requirements.

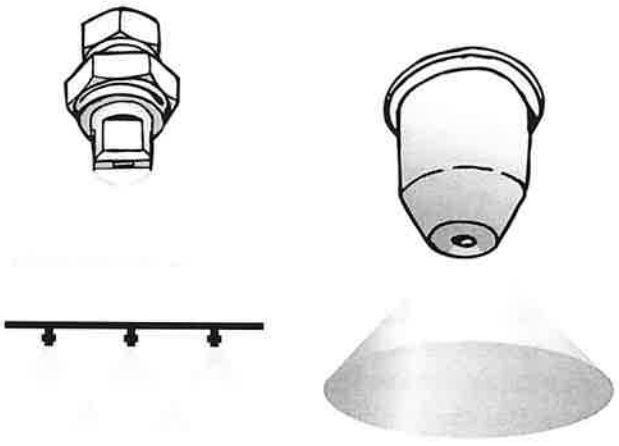
When you choose nozzles for a job, consider nozzle design, pattern, orifice size, and operating pressure. Read the label of the product you will apply. Check for droplet size recommendations or requirements. Consider your target and the properties of the active ingredient and finished spray mixture you will apply.

Never operate nozzles at a pressure outside the prescribed range. If the pressure is too low or high, the pattern the nozzle is supposed to produce will not form properly. Spray distribution will not be even or as expected. In addition, high pressure increases the rate of nozzle wear and the **drift** hazard.

Nozzles are made of aluminum, brass, ceramic, plastic or polymer, nylon, stainless steel, and hardened stainless steel. Ceramic and hardened stainless steel are most resistant to wear. They will last longer when used with abrasive formulations, such as wettable powders.

Many types of nozzles are available today. Two common types are the flat fan and the cone nozzle.

A fan nozzle produces a fan-shaped spray. A regular flat-fan nozzle makes a narrow oval pattern with lighter edges. Flat-fan nozzles are typically used for broadcast spraying and are often mounted on a boom. They are well-suited for making herbicide applications.



Flat-Fan Nozzle *Solid-Cone Nozzle*

Cone nozzles produce circular patterns. The hollow-cone nozzle delivers most of the material to the outer rim of the circle. The solid-cone nozzle delivers liquid droplets to the entire area of the circle. Both types of nozzles have circular openings. They are well-suited for applying insecticides or fungicides when complete coverage of leaf surfaces is necessary.

Use nozzle screens to reduce clogging. Keep nozzles clean and in good condition. Check their pattern and flow rate regularly. If a nozzle is damaged and producing a non-standard pattern, replace it.

Sprayer Types

Hand Sprayers

Hand sprayers are useful for applying small quantities of pesticides. They hold varying amounts of spray mix, from a quart to several gallons. You can use hand sprayers in structures as well as outside for spot treatments or in hard-to-reach areas.

Hand sprayers are usually small, simple to operate, inexpensive, and easy to clean and store. However, their pressure and output rate fluctuate. They also have no agitator, so it is difficult to keep wettable powders and similar pesticides in suspension. Hand sprayers may not work well for applying liquid suspensions.

Backpack (Knapsack) Sprayers

Backpack sprayers often have a hand-operated hydraulic pump that forces liquid pesticide through a hose and nozzles via a wand or "gun." Usually, moving a lever activates the pump. Some of these sprayers can generate pressures of 100 pounds per square inch (psi) or more. Typically, backpack sprayer tanks hold 5 gallons or less.

Backpack sprayers have a larger capacity than hand sprayers. They are simple to operate, inexpensive, and effective for applying

liquid spray solutions. Some have enough agitation to keep spray suspensions evenly distributed. However, their pressure and output may fluctuate. Spray released from low-pressure backpack sprayers may not penetrate thick foliage easily. Because of their small capacity, backpack sprayers are not suitable for wide-area broadcast treatments.

Small Motorized Sprayers

Small motorized sprayers have all the parts of larger field sprayers but are not self-propelled. Sometimes they are pulled manually or with a tractor or truck. Or they can be skid-mounted and carried on a truck. These sprayers will operate at low or high pressure and are suitable for smaller outdoor areas. Most have a hose and an adjustable nozzle on a handgun.

Small motorized sprayers have a larger capacity than either hand or backpack sprayers. They have built-in hydraulic agitation and are small enough for limited spaces. Like backpack sprayers, they are not suitable for wide-area broadcast treatments.

Boom Sprayers (Low Pressure)

Low-pressure boom sprayers typically have booms between 20 and 35 feet long. The number of nozzles used depends on the nozzle spray angle and boom length. The height of the boom must be easily adjustable. Some low-pressure sprayers have a hose and handgun nozzle. This allows the applicator to make spot treatments and/or spray small or hard-to-reach areas.

Low-pressure boom sprayers are suitable for **band applications** or for wide-area **broadcast applications**. They will evenly distribute liquid mixtures and give uniform treatment if configured and operated properly. However, these sprayers require large amounts of water and fuel to operate. Booms operated with high release points may result in drift.

Boomless Sprayers (Low Pressure)

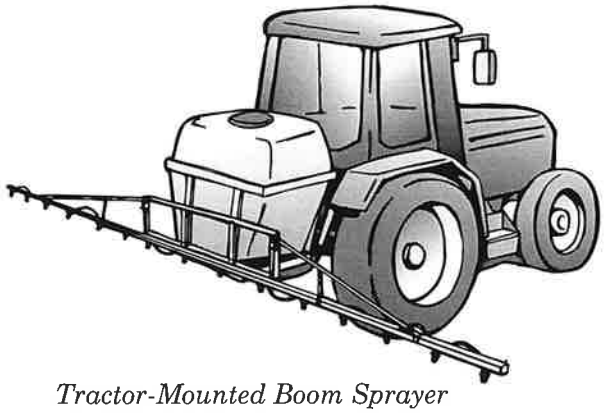
Low-pressure boomless sprayers have a special nozzle or cluster of nozzles that produce a horizontal spray pattern. **Swath width** and output depend on the nozzle orifice size and pressure. Operators may use two or three nozzles to achieve a desired spray pattern. These sprayers are useful in irregularly shaped areas and for treating fence lines.

Low-pressure boomless sprayers are small and compact. They may be mounted on a four-wheeler and used in areas not accessible by tractor or truck. However, their smaller tanks require frequent fill-ups. Treatment may not be uniform.

Large Power-Driven Sprayers (High Pressure)

High-pressure, power-driven sprayers can penetrate dense foliage, thick animal hair, the tops of tall trees, and into other areas needing high pressure. They can deliver large volumes of spray – usually 20 to 500 **gallons per acre (gpa)** – using pressures ranging from 150 to 400 psi or more.

These sprayers are usually mounted on tractors, trailers, trucks, or boats. Some are self-propelled. As a rule, they use piston pumps and provide outputs up to 60 **gallons per minute (gpm)**. They require large tanks (500 to 1,000 gallons) because the application rate is often high. When fitted with correct pressure unloaders, these sprayers can be used at low pressures. However, all hoses, valves, nozzles, and other parts must withstand high-pressure applications.



Tractor-Mounted Boom Sprayer

High-pressure sprayers provide good penetration of many treated surfaces. When fitted with a boom, they are suitable for wide-area broadcast treatments. However, these sprayers need large amounts of water, power, and fuel. Their high pressure may produce drift-prone droplets.

Spreaders (Granule Applicators) and Dusters

Spreaders and dusters are designed to apply solid, ready-to-use pesticide formulations. Dust applications are most common in greenhouses and other enclosed areas. Granules and pellets are often used outdoors to treat turf and crop fields.

When selecting a spreader or duster, look for one that is easy to clean and fill. Spreaders should have mechanical agitation over the outlet holes. This prevents clogging and helps keep the flow rate constant. Product release should stop when the apparatus stops, even if the outlets are still open.

Granule Applicators (Drop and Rotary Spreaders)

Granule applicators are simple machines. They distribute granular pesticides by two basic methods: (1) spinning or whirling disks (**rotary spreaders**) and (2) multiple gravity-feed outlets (**drop spreaders**).

Granular application devices can make broadcast treatments, distributing granules evenly over a wide area. They may also treat specific areas in banded, in-furrow, or side-dress applications.

Band applicators usually are a modification of the gravity-feed equipment. Granules drop through tubes and fall just above the soil to form bands of a specific width. For band applicators, the swath width is the number of bands multiplied by the bandwidth in feet. Watch the band applicators to be sure that bandwidth stays the same. Small changes in release height may cause a change in bandwidth.

Soil injectors are band applicators that release the granules into furrows, which are then covered. Ram-air equipment (on agricultural aircraft) uses a combination of airflow and gravity to deliver the granules to the target site.

Drop spreaders are hopper-type devices with sliding gate openings or augers. Drop spreaders treat the width of the hopper only. Rotary spreaders use air or spinning discs to cover **swaths** much wider than the machines themselves. They cover a wider swath than drop spreaders. Hence, you can treat a given area faster using a rotary spreader.

However, drop spreaders provide more even (uniform) coverage. This is because, for rotary spreaders, travel speed affects how fast the plate or disk that distributes the granules spins. This, in turn, affects the distribution of the released granules. In addition, turning changes the rotating plate speed. Even body sway can affect pattern or particle distribution. Rotary spreaders are less suitable for use on uneven or sloped terrain than drop spreaders are. Be careful not to apply pesticide particles outside the target area.

NOTE: Dry products that are not uniform in particle size or weight do not spread evenly, regardless of operator skill or the type of equipment used.

Granular applicators have many advantages. They are simple in design, have few moving parts, and are easy to clean, maintain, and repair. Since the pesticides used are ready-to-use, no mixing is necessary. Moreover, granules are less likely to drift, and they settle quickly after application. Applicator exposure hazard is less because there is no spray, little to no dust, and the active ingredient percentage is low.

Rotary Spreader

Drop Spreader

However, spreaders also have some drawbacks. Granules will not stick to foliage or nonlevel surfaces. You must recalibrate your equipment for each granular formulation used. Moreover, the calibration process is relatively difficult. Spreaders may not apply granules uniformly to uneven surfaces. In addition, rotary spreaders sometimes give poor lateral distribution.

Dusters

Hand dusters may use a squeeze bulb, bellows, tube, shaker, sliding tube, or a fan powered by a hand crank to deliver the pesticide to the target. No water or mixing is required. In addition, dusts easily penetrate confined spaces such as cracks and crevices.

However, dusts may not stick to foliage. They are often difficult to direct to the target and are likely to produce fine-particle drift.

Specialized Application Equipment

Some application equipment allows you to apply pesticides only to the pest – not to nontarget organisms in the treated area. Examples include shielded-sprayer, aerosol, injector, and wiper or wick (rope) applicators. You can use these devices when making a **directed application**. Shielded applicators can direct a spray to a crop row or between rows, leaving an untreated band. You can also fit shields onto backpack sprayers to spot treat weeds with an herbicide while protecting desirable plants.

Wiper applicators are devices used to apply herbicides selectively to weeds. They are particularly useful in pastures and crop fields. Wicks made of rope, rollers made of carpet or other material, or absorbent pads made of sponges or fabric are kept wet with a **concentrated** mixture of herbicide and water and wiped onto weeds. This kind of device will allow you to treat tall weeds growing above the crop or lower weeds between rows.

Shielded sprayers and wiper applicators are simple to operate. They are not prone to drift and use only a small amount of pesticide. However, this equipment is useful only in special situations.

Maintenance Guidelines

Sprayer Maintenance

At the end of the day or whenever you stop spraying, clean and store the sprayer. Follow these steps:

1. Rinse the inside and outside of the tank with clean water. Flush the tank and the hoses.
2. Refill the tank with clean water and spray it out again. A small amount of liquid detergent added to the water will help clean the inside of the sprayer system. If you use detergent, be sure to flush with clean water again.
3. Clean the nozzles, nozzle screens, and suction screens with compressed air or a soft brush. Replace worn or damaged screens and nozzles.
4. Lubricate all moving parts according to the manufacturer's recommendations.
5. Leave the tank open for ventilation, screened to keep out debris and pests.
6. Store the clean sprayer after draining it completely.
7. Never clean a sprayer near sensitive sites. Capture your rinsate to use later for mixing or apply it to a legal site.

Spreader Maintenance

Here is a maintenance checklist for dry application equipment:

1. Before each use, make sure the on/off mechanism and drive wheel are working properly.
2. Be sure the hopper and openings are clean and free of debris.
3. Make sure the release mechanism turns freely when the drive wheel turns.
4. Check all parts for signs of wear or abrasion.
5. Clean your spreader and store it in a dry place.
6. Use a rain cap or cover to protect the spreader while in transit.

Field Operation Guidelines

- Do not drive faster than the equipment is designed for or the terrain will safely allow.
- Check to be sure the pesticide is reaching the target.
- **Calibrate** your equipment if the label instructs you to apply a specified amount per unit area or volume.
- Check hoses, valves, nozzles, hoppers, and other equipment parts for clogs, leaks, and signs of wear.
- Be sure your equipment is dispensing liquid or granules evenly and uniformly.
- Shut off your equipment before turning and whenever you stop. Many types of application equipment will continue to release pesticide even when not in motion. Also, it is difficult to apply the product evenly as you turn.
- Check the pump and plumbing systems for leaks or loss of pesticide.
- Make sure no obstacle or machine part interferes with pesticide distribution.
- Keep your equipment clean and free of debris.
- To clean or unplug a nozzle or spreader orifice, use compressed air or a soft-bristle brush.
- Never operate a sprayer with the screens or filters removed.
- Do not run a sprayer pump without water.
- Dedicate one sprayer to herbicide use and another to insecticide and fungicide applications.

Test Your Knowledge

Q. Why is it so important to apply the right amount of pesticide to the target site?

A. If you apply too little pesticide, you may not control the pest. Applying more than the label-directed rate may cause damage or injuries, leave illegal residues, and subject you to fines and/or legal action.

Q. Why is being able to calibrate application equipment a skill all applicators must have?

A. To ensure that the equipment is applying the correct amount of material uniformly to the target site.

Q. Which type of pesticide application method involves applying pesticides uniformly to an entire area or field?

A. Broadcast.

Q. Which type of pesticide application procedure involves applying pesticides in strips (ex. between crop rows)?

A. Band.

Q. Which type of pesticide application procedure involves targeting specific pests (ex. dandelions in a landscape bed) while avoiding nontarget organisms?

A. Spot.

Q. Which type of indoor pesticide application procedure involves placing small amounts of pesticide into tight spaces, such as along baseboards or in cabinets?

A. Crack and crevice.

Q. Give two examples of directed applications.

A. 1. Using subsurface injectors to treat plants growing on the bottom of a pond.

2. Treating only infested areas of a forest for gypsy moth.

Q. Which type of pesticide application method would you use to control weeds on a golf course fairway?

A. Broadcast.

Q. Name some specialized application devices that would allow you to make a directed application.

A. A shielded-sprayer, aerosol, injector, or wiper or wick (rope) applicator.

Q. Name at least four parts found on most pesticide sprayers.

A. Tank, pump, agitator, hoses, screens and filters, pressure regulator, boom or wand, and nozzles.

Q. Why is it so important to choose the right kind of nozzle?

A. The nozzle you select affects output, droplet formation and size, droplet distribution, and spray pattern. Different nozzles are suitable for different types of jobs. Choose your nozzle based on its design, pattern, orifice size, and operating pressure.

Q. List the parts of a complete nozzle assembly.

A. Body, screen, cap, and nozzle or orifice plate.

Q. Why is it important to know the size of a nozzle orifice?

A. The size of the orifice (opening) affects the droplet size and flow rate.

Q. What kind of nozzle is often used for broadcast spraying and is well-suited for herbicide applications?

A. Flat fan.

Q. What kind of nozzle is well-suited for applying insecticides or fungicides when complete coverage of leaf surfaces is necessary?

A. Cone.

Q. Which kind of sprayer is the BEST choice to spot treat weeds with a nonselective herbicide in a landscape bed?

A. A hand-held or a backpack sprayer. (If using a backpack sprayer, add a shield to protect nontarget ornamentals.)

Q. Which kind of sprayer would you choose to make a broadcast application to a 25-acre field?

A. A boom sprayer.

Q. Name some advantages of using a low-pressure boom sprayer.

A. It is suitable for both band applications and wide-area broadcast treatments. This sprayer will evenly distribute liquid mixtures and give uniform treatment if configured and operated properly. With a hose and handgun nozzle, it is useful for spot treatments and for spraying hard-to-reach areas.

Q. Which kind of sprayer would you choose to spray a slope or a fencerow?

A. A boomless sprayer.

Q. Which kind of sprayer would you choose to treat a stand of tall trees with dense foliage?

A. A high-pressure sprayer.

Q. Briefly discuss the pros and cons of using a high-pressure, power-driven sprayer.

A. This sprayer can penetrate dense foliage, thick animal hair, the tops of tall trees, and into other areas needing high pressure. It can deliver large volumes of spray, providing outputs of up to 60 gallons per minute. Power-driven sprayers provide good penetration of many treated surfaces. However, these sprayers need large amounts of water, power, and fuel. Their high pressure may produce drift-prone droplets.

Q. What are the benefits and drawbacks of using hand-held and backpack sprayers?

A. Advantages: Both are simple to operate, relatively inexpensive, effective for applying liquid spray solutions, and easy to clean and store. Hand sprayers are useful in structures, for spot treatments, and in hard-to-reach areas. Backpack sprayers can hold more finished spray than hand sprayers. Some have enough agitation to keep spray suspensions evenly distributed.

Disadvantages: Pressure and output may fluctuate for both hand-held and backpack sprayers. Spray may not penetrate thick foliage, and these sprayers are not suitable for making wide-area broadcast treatments. Hand sprayers have no agitator and may not work well for applying liquid suspensions.

Q. When might a small motorized sprayer be useful?

A. To treat pests in relatively small outdoor areas (too small for a boom sprayer but too large for a backpack sprayer). It has high-pressure capability and hydraulic agitation – effective for applying spray suspensions. This sprayer has a hose and an adjustable nozzle on a handgun to treat small trees and penetrate canopies.

Q. Why are dusters rarely used outdoors?

A. Because pesticide dusts are likely to drift.

Q. Under what conditions would using a granule applicator be a poor choice?

A. When treating plant foliage or nonlevel, uneven surfaces.

Q. Which application device would you choose to apply a dust formulation to a hard-to-reach indoor area?

A. A hand duster (using a squeeze bulb, bellows, tube, shaker, sliding tube, or a fan powered by a hand crank).

Q. What are the pros and cons of using spreaders?

A. Advantages: They are simple machines – easy to clean, maintain, and repair. Spreaders are designed to apply ready-to-use products, and no mixing is necessary. Applicator exposure hazard is low, and there is little danger of drift.

Disadvantages: Because granules will not stick to foliage or uneven surfaces, they are not suitable at some sites. You must recalibrate spreaders for each granular formulation used, and the calibration process is often difficult. Uniform coverage is sometimes challenging, especially with a rotary spreader.

Q. Compare rotary spreaders to drop spreaders. Which allows you to make a more uniform application? Why?

A. You can treat more area in a given amount of time with a rotary spreader. This is because drop spreaders treat the width of the hopper only; rotary spreaders treat a wider swath. However, drop spreaders provide more even (uniform) coverage. Travel speed affects the rate that the plate or disk on a rotary spreader spins. This, in turn, affects the distribution of the released granules. Turning also changes the rotating plate speed. Even body sway can affect pattern or particle distribution. Rotary spreaders are less suitable on uneven or sloped terrain than drop spreaders are.

Q. What are wiper or wick applicators? How do they work?

A. Devices to apply herbicides selectively to weeds. They are particularly useful in pastures and crop fields. Wicks made of rope, rollers made of carpet or other material, or absorbent pads made of sponges or fabric are kept wet with a concentrated mixture of herbicide and water and wiped onto weeds. These devices will allow you to treat tall weeds growing above the crop or lower weeds between rows.

Q. Why should you shut off your application equipment when you stop and before turning?

A. Because it may continue to release pesticide even when it is not moving. Also, you often cannot apply the product evenly as you turn.

Q. List at least five guidelines for using pesticide application equipment properly.

A.
1. Do not drive too fast for the equipment and the terrain.
2. Check to be sure that the pesticide is reaching the target.
3. Calibrate your equipment if the label instructs you to apply a specified amount per unit area or volume.
4. Check hoses, valves, nozzles, hoppers, and other equipment parts for clogs, leaks, and signs of wear.
5. Be sure your equipment is dispensing liquid or granules evenly and uniformly.
6. Shut off your equipment before turning and whenever you stop.

7. Check the pump and plumbing systems for leaks or loss of pesticide.
8. Make sure no obstacle or machine part interferes with pesticide distribution.
9. Keep your equipment clean and free of debris.
10. Never operate a sprayer with the screens or filters removed.
11. Do not run a sprayer pump without water.
12. Dedicate one sprayer to herbicide use and another to insecticide and fungicide applications.
13. Clean the nozzles, nozzle screens, and suction screens with compressed air or a soft brush. Replace worn or damaged screens and nozzles.
14. To unplug a nozzle or spreader orifice, use compressed air or a soft-bristle brush.

Q. In general, why is regular sprayer and spreader maintenance important?

A. It prompts you to clean and inspect your equipment, replacing any parts and fixing problems as necessary.

Q. What should you do with rinsate generated by cleaning application equipment?

A. Capture and use it for mixing a finished spray or apply it to a legal site.

Section B: Calibration – General Principles

When label directions require you to apply a specific amount of pesticide per unit area (or volume), you must calibrate your equipment. Calibration is essential to:

- Comply with legal requirements.
- Make an effective pesticide application.
- Protect human health, the environment, and treated crops and surfaces.
- Conserve resources (time, financial, and environmental).

You can apply the basic principles of calibration to most types of equipment. 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. Calibrate your equipment before using it for the first time. Recheck it regularly to detect changes caused by wear, corrosion, and aging. Note that changing operators or formulations may require you to recalibrate your equipment.

Briefly, calibrate your equipment by treating a known area and measuring the output. For example, using a tractor-mounted boom sprayer, spray a premeasured test area with water using the same equipment, pressure, and techniques (i.e., travel speed and release height) you would use when applying the pesticide. After spraying the test area, determine how much water you used. You can use this volume to calculate the amount of water and pesticide you will apply to the intended application area. Once you know how much your equipment is applying, you will know if you are on target or if you need to adjust and try again.

Two important calibration elements are:

1. The uniformity of pesticide output or release.
2. The application rate and the factors that affect it.

Uniform Delivery

If your application equipment has more than one nozzle, nozzle cluster, or hopper opening, you must measure the output from each to be sure that they all are releasing the same amount. Note whether the pesticide output from each 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 several ways. One method requires using containers to collect the output from each nozzle, nozzle cluster, or hopper opening. Operate the equipment for a set period and compare the amount of output in each container to the amount desired. Another method, which works only for liquids, is to use a mechanical or digital flow meter to quantify the output from each nozzle.

A third method, most useful for ground-driven equipment, is to attach containers to each opening, operate the equipment over a known test area, and compare the amount collected in each container to one another and to the amount desired.

Calibration Steps

No matter what calibration method you use, you will measure how much pesticide you are applying in a specific area. Here are the basic steps:

1. Configure your equipment to suit the site and use pattern.
2. Mark off a representative test area (or volume).
3. Treat the test area (or space).
4. Determine the application rate of the equipment as configured – the amount used to treat the test area (or volume).
5. Figure out if you are on target.
6. Make adjustments as necessary.
7. Check calibration often.

Configure Your Equipment

The application rate partly depends on how you configure and operate your equipment. This includes equipment features, settings, and operating tactics. You can usually choose or control things like swath width, speed, the size of a spreader's openings (for granules), and nozzle orifice size and pressure (for liquids). The equipment manufacturer's directions are the best guide for making these choices.

The main factors affecting your application rate are system output, equipment speed, and concentration of the pesticide mixture.

System output depends on:

- Size of the nozzle orifice or hopper opening.
- Number of nozzles or openings and swath width.
- Pressure (for power-dispersal equipment).
- Formulation characteristics (ex. particle size and texture for solids; viscosity for liquids).

The slower application equipment moves, the more it applies per unit area. Conversely, the faster the equipment moves, the less it applies per unit area. You can make small to moderate changes in application rate by changing pressure or speed.

See "Calculating Dilutions" in Unit 10 for information on concentration of pesticide mixtures.

You will be most likely to adjust the size of the nozzle orifice or hopper opening used, equipment speed, and pressure (for spray or fog applications) to calibrate your pesticide application equipment. To make large changes in the amount applied, change nozzles or hopper settings (orifice size) or reconfigure your equipment.

Mark off a Representative Test Area (or Volume)

When setting up a calibration test, consider the size and type of equipment you will use, the size of the area (or space) you plan to treat, the amount of material you will apply, and the characteristics of the target site. See "Determining the Size of the Target Site" in Unit 10 for more information.

Small Equipment, Loads, and Sites

If you are using application equipment that carries a relatively small load (up to a few gallons of liquid or a few pounds of dry pesticide) or if the target site is small (less than an acre or 1,000 linear feet), choose a small test site.

If the label use directions are for 100 linear feet, you might choose a test site of 20 or 25 linear feet. If the directions are for 1,000 square feet, choose a test site of 200 or 250 square feet (ex. a rectangle measuring 10 feet x 25 feet). Measure the amount applied in this smaller site and then multiply to find the rate:

- The amount applied to 20 linear feet x 5 equals the rate per 100 linear feet.
- The amount applied to 25 linear feet x 4 equals the rate per 100 linear feet.
- The amount applied to 200 square feet x 5 equals the rate per 1,000 square feet.

If you are using smaller application equipment, choose a small test site.

- The amount applied to 250 square feet x 4 equals the rate per 1,000 square feet.
- The amount applied to 200 square feet x ~ 218 equals the rate per acre.
- The amount applied to 250 square feet x ~ 174 equals the rate per acre.

If you will be treating an acre or more, use a larger test area.

Large Equipment, Loads, and Sites

If you are using application equipment that carries a larger load (more than a few gallons of liquid or a few pounds of dry pesticide) or if the target site is large (more than an acre or 1,000 linear feet), choose a larger test site. If your test site is too small, your measurements may be inaccurate. Operating a boom or other equipment with multiple nozzles or hopper openings over a site as small as 10 feet x 25 feet, for example, would not allow you to carry or drive the equipment far enough to gauge average speed accurately.

If label directions are for an acre or more, use a test site of at least 1,000 square feet (ex. a rectangle measuring 20 feet x 50 feet). The output you measure during the test will be the actual application rate for 1,000 square feet. To find the rate per acre, multiply the test output by 43.56, the number of square feet in an acre (43,560) divided by 1,000.

Treat the Test Area (or Space)

Operate the equipment over a premeasured course to treat a known area while maintaining your chosen speed. Accurately measure the amount needed to fill the tank or hopper back up to the preapplication level.

If using power-dispersal equipment, one option is to treat a specified area (or volume) and record the time it takes to make the application. Then, run the equipment in place (using the same settings) for the same length of time, collecting the output from the system. (If your application equipment has multiple nozzles or hopper openings, add together the output from all of the release points.) Another option is the ounce method, a shortcut based on the "time-and-collect" method. Each of these tactics is described in more detail later in this unit.

Determine the Application Rate

The amount of pesticide dispersed divided by the area treated is the application rate.

For example, the label may list the application rate as "per acre." If you treat exactly 1 acre and measure your equipment's output, you will know how much your equipment delivers per acre. If the amount you are applying matches the label rate, you are ready to go to work. If your equipment is applying too much or too little, you can make adjustments and try again. However, you may not have the time to test your equipment over such a large site. Under these conditions, you can test smaller sites, calculate the application rate, and make adjustments as needed.

Some labels give application directions in amount of product per distance. For example, application directions for granular pesticides for row crops are often given in dry ounces of product per 1,000 feet or per row. In these cases, the row spacing is also given. The number of linear feet in an acre depends on the row spacing. The application rate is still expressed in pounds per acre.

Pesticides applied as crack and crevice treatments to control household pests as well as those used for perimeter treatments may have application directions that use distances. Such labels may tell you how wide a band to treat or the spacing of application points and the injection time at each.

Are You on Target?

When you measure output (flow rate), calculate application rate, or do other calibration-related calculations, the acceptable variation is 10% (plus or minus 5%). That is, if actual nozzle output is within 5% of the target, or if your application rate is within 5% of the label rate, you are on target.

Here's an example. If the target number is 15 gallons per acre, multiply 15 by 5% (0.05). Add the result to 15 to find the largest acceptable number; subtract it from 15 to find the lowest acceptable number:

15 x 0.05 = 0.75

15 + 0.75 = 15.75 (5% more than 15)

15 – 0.75 = 14.25 (5% less than 15)

Therefore, if the label instructs you to apply 15 gallons of product per acre and your equipment applies between 14.25 and 15.75 gpa, you are within the acceptable range.

Make Adjustments as Necessary

Calibration often requires adjustments in your application equipment. For sprayers, you might adjust:

- Amount of carrier per acre.
- Nozzle orifice size.
- Pressure.
- Speed.

When troubleshooting sprayers during calibration, check:

- Pump pressure.
- Operating speed.
- Nozzle condition and configuration.
- Boom/release height.

For spreaders, you might adjust:

- Drop opening size.
- Slinger speed.
- Apparatus speed.

When troubleshooting spreaders during calibration, check:

- Operating speed.
- Speed of slinger (if adjustable).
- Condition of hopper openings.

Remember that travel speed and body sway can affect distribution when using hand-propelled spreaders.

For aerosol, fog, and fumigant applicators using pressurized gas as a carrier, you might adjust temperature, ventilation, and time. Some equipment may have other items to check and adjust. Consult manufacturer guidelines.

Check Calibration Often

Once you have calibrated your equipment, do not assume that it will have the same output indefinitely. Clogging, corrosion, and wear may change the delivery rate. Settings may gradually go out of adjustment. It is important to check and recalibrate your equipment regularly.

Be alert for possible calibration problems each time you use your application equipment. During the application, notice whether you are treating the same area per load that you figured. If you find that you are covering more or less area than you expected, stop the application. Check both your calculations and your equipment. If you have figured wrong or if your application equipment delivery rate changed, you can correct the mistake before you have a major problem.

Test Your Knowledge

Q. What is calibration?

A. The process of measuring and adjusting the amount of pesticide a piece of equipment applies to a target.

Q. Name four reasons to calibrate your application equipment.

A. 1. Comply with legal requirements.

2. Make an effective pesticide application.

3. Protect human health, the environment, and treated crops and surfaces.

4. Conserve resources (time, financial, and environmental).

Q. Briefly summarize the calibration process.

A. Calibrate your equipment by treating a known area and measuring the output. Compare this to the label rate, and make adjustments if necessary.

Q. Why should you recheck equipment calibration regularly?

A. To detect changes caused by wear, corrosion, clogging, and aging. These factors may change the delivery rate. Settings may gradually go out of adjustment. In addition, changing operators or formulations may require recalibration. When using granular applicators, you must recalibrate your equipment for each different formulation.

Q. Name two important calibration elements.

A. 1. The uniformity of pesticide output or release.

2. The application rate and the factors that affect it.

Q. Why is it important to make sure all your nozzles or hopper openings are releasing the same amount of pesticide?

A. Because uniform delivery or output is essential to a safe and effective pesticide application.

Q. What principal factors affect application rate?

A. System output, equipment speed, and concentration of the pesticide mixture.

Q. What factors determine system output of a sprayer or spreader?

A. 1. Size of the nozzle orifice or hopper opening.

2. Number of nozzles or openings and swath width.

3. Pressure (for power-dispersal equipment).

4. Formulation characteristics (ex. particle size and texture for solids; viscosity for liquids).

Q. How does speed affect application rate?

A. The faster you travel, the less you apply per unit area. The slower you travel, the more you apply. You can make small to moderate changes in application rate by changing pressure or speed. To make large changes, change nozzles or reconfigure your equipment.

Q. What variables might you adjust to calibrate a sprayer?

A. Amount of carrier per acre, nozzle orifice size, pressure, and speed.

Q. List the basic steps in calibrating application equipment.

A. 1. Configure equipment to suit the site and use pattern.

2. Mark off a representative test area (or volume).

3. Treat the test area (or space).

4. Determine your application rate – the amount used to treat the test area (or volume).

5. Figure out if you are on target.

6. Make adjustments as necessary.

7. Check calibration often.

Q. You plan to treat several areas measuring 1,000 square feet, using a 4-foot drop spreader. You set up a 50-foot linear course to calibrate the spreader. The area of this test course is 200 square feet (4 feet x 50 feet). Is this test area the right size?

A. Yes. A course measuring 200 square feet is an appropriate size to calibrate small equipment, loads, and sites.

Q. After calibration, a sprayer delivered 2 gallons of water over a test area measuring 250 square feet. Your target site is four times the size of the test area (1,000 square feet). How much spray mixture will you need?

A. The amount applied to 250 square feet (2 gallons) x 4 equals the rate per 1,000 square feet. You need to use 8 gallons of spray mixture to cover 1,000 square feet.

Q. How precise should calibration be?

A. The acceptable variation is 10% (plus or minus 5%). For example, if actual nozzle output is within 5% of the target, or if the application rate is within 5% of the recommended rate, you are on target.

Q. A label instructs you to apply a pesticide at a rate of 2 pints of product per acre in 20 to 30 gallons of finished spray mix per acre. In your first test run, you apply 15 gallons of water per acre. Is this within the acceptable range?

A. No. The margin of error for both the upper and lower limits of the desired output is 5%:

20 x 0.05 = 1.0; 20 – 1.0 = 19.0

30 x 0.05 = 1.5; 30 + 1.5 = 31.5

The lower acceptable limit is 19 gallons per acre (gpa); the upper limit is 31.5 gpa. Your result of 15 gpa is not within this range.

Q. You are planning to calibrate a boom sprayer and a rotary spreader, using a test area. What sprayer and spreader features should you check during calibration?

A. Sprayer: pump pressure, operating speed, nozzle condition and configuration, and boom/release height. Spreader: operating speed, speed of slinger (if adjustable), and condition of hopper openings.

Section C: Calibration – Specific Tactics

The following section is of particular interest to private applicators and registered technicians. These applicators may not read the commercial category manuals that provide specific calibration information. This section is meant to teach private applicators and registered technicians the basics of sprayer and spreader calibration. It should be a useful review for commercial applicators who use sprayers and spreaders.

Calibration of Sprayers

To calibrate spray equipment, you must determine the volume of liquid your equipment applies to a unit area. When your equipment is applying the correct amount, you can prepare the proper concentration of finished spray mixture by following label directions.

Spray Volume

The **spray volume** or output is the amount of diluted pesticide mixture to apply per unit area. The label may cite a specific volume per unit area (ex. 2 gallons per 1,000 square feet). Or it may list a wide range of acceptable volumes (ex. 15 to 40 gallons of finished spray per acre). Usually, higher spray volumes give better coverage. Choose the spray volume most suitable for your spray job. Consider the:

- Size of the spray tank.
- Availability and cost of water or other label-specified diluent.
- Time and effort involved in returning to a mixing/loading area, measuring, and refilling.
- Surface to be treated.

Factors That Affect Sprayer Output

The variables that affect the amount of finished spray mixture a sprayer will apply per unit area are:

- Nozzle flow rate (which depends on orifice size and operating pressure).
- Sprayer configuration (swath width).
- Speed.

The application rate depends on these factors and the concentration of active ingredient in the finished spray solution or suspension.

Nozzle Flow Rate (Design, Orifice Size, and Operating Pressure)

To make an effective and efficient spray application, you must choose the right nozzle. First, consider the orifice size you will need to deliver the desired output at the chosen pressure. The larger the orifice, the greater the volume released. Also, if the label specifies a droplet size, be sure to review droplet size charts. Consider coverage requirements, pesticide mode of action, and drift potential in making decisions. Choose a nozzle type, orifice size, and operating pressure that will meet the droplet classification listed on the label. If the nozzles will be on a boom, be sure they are positioned and spaced correctly. Nozzle manufacturer catalogs list droplet sizes, flow rate (gpm), and application rate (gpa) at a given speed and pressure. For more information about nozzle selection, visit the Virginia Cooperative Extension (VCE) website or contact your local Extension agent.

Pump Pressure

Pressure is another factor that affects flow rate. The type of equipment and pump you use will, within limits, dictate your operating pressure. Each pump is designed to provide a range of pressures. To protect the pump and to ensure steady pressure output, do not operate it at pressures above or below its optimum range. You can determine which pressure to use by considering:

- Nozzle specifications.
- Drift hazard (lower pressure produces less drift).
- Penetration required (penetration of foliage, animal hairs, soil surfaces, and other barriers requires higher pressure).
- Pesticide label requirements.
- Research-based recommendations from other sources.

Increasing pressure will increase the flow rate. Decreasing pressure reduces output. Note that doubling the pressure does NOT double the flow rate. To double the flow rate, you must increase the pressure fourfold. You cannot use pressure to make major changes in application rate. However, you can use it to make minor adjustments.

Sprayer Configuration (Swath Width)

Swath width is a side-to-side measurement of the band or strip of pesticide released by application equipment. A swath is the width of the area covered by application equipment in one pass. You need to know your equipment's swath width in order to calibrate equipment – and to treat a large area uniformly by spraying successive swaths.

Speed

The faster you travel, the less you apply per unit area. The slower you travel, the more you apply per unit area. If you double your speed, your application rate will be reduced by half. If you reduce your speed by half, your application rate will double. In theory, you can make moderate changes in output by changing speed. However, there are practical limits on speed adjustments. Consider the label-directed output per unit area, time constraints, and safety when deciding how fast to travel.

Calibrating Boom Sprayers

Install the nozzles in the nozzle bodies on the boom, using the right spacing and boom height. Align them carefully. Misalignment of nozzles is a common cause of uneven coverage. As a rule, do not use nozzles of different sizes and spray angles on the same boom except in special multiple-nozzle arrangements designed for directed spraying. Check the boom to be sure it is level. If it is not, the spray pattern will be uneven.

Nozzles

To ensure that all your nozzles are working properly, check two important factors: (1) pressure at the nozzle and (2) flow rate.

Unless these two factors match the figures on the manufacturer's charts, your equipment will not deliver the expected amount of pesticide. Even new nozzles may deliver rates that differ from the manufacturer's charts.

Nozzle selection charts are based on pressure at the nozzles. To check nozzle pressure, mount a pressure gauge close to the nozzles. Then, compare that reading with the pressure reading at the main line pressure gauge. (After the test, remove the pressure gauge near the nozzles and plug the connection.)

Use a flow meter to measure output. Alternatively, catch the output from each nozzle. You can check nozzle flow rates by measuring the length of time needed to collect a quart of diluent from each nozzle, or by measuring the amount you collect per minute.

Replace any nozzles that vary in flow rate more than plus or minus 5%. Check to be sure pressure gauges are reliable and pump pressure is set properly.

Spray Distribution Pattern

The best way to check your spray distribution pattern is by using a pattern check tray. You can also spray water on hot, dry pavement or asphalt and watch how the wetted area dries. Areas that receive more liquid will dry more slowly. Fill the spray tank with diluent and run the pump to pressurize the system. Operate the sprayer briefly on a paved surface, such as a road or driveway, and check for:

- Correct broadcast overlap or band pattern.
- Streaks and uneven patterns caused by worn or partly plugged nozzles.

Make any necessary adjustments. Then, refill the tank so you can proceed to calibrate your sprayer.

Many nozzles must be positioned so their spray pattern overlaps. The amount of overlap depends on the boom height and nozzle type. Use the boom height and spacing recommended by the nozzle manufacturer. If you follow the manufacturer's instructions, you will get the right amount of overlap and make a uniform application.

In band spraying, the boom height affects the width of the band the nozzle is delivering. Adjust the boom height to get the desired bandwidth.

Calibrating Other Types of Sprayers

Boomless Sprayers

To calibrate boomless sprayers, use either the volume output technique or the ounce method. When using boomless sprayers, your swath width will depend on the nozzle orifice size and capacity as well as the release height. Nozzle selection charts often specify the **effective swath width** produced by a nozzle or nozzle pair at a given height. Sometimes, overlapping nozzles or using a third nozzle in between two boomless nozzles is necessary to produce uniform spray distribution. To measure the effective swath width, spray water on a dry surface under calm conditions at the desired operating pressure and nozzle height. Measure the sprayed width (in feet). The completely wet portion is the effective swath width. The width of the area on the fringe that is not completely wet is the area you need to overlap on the next pass.

High-Pressure Sprayers

High-pressure sprayers are sometimes equipped with booms. Even a boomless sprayer may have nozzles that spray a swath. When used in this way, a high-pressure sprayer is calibrated in the same way as a low-pressure boom or boomless sprayer. High-pressure sprayers also may have spray guns for treating livestock, orchards, nurseries, roadsides, or rights-of-way. Once you choose the appropriate spray gun tip and check the flow rate, no further calibration is necessary.

Air-Blast Sprayers

Air-blast sprayers use lots of air and smaller amounts of water to deliver the pesticide to the target. Some air-blast sprayers (especially smaller ones) spray to only one side at a time and so may require two passes per row. Others direct the spray to both sides and require only one pass between each crop row. For information on calibrating air-blast sprayers, consult **Virginia, West Virginia, and Maryland Cooperative Extension 2011 Spray Bulletin for Commercial Tree Fruit Growers** (VCE publication 456-419) and **2010 Commercial Vegetable Production Recommendations** (VCE publication 456-420).

Sprayer Calibration Methods

Do calibration test runs with water before mixing and loading the system with a pesticide. Be sure you are using the right kind of nozzle and that your sprayer is properly configured for the job. Operate at the proper pressure and speed. Check ALL nozzles (or sets of nozzles) to be sure the output from each is the same. You can do this by using a flow meter or by catching the output for a short time (ex. 15 seconds) from each nozzle or nozzle set. You can check each nozzle's pattern by using a pattern check tray or by spraying water on a solid surface and observing how the treated area dries. Replace any nozzles that do not match.

Air-Blast Sprayer

Using a Test Area (or Volume)

The calibration test area should be proportional to the size of the treatment site. For small areas, equipment, and loads, use a test area one-fifth or one-quarter of the area you will treat. For larger areas, equipment, and loads, use a test area of at least 1,000 square feet. See "Mark off a Representative Test Area (or Volume)" above for more information. Below are detailed instructions for sprayer calibration using the large-area method.

Large-Area Method

1. Measure and stake off a prescribed area (ex. 1 acre or 1,000 square feet) in an area similar to the target site.

2. Figure out how much your equipment should apply to this area, based on label directions.

3. Fill the sprayer tank with water.

4. Maintain constant pressure and speed while spraying the area. Mark pressure, throttle, and gear settings.

5. Measure the amount of water used. The amount of water necessary to refill the tank is equal to the amount (gallons per acre or gallons per 1,000 square feet) applied.

6. Determine if your equipment is applying the correct amount. If yes, proceed to steps 7 and 8. If not, adjust your equipment (or, within limits, change speed) and do another test.

7. Make up the spray solution with the right amount of chemical, based on the amount of water applied per acre or per 1,000 square feet.

8. Make the application at pressure, throttle, and gear settings used in calibrating.

Test Area of 5,000 Square Feet

You may need to use a test area of 5,000 square feet (just over 1/10 acre). If you know your swath width, you can divide 5,000 square feet by your effective swath and figure out how long a test course should be.

To convert the volume used to treat 5,000 square feet to the volume applied per acre (gpa), use ratio and proportion:

$$\frac{\text{gallons used to treat 5,000 sq ft}}{\text{5,000 sq ft}} = \frac{\text{? gallons (volume used to treat 1 acre)}}{\text{43,560 sq ft (1 acre)}}$$

Example: If you applied 3 gallons to the test area, how many gallons would you use to treat an acre?

Solution:

$$\frac{\text{3 gal}}{\text{5,000 sq ft}} = \frac{\text{? gal}}{\text{43,560 sq ft}}$$

$$(3 \times 43{,}560) \div 5{,}000 = \text{number of gpa (43,560 sq ft)}$$

$$130{,}680 \div 5{,}000 = 26.14 \text{ gpa}$$

Your equipment would apply just over 26 gallons per acre.

To set up a test course with large equipment, you can divide 4,356 square feet (the number of square feet in 1/10 acre) by your swath width. This will tell you how long a 1/10-acre test course should be.

Example: How long should a 1/10-acre test course be if the effective swath width is 20 feet?

Solution:

$$\frac{\text{4,356 sq ft (1/10 acre)}}{\text{20 ft (effective swath)}} = 217.8 \text{ ft}$$

The test course should be about 218 feet.

Ounce Calibration Method for Boom Sprayers (Gallons per Acre)

The ounce calibration method is easy to use and a good way to check and adjust a sprayer's output. It works because the test course is 1/128th of an acre – and there are 128 fluid ounces in a gallon. The proportions are the same. Follow these steps:

1. Mark off a test course, based on Table 9-1. (Measure nozzle spacing for booms and row spacing for directed applications and band rigs.)

2. Fill your tank half full (the average weight of a full load, from start to finish).

3. Set the throttle for spraying. Get a running start (so you are traveling at the application speed when you begin).

Table 9-1. Calibration distances

Row width or nozzle spacing (inches)	Course length (feet)
48	85
46	89
44	93
42	97
40	102
38	107
36	113
34	120
32	128
30	136
28	146
26	157
24	170
22	186
20	204
18	227
16	255
15	272
14	292
12	340
10	408
8	511
6	681

Drive the course as you would under field conditions. Do this at least three times, recording driving times (in seconds).

4. Calculate the average time (in seconds) required to drive the measured distance.

5. Run the equipment as you would in the field for the average time it took to drive the course, using the same settings (ex. revolutions per minute [rpm] and pressure). Catch output during that time in a container marked in fluid ounces. (If you are using a boom sprayer, catch the output from one nozzle. For directed or banded applications, catch the spray from all nozzles per row for the prescribed time.)

6. Output in ounces = gallons per acre applied.

NOTE: If you use the ounce method, your calibration check is based on the output from each nozzle. Check all nozzles to be sure the output from each is the same.

For more information about the ounce calibration method, see "Fine Tuning a Sprayer with 'Ounce' Calibration Method" (VCE publication 442-453; www.ext.vt.edu/pubs/bse/442-453/442-453.html).

Volume Output Method for Boomless Sprayers

1. Determine total swath width. (See manufacturer's specifications or use 80% to 85% of wetted spray width.)

2. Using swath width, determine the calibration (travel) distance using Table 9-2.

3. Measure and mark a calibration course on terrain similar to what you will spray.

4. Drive course under field conditions, traveling at application speed. Note engine rpm and gear.

5. Record the time required to drive the measured distance in seconds.

6. Run in place at same throttle setting or engine rpm used in step 4. Adjust pressure.

7. Collect from all nozzles or outlets for the number of seconds required to travel the calibration course. (Volume collected will be large.)

8. Measure the total amount of liquid collected in fluid ounces.

9. Divide the number of fluid ounces by 10 to obtain gpa applied.

Calibrating Backpack Sprayers

Certain factors affect backpack sprayer calibration:

- Nozzle type (ex. orifice size, pattern, and condition).

- Sprayer configuration (ex. wand length and shape).

Table 9-2. Boomless sprayer calibration

Swath width (feet)	Course distance (feet)	Time in seconds for groundspeeds (mph)					
		3	4	5	6	8	10
10	340	77.3	58.0	46.4	38.7	29.0	23.2
12	284	64.5	48.3	38.7	32.2	24.2	19.3
14	243	55.2	41.4	33.1	27.6	20.7	16.6
16	213	48.3	36.3	29.0	24.2	18.1	14.5
18	189	43.0	32.2	25.8	21.5	16.1	12.9
20	170	38.7	29.0	23.2	19.3	14.5	11.6
24	142	32.2	24.2	19.3	16.1	12.1	9.7
28	122	27.6	20.7	16.6	13.8	10.4	8.3
36	95	21.5	16.1	12.9	10.7	8.1	6.4

NOTE: For times less than 20 seconds (shaded area), you will improve accuracy by doubling the collection time and dividing the output collected by 2.

- Person using sprayer (ex. walking speed, nozzle/release height, and swath width).

Most good-quality backpacks have a built-in pressure regulator. This device allows the sprayer to operate at a constant pressure. You do not need to know the exact operating pressure to calibrate a backpack sprayer. However, the pressure must be constant. This means that the backpack must be in good working order, and the person using it must walk and pump at a relatively steady pace. Controlled-flow valves help to deliver a uniform output.

The person who will use the backpack should calibrate it. If several people will use one sprayer, each should calibrate it. Walking speed and release height (therefore, swath width) will vary from user to user. If the sprayer or nozzle is changed in any way, recalibrate the equipment. Do recalibration checks throughout the season at regular intervals.

Making Adjustments

- Consider safety (and application uniformity) when you choose a speed.
- Remember that you can only adjust pressure within system or nozzle specification limits. Also, increasing pressure will increase the number of small droplets released. This, in turn, increases the risk of drift.

If your sprayer is applying too much, you can travel faster and/or reduce pressure to decrease your output by a small amount. Otherwise, change nozzles and use a set with smaller orifices.

If your sprayer is applying too little, you can travel slower and/or increase pressure to increase your output by a small margin. Otherwise, change nozzles and use a set with larger orifices.

Calibration of Spreaders

Many types of application equipment can deliver pesticides formulated as granules or pellets. In all cases, however, the amount of product applied per unit area depends on the size and number of the adjustable opening(s), travel speed (and perhaps the speed of the impeller or rotor), and the formulation. In addition, except for aerial applications, the terrain of the application site will affect travel speed. (The application site surface may also affect particle distribution.)

You must apply granular pesticides with precision. To make an application according to label directions, carefully calibrate your spreader. To calibrate granular equipment, collect and weigh the amount of product applied to a test course of a known area. When you calibrate these devices, make several practice runs over a test area and average the results to determine the application rate. Each test should produce about the same output. If not, there is a problem with the equipment, the operator, or both.

Factors That Affect Spreader Output

For a spreader, flow rate depends on the metering openings (number, size, and type); formulation characteristics (ex. size and shape); and any mechanical devices that help mix or distribute particles. How much product a spreader will apply per unit area depends on:

- Flow rate of the granules or pellets.
- Equipment swath width.
- Operating speed.

The application rate depends on how much product is applied per unit area and the concentration of active ingredient in the particles. To calibrate granular equipment, you must collect and weigh the amount of product applied to a test course of a known area.

The most common variable adjusted in calibrating spreaders is the size of the opening(s), or metering settings. If the spreader is applying too little to a test area, make the openings larger. If too much, make them smaller. In some cases, you can change the impeller speed. You can alter the operating speed too, but only within certain limits. The terrain of the application site may dictate what is a safe and reasonable travel speed. (Terrain may affect particle distribution as well.) Travel speed will affect the amount applied per unit area and, with some equipment, swath width.

Metering, Swath Width, and Particle Distribution

For drop spreaders – full-width sliding gate and auger types – the swath width is the width of the machine. The best way to check the evenness of distribution is by setting the gate at a particular opening, turning the drive mechanism, and comparing the output from each opening for a given period. Choose a preliminary setting based on the equipment manual for the pounds per acre desired. If possible, use calibration blanks that match the formulation of pesticide you will apply. Alternatively, you can run the equipment over catch pans and measure the material collected in each pan (by weight or volume). Or run over a hard surface and inspect the output.

If you use a rotary spreader, check the distribution pattern and application rate regularly. For the air and spinning disc types, select a preliminary setting as recommended by the operator's manual for the application rate desired. Choose and determine your actual travel speed. Then, check the distribution pattern in the field.

To do this, use shallow containers of a uniform size (boxes, trays, or pans). They must be shallow enough to allow the spreader to pass over them but deep enough to keep the granules from bouncing out. Place one container in the center of your pattern test course. Then, place the remaining containers on 2-foot centers across the swath. Use an odd number of containers in a row, covering about twice the anticipated effective swath width. Push the rotary spreader over the center box in this line of containers, traveling perpendicular to the line. Compare the output at each station. This will alert you to any correction needed and allow you to determine your effective swath width. Another way to determine swath width is to treat a hard surface with blank granules or cat litter and measure the actual width of applied material.

When checking particle distribution on a hard surface, you can collect and reuse the material if you cover the surface with a tarp.

NOTE: Dry products with different particle sizes and weights do not spread uniformly.

Operating Speed

Consider the label-directed output per unit area, safety, and application uniformity when deciding how fast to travel. If the equipment is motorized, check the equipment specifications for manufacturer recommendations. In some cases, you can adjust the slinger speed. Consider the condition of the application site. Soft, muddy, or uneven surfaces and small areas with many obstacles require you to go more slowly.

Formulation Characteristics

Dry pesticide formulations vary in particle shape, texture, size, and carrier composition. Shape and texture affect how particles will move from a spreader's hopper through its openings. Many different ingredients may be carriers for granule and pellet formulations (ex. fertilizer, silica, and clay). Temperature and humidity also affect a product's particle size and weight. All of these variables affect flow rate. Even different batches of the same formulation may differ slightly in particle size and density and have different flow rates.

This means you must calibrate your equipment for each product you apply and if application conditions change. Each person who operates a piece of hand-propelled equipment must calibrate it. Additionally, you may need to recalibrate if you are using granules or pellets that have been stored for long periods. Because so many variables can affect the delivery rate, you should calibrate your equipment for each batch of product and for different field conditions.

Granular pesticides are not concentrated. Even so, applicators must use label-directed personal protective equipment when handling granules and application equipment.

Spreader Operation

Spreader output is speed-sensitive, so it is important to maintain a uniform operating speed. Do not travel too fast for ground conditions. Bouncing equipment will cause the application rate to vary. Stay out of any dust created by the equipment.

Turning a spreader sharply will produce an irregular pattern. When treating an area with parallel passes, turn off the spreader before turning to start the next pass. Apply a header strip across each end of a rectangular area (or completely around circular or irregularly shaped areas). This allows you to reach the proper speed when starting in the first trip and shut off the spreader when turning in the strip at the far end to prepare for the next pass. To prevent skips or overlaps when using a drop spreader, be sure that wheels slightly overlap the wheel tracks of the previous pass.

Note that using spreaders to apply gritty materials will cause the gate or metering openings to wear. Also, remember that the openings of all spreaders will wear with use. Wear will enlarge the openings and change the application rate.

Calibrating Broadcast Granular Applicators

When you calibrate a spreader, you need to collect and weigh the particles delivered to a test area. Using a scale or balance, weigh the amount you put in a spreader, weigh the amount left after treating a known area, and subtract to determine the amount used. You can also use a tarp and/or catch pans placed on the ground to collect material. Some granular applicators have devices to catch applied particles. You can also make a catch tray or pan.

Guidelines, Materials, and Procedures

When practicing calibration, use blank granules that match the formulation you plan to use. You could also use cat litter or a good-quality fertilizer.

However, to calibrate a spreader for a specific job, use the actual product you plan to apply. Granular formulations vary in particle size, shape, and density. The flow rate varies from product to product. You cannot calibrate a drop spreader with blanks and then expect all formulations to flow out of the spreader at the same rate.

Usually, you will apply granular products by weight per unit area. Often, you can use a

half rate in each of two loads. Making the two applications at a 90° angle (perpendicular to one another) ensures uniform coverage. A split application is a good idea in many situations (ex. when applying granular products to turf).

The labels of some granular formulations provide spreader settings for various application rates. If your product label gives equipment settings, use them as a starting point. However, remember that spreader settings are not linear. Using a setting number that is half the number recommended on the product label will not result in half the application rate.

To check the application rate, fill the hopper with calibration granules, allow them to settle, and add more if needed. Be sure to use at least 10% of the hopper contents in your trial. Treat a prescribed test area. Determine how much you used. Once you know the amount used (in pounds) to treat the calibration test area, you can calculate the amount you would use per 1,000 square feet or per acre.

If the application rate in the test is within 10% (plus or minus 5%) of the rate desired, treat another test area and recheck the delivery rate. If the amount used is not within this range, change the spreader settings and recalibrate. Keep calibrating until the rate is within plus or minus 5% of the label rate.

Recheck the delivery rate often. Remember: most units require constant speed to keep the application rate constant. Humidity also affects granular flow rates.

Step-by-Step Calibration

1. Determine the swath width.

2. Using your swath width, choose a travel distance that will allow you to treat a representative area. Base the size of your calibration test area on the size of the target site.

3. Figure out how much product you should apply to the test course when your spreader is calibrated. Use this formula:

$$\frac{\text{weight of product (label)}}{\text{? weight of product (test course)}} = \frac{\text{area (label)}}{\text{calibration area (test course)}}$$

? = amount (by weight) of product to apply to the test course if your spreader is properly calibrated.

NOTE: If you will treat the target area in two passes, divide the amount to apply to the test course in half. Apply half the amount in the first pass and the other half in the second.

4. Consult the label or equipment manual for the manufacturer's recommended settings. For your first attempt, use a flow rate setting that matches (or is close to) the label application rate.

5. Calibrate your equipment using one of the two methods described below, depending on whether you use a collection attachment. Start with the spreader hopper about half full. Apply, collect or catch, weigh, and adjust as necessary. Calibrate as you will operate when making the application itself. Be sure equipment is up to speed at the start of your test runs. If the application rate differs more than plus or minus 5% from the label rate, adjust the equipment and recalibrate. Double-check your results at least once.

Method 1: Not Using a Collection Attachment

- Gather enough product to fill the spreader about half full. Place it in an empty container.
- Weigh the container and particles.
- Put the particles into the spreader hopper.
- Treat the test area (known swath x distance).
- Place the unused product back into the same container you used to weigh all of the particles before your test application.
- Weigh again.
- Subtract the weight of the remaining particles from the weight of all of the particles you started with to determine amount applied.

- Adjust as needed if not within application rate range.

Method 2: Using a Collection Attachment

- Gather enough product to fill the spreader about half full. Place it in an empty container.
- Weigh the container and particles.
- Place product in spreader with a catch tray or bag attached. (You may be able to calibrate multiple-outlet broadcast spreaders, band applicators, and soil injection equipment by collecting particles in individual pans.)
- Treat the test area (known swath x distance).
- Put the product collected back into the same container you used to weigh all of the particles before your test application.
- Weigh again to determine amount applied.
- Adjust as needed if not within application rate range.

You can also use method 2 for motorized equipment. Make a test run without releasing granules. Record the time needed to treat the calibration area. Then, run the equipment in place and collect particles discharged in the measured time.

Table 9-3 depicts calibration test areas for drop and rotary spreaders.

Shortcuts for Calculating the Application Rate

Weight (in pounds) of dry material collected in 1,000 square feet x 43.56 = pounds per acre

Pounds used in test run ÷ area (in acres) treated in test run = pounds per acre

Making Adjustments

Granular equipment with wheel-driven dispersal delivers granules at a rate geared to the turns of the hopper agitator. The agitator is geared to the revolutions of the ground wheels. The faster the equipment moves, the faster the release of granules. For this reason, minor changes in equipment speed do not greatly affect the amount of granules deposited per unit area. The best way to change the application rate for this type of equipment is by changing the feed gate settings.

Granular equipment with powered or gravity-flow dispersal distributes the granules at a constant rate independent of the groundspeed of the equipment. The application rate per acre (or other unit area) depends on both the metered opening and the equipment speed. Altering the rate of speed allows you to make minor adjustments in flow rates. (Faster speed means fewer granules delivered per unit area.) Make larger adjustments by altering the equipment settings.

Table 9-3. Calibration test areas for a drop spreader and a rotary spreader

	Swath width (feet)	Linear course length (feet)
Drop spreader (200 square feet)	1.0	200.00
	1.5	133.33
	2.0	100.00
	2.5	80.00
	3.0	66.66
	3.5	57.00
	4.0	50.00
Rotary spreader (1,000 square feet)	6.0	167.00
	8.0	125.00
	10.0	100.00
	12.0	84.00
	14.0	72.00

Test Your Knowledge

Q. What factors affect sprayer output?

A. Nozzle flow rate (which depends on orifice size and operating pressure), sprayer configuration (swath width), and speed.

Q. What characteristics should you consider when choosing nozzles?

A. Type of nozzle, orifice size, and operating pressure. These factors help determine the output. Be sure these characteristics meet the droplet classification listed on the label.

Q. How does pressure affect flow rate?

A. Increasing pressure will increase the flow rate. Decreasing pressure lowers output. However, doubling the pressure does not double the flow rate. To double the flow rate, you must increase the pressure fourfold.

Q. Why is it important to know your equipment's swath width?

A. In order to calibrate equipment – and to treat a large area uniformly by spraying successive swaths.

Q. How does travel speed affect the amount of spray mixture applied?

A. The faster you travel, the less you apply per unit area. The slower you travel the more you apply per unit area. If you double your speed, your application rate will drop by half. If you reduce your speed by half, your application rate will double.

Q. What two factors should you check to make sure that all the nozzles on a boom sprayer are working properly? Why?

A. Pressure at the nozzle and flow rate. Unless these factors match the figures on the manufacturer's charts, your equipment will not deliver the expected amount of pesticide.

Q. Describe how to check the distribution pattern of a sprayer.

A. Use a pattern check tray. You can also spray water on hot, dry pavement or asphalt and watch how the wetted area dries. Areas that receive more liquid will dry more slowly.

Fill the spray tank with diluent and run the pump to pressurize the system. Operate the sprayer briefly on a paved surface and check for correct broadcast overlap or band pattern. Also check for streaks and uneven patterns caused by worn or partly plugged nozzles. Adjust as necessary.

Q. How do you measure the effective swath width of a boomless sprayer?

A. Spray water on a dry surface under calm conditions at the desired operating pressure and nozzle height. Measure the sprayed width (in feet). The completely wet portion is the effective swath width.

Q. The tank of a calibrated sprayer holds 4 gallons. Your treatment area is 1,000 square feet. Your sprayer applies 2 gallons to 250 square feet and 8 gallons to 1,000 square feet. Can you treat the entire treatment area in one load? If not, how many loads must you apply? How much water and product do you need per load?

GIVEN: The label rate is 4 fluid ounces of liquid pesticide per gallon.

A. No. As configured, your 4-gallon sprayer will treat only 500 square feet per load. To treat 1,000 square feet, you need to fill up the tank twice (500 x 2 = 1,000). For each load, you will use 16 fluid ounces of product (4 ounces per gallon x 4 gallons) and 4 gallons of water.

Q. Your calibrated boom sprayer delivered 10 gallons of water over a quarter-acre test area. You need to apply a pesticide product to an 8-acre field. The pesticide label tells you to use 4 ounces of liquid product per gallon to make a finished spray mixture. How much spray volume and how much product do you need?

GIVEN: 1 acre = 43,560 square feet; 1 gallon = 128 liquid ounces.

A.

$$\frac{10 \text{ gal}}{0.25 \text{ acre}} = \frac{? \text{ oz}}{8 \text{ acres}}$$

(10 x 8) ÷ 0.25 = 320 gal of spray mix

4 oz of product x 320 gal = 1,280 oz (10 gal) of liquid pesticide

To treat 8 acres, you need a spray mix of 320 gallons that includes 10 gallons of product.

Q. Your calibration test course is 20 feet wide and 1,000 feet long (20,000 square feet). As configured, your sprayer applied 8 gallons to the test area. The label of your product tells you to apply 18 gallons per acre (gpa) total spray mix. Is the sprayer applying the correct amount for the job?

A. Yes. The test course is just under half an acre (20,000 square feet ÷ 43,560 square feet per acre = 0.46 acre).

Using ratio and proportion, figure how much your sprayer is applying per acre:

$$\frac{8 \text{ gal}}{0.46 \text{ acre}} = \frac{? \text{ gal}}{1 \text{ acre}}$$

(8 x 1) ÷ 0.46 = 17.4 gpa

The target is 18 gpa. However, a range of plus or minus 5% of 18 (17.1 to 18.9 gpa) is acceptable. Therefore, if the sprayer is applying 17.4 gpa, it is within this range and is correctly calibrated.

Q. What is the ounce calibration method for sprayers? Briefly explain.

A. A simple calibration technique that relies on the output of each nozzle. This method works because the test course is 1/128th of an acre – and there are 128 fluid ounces in a gallon. After determining the calibration distance from a chart, calculate the average time needed to drive the measured distance. Run the equipment as you would in the field for the average time it took to drive the course, using the same settings. Catch output in a container marked in fluid ounces. Output in ounces = gallons per acre applied.

Q. You want to spray a crop field with 30-inch rows, using two banding nozzles per row (one on each side) at 50 psi. Using the ounce method, the travel distance for a calibration test course is 136 feet. Operating your sprayer at 6 mph, it took you about 15.5 seconds to drive this distance. After driving the course, you set the sprayer pressure at 50 psi and caught the output from one pair of nozzles for 15.5 seconds. If each nozzle delivers 7 fluid ounces in 15.5 seconds (14 ounces per 15.5 seconds for the pair), what is the sprayer output in gallons per acre?

A. When you calibrate a sprayer using the the volume output method, its output in ounces equals gallons per acre applied. In this case, 7 ounces released per nozzle in 15.5 seconds equals 14 total ounces from a two-nozzle banding set. So, this spraying system is delivering 14 gallons per acre.

Q. You are calibrating a boomless sprayer using the volume output method. What steps do you take after collecting output from all nozzles or outlets?

A. Measure the total amount of liquid collected in fluid ounces. Then, divide the number of fluid ounces by 10 to obtain the gallons per acre (gpa) applied.

Q. A product label tells you to apply 2 pints per acre in 25 to 30 gallons of finished spray mixture per acre. In your first test run, your sprayer applied 22 gpa. What adjustment would you make before doing another calibration test run?

A. Drive a little slower or increase pressure slightly, staying within nozzle specifications.

Q. A product label tells you to apply 2 pints per acre in 25 to 30 gallons of finished spray mixture per acre. In your first test run, your sprayer applied 32 gpa. What adjustment would you make before doing another calibration test run?

A. Drive a little faster (if safe) or decrease pressure slightly, staying within nozzle specifications.

Q. A product label tells you to apply 2 pints per acre in 25 to 30 gallons of finished spray mixture per acre. In your first test run, your sprayer applied 10 gpa. What adjustment would you make before doing another calibration test run?

A. Change nozzles. Use a set with larger orifices to increase output.

Q. A product label tells you to apply 2 pints per acre in 25 to 30 gallons of finished spray mixture per acre. In your first test run, your sprayer applied 50 gpa. What adjustment would you make before doing another calibration test run?

A. Change nozzles. Use a set with smaller orifices to decrease output.

Q. Why should each person who uses a backpack sprayer calibrate it?

A. Walking speed and release height (therefore, swath width) differ from user to user.

Q. Briefly summarize how to calibrate granular equipment.

A. Collect and weigh the amount of product applied to a test course of a known area. Make several practice runs over the test area and average the results to determine the application rate. Each test should produce about the same output. Correct and recalibrate as needed.

Q. What factors affect a spreader's application rate?

A. Flow rate of the granules or pellets, equipment swath width, and operating speed. Flow rate depends on the metering openings (number, size, and type); formulation characteristics (ex. size and shape); and any mechanical devices that help mix or distribute particles.

Q. What variables would you adjust to calibrate a spreader?

A. The size of the metering openings; sometimes impeller (rotor) speed and apparatus (travel) speed.

Q. How can you determine the width of a swath treated by a spreader?

A. For drop spreaders, the swath width is the width of the machine. For rotary spreaders, you can measure swath width when you check the distribution pattern in the field.

Q. Describe how to check the distribution pattern of a spreader.

A. Drop spreaders: Set the gate at a particular opening, turn the drive mechanism, and compare the output

from each opening for a given period. You can also run the equipment over catch pans and measure the material collected in each pan (by weight or volume). Or run over a hard surface and inspect the output.

Rotary spreaders: For air and spinning disc types, select a preliminary setting as recommended by the operator's manual. Choose and determine your actual travel speed. Then, check the distribution pattern in the field.

Q. How should a lawn care applicator using a granular product treat a yard to make an even application?

A. By making two 90□ passes, applying half of the product in each pass.

Q. What are some of the ways in which dry pesticide formulations vary? How does this variation affect how often you should calibrate a spreader?

A. Particle shape, texture, size, and carrier composition. Shape and texture affect how particles will move from a spreader's hopper through its openings. Many different ingredients may be carriers for granule and pellet formulations. Temperature and humidity also affect a product's particle size and weight. All of these variables affect flow rate. Therefore, you must calibrate your equipment for each batch of product and field condition.

Q. You plan to mark off a test course measuring 200 square feet to calibrate your 4-foot drop spreader. How long should this course be?

A. 50 feet. If area = length x width, then length = area ÷ width (200 ÷ 4 = 50).

Q. The effective swath width of a rotary spreader is 12 feet. You want to flag the corners of a calibration test course (1,000 square feet) that you can treat in two passes. How wide and long does this course need to be?

A. 24 feet wide and about 42 feet long. Since your effective swath width is 12 feet, two passes will cover 24 feet. To calculate the length, divide area by width: (1,000 ÷ 24 = 41.66, or ~ 42 ft).

Q. You want to apply a 2G (2% granule) product at the rate of 200 pounds of formulated product per acre. How much active ingredient (a.i.) will you apply per acre?

A. 4 pounds. A 2G (2%) product contains 2 pounds of active ingredient per 100 pounds of formulated product. So, if you apply 100 pounds of product per acre, you apply 2 pounds of active ingredient. If you apply 200 pounds of product per acre, you apply 4 pounds of active ingredient. Use ratio and proportion:

$$\frac{2}{100} = \frac{?}{200}$$

(2 x 200) ÷ 100 = 4 lb a.i.

Q. A label instructs you to apply 200 pounds of granular formulation product per acre. Your calibration test area is 1,000 square feet. If your spreader is calibrated properly, how much product should it apply?

GIVEN: 1 acre = 43,560 square feet.

A. 4.59, or ~ 4.6 lb per 1,000 sq ft:

$$\frac{200 \text{ lb}}{43{,}560 \text{ sq ft}} = \frac{? \text{ lb}}{1{,}000 \text{ sq ft}}$$

(200 x 1,000) ÷ 43,560 = 4.59, or ~ 4.6 lb

Q. You want to apply 5 pounds of a granular product to 1,000 square feet in two separate (split) applications. How should you calibrate your spreader? How much should it apply to a test area measuring 200 square feet?

A. Calibrate your spreader to apply half the label rate: 2.5 pounds of product to 1,000 square feet. Since your test area is one-fifth of the target, it should apply one-fifth of 2.5 pounds to 200 square feet:

$$\frac{2.5 \text{ lb}}{1{,}000 \text{ sq ft}} = \frac{? \text{ lb}}{200 \text{ sq ft}}$$

$(2.5 \times 200) \div 1{,}000 = 0.5$ lb

Q. A lawn care company applies a preemergent herbicide to clients' yards every spring at a rate of 3 pounds of active ingredient (a.i.) per acre. The company uses a 2% granular product. How much formulated product is applied per acre?

GIVEN: 100 pounds of a 2% product contains 2 pounds active ingredient.

A. 150 pounds. Use ratio and proportion:

$$\frac{2 \text{ lb a.i.}}{100 \text{ lb product}} = \frac{3 \text{ lb a.i.}}{? \text{ lb product}}$$

$(100 \times 3) \div 2 = 150$ lb per acre

Q. If a label instructs you to apply 150 pounds of a formulated granular product per acre, how much product should you apply per 1,000 square feet?

GIVEN: 1 acre = 43,560 square feet.

A. 3.44 pounds. Use ratio and proportion:

$$\frac{1{,}000 \text{ sq ft}}{43{,}560 \text{ sq ft}} = \frac{? \text{ lb}}{150 \text{ lb}}$$

OR

$$\frac{150 \text{ lb}}{43{,}560 \text{ sq ft}} = \frac{? \text{ lb}}{1{,}000 \text{ sq ft}}$$

$(150 \times 1{,}000) \div 43{,}560 = 3.44$ lb

Q. Your spreader is calibrated to apply 2.5 pounds of product per 1,000 square feet. The area you want to treat is 3,000 square feet. How much product will you need?

A. 7.5 pounds. If 2.5 pounds cover 1,000 square feet, then you will need three times as much to cover 3,000 square feet ($2.5 \times 3 = 7.5$).

Q. Why should you apply a granular or pellet formulation in two passes instead of one?

A. For more uniform coverage.

Q. A product label says that one 14-pound bag of formulated product will treat 5,000 square feet. How much should you apply to 1,000 square feet?

A. 2.8 pounds. Using ratio and proportion:

$$\frac{14 \text{ lb}}{5{,}000 \text{ sq ft}} = \frac{? \text{ lb}}{1{,}000 \text{ sq ft}}$$

$(14 \times 1{,}000) \div 5{,}000 = 2.8$ pounds. If making a split application, you would apply 1.4 pounds per 1,000 square feet in each application.

Q. A rotary spreader with a 12-foot swath applies about 2 pounds of a product per 1,000 square feet on setting 4. In a test run 83 feet long, you used about 2 pounds. Using this setting, how much will this spreader apply to an acre?

GIVEN: 1 acre = 43,560 square feet.

A. About 87 pounds. Using ratio and proportion:

$$\frac{2 \text{ lb}}{1{,}000 \text{ sq ft}} = \frac{? \text{ lb}}{43{,}560 \text{ sq ft}}$$

$(2 \times 43{,}560) \div 1{,}000 = 87.12$, or ~ 87 lb per acre

Q. How could you adjust a hand-propelled spreader that is not applying the correct amount to a test area?

A. Change the size of the openings. If the spreader is applying too little, make the openings larger. If it is applying too much, make them smaller.

Q. A label instructs you to apply 3 pounds of a granular product to 1,000 square feet. When you treated a test course measuring 250 square feet, you applied 1/2 (0.5) pound. Is your spreader properly calibrated for this job?

A. No. Your spreader should apply 3/4 (0.75) pound to the test course. Using ratio and proportion:

$$\frac{3 \text{ lb}}{1{,}000 \text{ sq ft}} = \frac{? \text{ pound(s)}}{250 \text{ sq ft}}$$

$(3 \times 250) \div 1{,}000 = 0.75$ lb

A range of plus or minus 5% of 0.75 (0.71 to 0.79 pound) is acceptable. If the sprayer is applying 0.5 pound, it is not within this range and must be recalibrated.

Section D: Drift Management

Being able to manage drift is an essential skill. Drifting pesticides may:

- Damage sensitive areas.
- Harm nontarget organisms or surfaces.
- Leave illegal residues on crops.
- Violate state and federal law.

Drift can be a problem both indoors and outdoors. Indoors, ventilation systems move air throughout a building. Pesticide particles or vapors may be drawn into these systems and move within the structure. Outdoors, pesticide drift may harm wildlife, contaminate water supplies, and cause other environmental or economic damage.

Considering drift management tactics when configuring and calibrating an application device can prevent many problems. Managing spray drift also improves pesticide efficacy by ensuring that the correct amount reaches the target.

Any spray application can drift. However, herbicide drift, especially for nonselective products, is often more noticeable than other types of pesticide drift. You can manage drift by using the proper equipment and application procedures.

This section is meant as a supplement to the drift discussion ("Movement in Air") in Unit 5.

Causes of Drift

Many factors influence drift. They fall into four general categories: (1) equipment features and settings, (2) spray characteristics, (3) environmental conditions, and (4) application site features. Some factors (ex. wind speed and direction, temperature, and relative humidity) cannot be controlled. However, you can manage their impact by making good decisions. Other factors (ex. operating pressure, travel speed, and nozzle type) can be controlled. Nozzle selection and equipment configuration are choices you make.

Many pesticide product labels contain either recommendations or specific requirements to control drift. For example, some pesticide labels have buffer zone requirements. Others have wind speed or temperature restrictions. You can minimize the risk of drift by following the label and making good decisions.

Many factors contribute to spray drift:

- Droplet size.
- Nozzle selection.
- Sprayer configuration.

- Release height.
- Operating pressure.
- Operating speed.
- Wind speed and direction.
- Air temperature and relative humidity.
- Atmospheric conditions.
- Application volume.
- Properties of the active ingredient.
- Properties of the finished spray mixture.
- Buffer zones and application site characteristics.

Managing Drift

Here are tactics you can use to manage each of the factors listed above.

Droplet Size

Large spray droplets are less likely to drift. This is because they are bigger, heavier, and harder to blow off course than smaller droplets. They are also less likely to evaporate before they reach their target. Consult the product label to choose the best droplet size that will minimize drift.

Nozzle Selection

When possible, choose a nozzle designed to reduce drift. Nozzle catalogs will tell you the drop size a certain nozzle will produce at a given pressure. The product label may specify what droplet size to use. When you spray, use the largest droplets that will provide the necessary coverage. Avoid using nozzles (and pressures) that will produce fine or very fine droplets.

When choosing nozzles and droplet sizes for spray applications, consider both coverage needed and drift potential. As a rule, smaller droplets provide better coverage but are more likely to drift. The larger a nozzle's orifice, the larger the droplets it releases.

Many labels provide recommendations and/or requirements regarding droplet size, nozzle selection, and sprayer configuration. Research in application technology supports recommendations in nozzle-selection guides and directions on product labels. For additional help, contact your local Extension agent or nozzle manufacturer.

Sprayer Configuration

To maintain a proper spray pattern, position nozzles on a boom according to the manufacturer's recommendations. If appropriate, use new drift-reduction hardware, such as spray shields, air-assist sprayers, and pulse-width modulated flow control.

Release Height

Spray release height or distance from the target site is also an important factor in reducing drift. The closer the boom or spray nozzle is to the ground or target, the less chance of drift. Lowering the boom height by a few inches can reduce off-target drift because wind speed increases with height. Note that for flat-fan nozzles, boom height depends on nozzle spray angle: the wider the spray angle, the lower the boom.

Operating Pressure

Keep the operating pressure within the recommended range for the nozzles you choose. Try to operate at a pressure within the lower part of the range. Exceeding the recommended pressure range often results in smaller droplets and more drift. High pressures increase drift potential.

Operating Speed

Travel at a slow and steady pace. Operating at high speed can contribute to wind shear, which causes droplets to move off target. It also promotes evaporation, which reduces droplet size. Fast operating speeds may result in an unstable or bouncing boom. Moreover, speed changes may cause pressure changes, which affect droplet sizes.

Wind Speed and Direction

Check wind speed and direction when starting to spray a field. Also, check the product label for wind speed restrictions. Avoid making an application if wind speed exceeds 10 miles per hour (mph). The faster the wind, the more spray volume moves off target. Wind can also reduce droplet size. On a windy day, some of a pesticide droplet will evaporate, leaving a smaller droplet. Smaller droplets are more likely to move offsite. It is best to spray when winds are light (3 to 5 mph) and steady.

Spray when wind is moving away from sensitive crops or areas. Use wind direction to your advantage and compensate for swath displacement.

Air Temperature and Relative Humidity

Check the product label for temperature restrictions. Do not spray in hot weather, especially when the relative humidity is low. The water diluent in a pesticide droplet may evaporate. This will reduce the size of the droplet and make it more likely to drift. Heat may also be a problem if the active ingredient is **volatile** (evaporates readily). The active ingredient may vaporize before being absorbed or adsorbed.

Atmospheric Conditions

Indoors, make sure airflow will not carry pesticides offsite. Outdoors, avoid certain weather conditions, such as high or variable winds and dead calm (no wind). Do not spray during a temperature inversion. During an inversion, spray droplets are often trapped near the ground like fog. Later, these droplets may be transported offsite onto nontarget areas. Drift is very likely.

During a temperature inversion, normal mixing of air molecules will not occur. A lack of wind – very calm, stable air – may indicate an inversion. Wind meters will record little to no air movement at the surface if an inversion exists. During an inversion, smoke plumes move parallel to the surface of the earth instead of forming a rising column. Other visual clues include low-hanging layers of fog in valleys and over water, no movement of tall grass or tree leaves, limp flags, and hazy air. See "Weather Factors" in Unit 5 for more information about temperature inversions.

Application Volume

If a label gives you a range of volumes of finished spray to apply per unit area, choose one at the high end. This will help reduce the amount of spray deposited off target.

Properties of the Active Ingredient

Consider using a formulation (ex. granular) or an application method (ex. soil drench or basal bark treatment) that will minimize drift. Avoid using products that are volatile or applied as fine particles.

Properties of the Finished Spray Mixture

Avoid using volatile diluents. Consider using drift control additives. Tests indicate that some may reduce drift. Be aware that not all drift control products live up to claims. In any case, even effective drift control additives do not make up for poor spraying practices.

Buffer Zones and Application Site Characteristics

Consult the label to see if it requires an untreated buffer (no-spray) zone. Even if it does not, consider leaving a buffer zone between the target and nearby sensitive areas – especially if the sensitive area is downwind. Move nontarget plants if possible. Note that wind may deflect around objects such as trees or buildings. Check wind speed and direction in several places if obstacles are in the treatment area. Take advantage of vegetative barriers (ex. hedgerows) if possible.

Always follow label directions for reducing drift. Be sure to consider weather conditions and predictions when planning a pesticide application. For more information about drift, see "Pesticide Movement" in Unit 5.

Test Your Knowledge

Q. Why is drift management so important?

A. Drifting pesticides may:

1. Damage sensitive areas.
2. Harm nontarget organisms or surfaces.
3. Leave illegal residues on crops.
4. Violate state and federal law.

Q. Name at least eight factors that contribute to spray drift.

A. 1. Droplet size.
2. Nozzle selection.
3. Sprayer configuration.
4. Release height.
5. Operating pressure.
6. Operating speed.
7. Wind speed and direction.
8. Air temperature and relative humidity.
9. Atmospheric conditions.
10. Application volume.
11. Properties of the active ingredient.
12. Properties of the finished spray mixture.
13. Application site characteristics and buffer zones.

Q. Which size droplet is less likely to drift: large or small?

A. Large.

Q. Which size droplet usually provides better coverage: large or small?

A. Small.

Q. What atmospheric and wind conditions are best for ground applications?

A. The absence of a temperature inversion and light, steady winds.

Q. Why is a temperature inversion likely to produce drift?

A. During an inversion, spray droplets are often trapped near the ground like fog. Later, these droplets may be transported offsite onto nontarget areas. Drift is likely.

Q. List at least eight techniques that help minimize spray drift.

A. 1. Use the largest droplets practical that provide good coverage.
2. Choose a nozzle designed to reduce drift potential. Avoid using nozzles that will produce fine or very fine droplets.
3. Position nozzles on a boom according to the manufacturer's recommendations. If appropriate, use new drift-reduction hardware.
4. Use as low a spray release height as possible.
5. Keep the operating pressure as low as possible within the recommended range.
6. Travel at a slow and steady pace.

7. Work when winds are light (3 to 5 mph) and steady. Avoid application if wind speed exceeds 10 mph. Spray when the wind is blowing away from sensitive crops or areas.

8. Observe all label temperature restrictions. Do not spray in hot weather, especially when the relative humidity is low.

9. Do not spray during a temperature inversion or in dead calm conditions.

10. If a label gives you a range of volumes of finished spray to apply per unit area, choose one at the high end.

11. Avoid using volatile active ingredients and diluents.

12. Use drift control additives if appropriate.

13. Choose a formulation or application method that will minimize the risk of drift – especially around sensitive areas.

14. Leave untreated buffer zones between the treatment area and nontarget sites. Take advantage of vegetative barriers (ex. hedgerows) if possible.

15. Read the label and follow its directions.

Unit 10. Calculating the Correct Amount to Apply

Learning Objectives

After studying this unit, you should be able to:

- Explain the importance of accurate measurements.
- Describe how to determine application rate.
- Identify ways that application rate is expressed.
- State what situations require the use of properly calibrated application equipment.
- Describe what information you need from the pesticide labeling (or other sources) to dilute a pesticide product correctly.
- Use ratio and proportion to determine how to make an end-use dilution.
- Identify the types of pesticides you must dilute before application.
- Determine how much pesticide concentrate and diluent to use when making a spray application.
- Identify what information you need about your equipment and application site to calculate how much pesticide mixture to prepare.
- Calculate the size of an area or volume of space you plan to treat.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Active Ingredient (a.i.) – A chemical in a pesticide product that affects or controls the target pest.

Calibrate – To measure the delivery rate and distribution of application equipment; to adjust application equipment so the desired amount of pesticide is applied uniformly to a given area or space.

Calibration – The process of measuring and adjusting the amount of pesticide a piece of equipment applies to a target.

Gallons per Acre (gpa) – The volume of liquid applied to an acre unit area.

Release – To discharge pesticide from its container or the equipment or system used to apply it. Release can be intentional (as in an application) or accidental (as in a spill or leak).

Measure Accurately

Measure pesticides and diluents accurately. Inaccurate measurements can lead to underdosing, overdosing, running out of pesticide mix, having "leftovers," or having to deal with a batch of pesticide mix that is the wrong strength.

Pesticide labels use the English system of measurement. For example, liquid products are measured in fluid ounces, pints, quarts, and gallons. Solid products, such as wettable powders, granules, and water-dispersible granules (WDG)/dry flowables (DF), will give rates in dry ounces and pounds.

Dry Formulations

If you are measuring a dry formulation, use a scale to weigh out the exact number of dry ounces or pounds you need. Note that some dry formulation products, such as WDGs and DFs, are preweighed and sold with a measuring device. The graduations (lines) on these devices indicate a dry weight, not a fluid volume. Mixers/loaders must use the measuring device that came with each specific product (or use a scale). Different products – and even different batches of the same product – will vary in density. So, the lines on WDG/DF measuring devices will vary from product to product and batch to batch. Use the devices ONLY to measure the product they were designed for and were sold with.

Liquid Formulations

If you are measuring a liquid formulation or diluent, be sure your container is suitable for measuring liquids. Good-quality containers will have graduations indicating fluid ounces or liters. Choose a graduated measuring device of appropriate size. Use one of the following:

- A small graduated cylinder or container (or a tip-and-pour dispenser) to measure small volumes (ex. a few ounces or teaspoons).
- A medium-size graduated cylinder or **calibration** container to measure from about 1 pint (16 fluid ounces) to 1 gallon (128 fluid ounces).
- A large graduated jug or pail to measure volumes greater than 1 gallon.

A tall, thin cylinder will give a more accurate measurement than a short, wide jug of the same capacity. This is because more indicator marks fit on a tall, thin container. More marks give a more precise measure. Never use kitchen utensils to measure liquid volume. Mark each item you use to measure pesticides – NEVER use it for another purpose. Rinse your utensils with diluent, and put the rinsate into the mix tank. Store your measuring utensils, including scales and pans for weighing, in a locked pesticide storage area.

Measure concentrates and diluents accurately.

Measure carefully. Do not guess or approximate. Do not add a little extra "just to be sure." Measure the amount of diluent you use carefully as well. Adding the correct amount of concentrate to an incorrect amount of diluent can result in an entire tankful

of the wrong strength of pesticide mixture. Mix only the amount you will need for the application.

Do not assume that the tank is exactly the size of its claimed capacity. A "5-gallon" tank may hold more or less than 5 gallons. A "100-gallon" tank often holds quite a bit more than 100 gallons when filled. The graduated marks on some tanks or hoppers that indicate levels of partial fill are often inaccurate. Measure the tank yourself to be sure.

You can measure the capacity of your tank and check (or make) gauge marks indicating partial-fill levels in two ways:

1. Fill the tank by hand using a container of known capacity.
2. Attach a flow meter to a hose and measure the quantity of water as it flows into the tank.

For either method, be sure the tank is level before you start. As you fill the tank, check or mark measured volumes on a dipstick or sight gauge. Make your own volume graduation marks on the tank if necessary.

Weights, Measures, and Conversions

Here are some weights and measures often used in measuring and diluting pesticides and calibrating pesticide application equipment. Also included are formulas you can use to convert units (ex. fluid ounces to gallons).

Weights and Measures – Equivalents

Weight

16 dry ounces = 1 pound

1 gallon of water weighs 8.34 pounds.

Liquid/Volume Measure

2 tablespoons = 1 fluid ounce

16 fluid ounces = 1 pint

2 pints = 1 quart

8 pints = 4 quarts

4 quarts = 1 gallon

1 gallon = 128 fluid ounces

Length/Distance

3 feet = 1 yard

5,280 feet = 1 mile

Area

9 square feet = 1 square yard

43,560 square feet = 1 acre

Volume

27 cubic feet = 1 cubic yard

Speed

1.466 feet per second = 88 feet per minute

88 feet per minute = 1 mile per hour

Conversion Factors

Weights

28.35 grams = 1 dry ounce

454 grams = 1 pound

Liquid Volume

8 fluid ounces = 1 cup

cups x 8 = fluid ounces

fluid ounces ÷ 8 = cups

16 fluid ounces = 1 pint

pints x 16 = fluid ounces

fluid ounces ÷ 16 = pints

32 fluid ounces = 2 pints = 1 quart

quarts x 32 = fluid ounces

fluid ounces ÷ 32 = quarts

quarts x 2 = pints

pints ÷ 2 = quarts

8 pints = 4 quarts = 1 gallon

gallons x 4 = quarts

quarts ÷ 4 = gallons

gallons x 8 = pints

pints ÷ 8 = gallons

128 fluid ounces = 4 quarts = 1 gallon

gallons x 4 = quarts

quarts ÷ 4 = gallons

gallons x 128 = fluid ounces

fluid ounces ÷ 128 = gallons

To convert fluid ounces to gallons, do one of the following:

- Divide by 128.
- Multiply by 1/128 (~ 0.008).

To convert gallons to fluid ounces:

- Multiply by 128.

Area

43,560 square feet = 1 acre

To convert square feet (ft^2) to acres, do one of the following:

- Divide by 43,560.
- Multiply by 1/43,560 (~ 0.000023).

To convert acres to square feet (ft^2):

- Multiply by 43,560.

In the **Pest Management Guides (PMGs)**, you will find other useful equivalents and conversions for liquid measure, dry measure, area, and speed. Virginia Cooperative Extension (VCE) publishes these guides each year. Specifically, refer to **Pest Management Guide: Horticultural and Forest Crops** (VCE publication 456-017) and **Pest Management Guide: Field Crops** (VCE publication 456-016). In each book, look in the "Calibration Tables and Information" subsection of "Regulations and Basic Information."

Deciding How Much to Apply: An Overview

Study the directions for use section of the pesticide label to find out how much pesticide to apply. Some labels have charts listing a range of application rates. Often, the rate depends on variables, such as soil type, application conditions, or pest life cycle stage. The PMG series may be helpful. Alternatively, consult your local Extension agent, university pest management specialists, certified crop consultants, industry organizations, or pesticide dealers for recommendations on the right amount to use. Use the least amount of pesticide that will achieve good pest control.

Read the product label to find out how much pesticide to apply.

Application Label Rates

The amount of pesticide to use is expressed in various ways. Application rates are sometimes given as amount of **active ingredient** (a.i.) per unit area or volume.

Example: A label of a 2% granular herbicide directs you to apply 3 pounds of active ingredient per acre.

Application rates may also be given as amount of active ingredient per volume of finished spray.

Example: 2 pounds of active ingredient per 100 gallons of spray mix.

Application rates are more often expressed as how much formulated pesticide to apply to an area or space. Different labels may direct you to apply:

- 5 gallons of an emulsifiable concentrate (EC) per acre.
- 10 pounds of a granular product per 1,000 square feet.
- 1 to 2 dry ounces of a water-dispersible granule (dry flowable) per acre.
- 2 to 4 pounds of a fumigant (gas) per 1,000 cubic feet.

Some application rates are expressed as amount of formulated product per total volume of finished mixture. As a rule, labels for products applied as a liquid mixture (solution or suspension) will give mixing proportions (ratio of formulated product to diluent). They will also tell you how large an area a specific amount of finished spray will treat.

Example 1: A label instructs you to use 1 pint of product per 1,000 square feet, applied in 1 to 2 gallons of finished spray. In this case, you need to **calibrate** your sprayer so it applies at least 1 gallon – and no more than 2 gallons – of water to that area. Once you determine exactly how much water you used to treat 1,000 square feet, mix 1 pint of product with that amount of water.

Example 2: A label instructs you to mix 4 gallons of product in 100 gallons of water, then apply 20 gallons of finished spray per acre. Some labels will provide charts with various mixing proportions, depending on application volume (ex. gallons applied per acre).

Occasionally, the application rate is expressed as a percentage of the final dilution (ex. 0.5% by volume or 1% by weight). Adjuvant products often express the application rate in this way (ex. surfactant at 0.25% volume per volume). Expressing application rate as a percentage allows the user to calculate the dilution for this part of the finished spray independently.

If a label tells you how much product or a.i. to use per unit area (or space), you must calibrate your application equipment. However, sometimes calibration is not necessary. The section that follows explains when calibration is required to make a safe, legal, and effective application.

Calibration, Mixing, and Loading Options

Using the label to find out how much pesticide to apply is only the first step in making an application. Next, you must determine how to deliver the correct amount to the target site – and be sure it is distributed properly. Depending on your formulation and application equipment, you will do some combination of three basic tasks: calibrate the equipment, mix the pesticide correctly, and load it into your equipment.

1. Calibration – For many kinds of applications, you must measure and adjust the amount of pesticide your equipment will uniformly apply to a given area (or volume). Calibration tells you exactly how much material you are delivering to an area or space.
2. Mixing – Unless the pesticide is a ready-to-use formulation or must be applied full strength, you must carefully combine the

right amounts of formulated product and diluent to make the application-strength, end-use pesticide mixture as directed by the label.

3. Loading – Unless the pesticide is packaged in an application device, you will need to transfer it into the application equipment.

Calibration, mixing, and loading are basic tasks associated with applying pesticides.

The product label(s) will have specific instructions. Here are some common options:

No Calibration, Mixing, or Loading Needed

Some pesticide formulations are sold at application strength and packaged in an application or delivery device. Examples include aerosol cans; squeeze-trigger sprayers; delayed-trigger foggers; baits; shaker-can dusters; spot-treatment devices; single-dose containers that double as applicators; impregnated collars, ear tags, strips, and rollers; and wiper bags. As a rule, these pesticides are either applied to the point of runoff, applied at a predetermined and regulated volume, directed at a specific target, placed so the target contacts it, or **released** to fill an enclosed space. Most of these products are limited to a few specialized sites or situations.

Loading Needed, No Mixing or Calibration

Some ready-to-use (RTU) pesticides are not sold in an application device. The user must load them into the application equipment. If you are using an RTU in a squeeze-trigger sprayer, shaker-can duster, vat for dipping animals or plants, spray-dip vat, 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 (such as dilute, end-use solutions); and some fumigant formulations. The pesticide is loaded directly into application equipment without any further dilution. However, calibration is necessary 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 without requiring calibration. Examples include plant and animal dips, spot spray treatments, applications made with wicks or wipers, tree-canopy sprays, and crack and crevice treatments. Application instructions are to "cover the plant, animal, or surface thoroughly" or "apply to the point of runoff."

Backrubbers for livestock are examples of equipment that does not need to be calibrated.

An example is a label with directions like these: "For control of annual weeds less than 6 inches in height or runner length, apply as a 0.5% solution. To control annual weeds over 6 inches tall, use a 1% solution. For best results, use a 2% solution on harder-to-control perennials. When using application methods that will result in less than complete coverage, use a 5% solution for perennial weeds and a 5% to 10% solution for woody brush and trees." Note that there is no mention of how much to use per unit area. Instead, the directions tell you how concentrated a mixture to use and how to effectively apply it.

Calibration, Mixing, and Loading Needed

Many concentrated pesticides must be diluted (mixed) correctly and loaded into properly calibrated equipment. For most certified applicators, being able to calibrate application equipment is an essential skill. Both steps – proper dilution and calibration – are crucial to applying the correct amount of pesticide to a target site. If there is an error either in dilution or in calibration, you will apply the wrong amount of pesticide.

Here are excerpts of label instructions for products that you must apply with calibrated equipment:

- "2 pints of a liquid pesticide product in 1-2 gallons of finished spray mix per 1,000 ft^2."
- "3 pounds of a granular pesticide product per 1,000 ft^2."
- "2 pounds of a fumigant per 1,000 ft^3 for 12-18 hours."

Applicator Calculations

Solving Ratio and Proportion Problems

Pesticide labels express the desired dilution for an application-strength pesticide mixture in a variety of ways, depending on the type of product and the intended use. To follow labeling directions, you may have to convert the quantities to different units of measure. You can do this by using ratios.

To compare ratios, write them as fractions. To set up a ratio and proportion equation, align corresponding figures, cross multiply, and then divide by the unused number. Be sure that you are using the same units in both fractions.

Example 1: If there are 12 inches in a foot, how many inches are there in 5 feet?

Solution: 1 foot is to 12 inches as 5 feet is to ? inches:

$$\frac{1\text{ ft}}{12\text{ in}} = \frac{5\text{ ft}}{?\text{ in}}$$

To solve, cross multiply and divide:

(12 x 5) ÷ 1 = number of inches in 5 ft

60 ÷ 1 = number of inches in 5 ft

60 = number of inches in 5 ft

Example 2: If the label application rate is **2 gallons per acre (gpa)**, how many fluid ounces should you use to treat 1,000 square feet?

GIVEN: 1 acre = 43,560 sq ft;
1 gallon = 128 fluid ounces.

2 gallons per acre = 256 fluid ounces per acre = 256 fluid ounces per 43,560 square feet

Solution:

$$\frac{256\text{ fl oz}}{43{,}560\text{ sq ft}} = \frac{?\text{ fl oz}}{1{,}000\text{ sq ft}}$$

(256 x 1,000) ÷ 43,560 = number of fl oz per 1,000 sq ft

256,000 ÷ 43,560 = number of fl oz per 1,000 sq ft

5.9 (~ 6) = number of fl oz to apply per 1,000 sq ft

You will also have to convert units of measure if the label gives the application rate in pounds, pints, quarts, or gallons per 1,000 square feet and you have calibrated your equipment in acres.

Example 3: How do you convert the 1,000-square-foot rate to the rate per acre?

Solution:

$$\frac{\text{rate per acre}}{\text{sq ft in 1 acre}} = \frac{\text{rate per 1,000 sq ft}}{1{,}000}$$

If the label rate is 2 pints per 1,000 square feet, your ratio will be:

$$\frac{\text{pt per acre}}{43{,}560 \text{ sq ft}} = \frac{2 \text{ pt}}{1{,}000 \text{ sq ft}}$$

(43,560 x 2) ÷ 1,000 = number of pt per acre

87,120 ÷ 1,000 = number of pt per acre

87.12 (~ 87) = number of pt to apply per acre

To convert pints per acre to quarts or gallons per acre, use conversion factors of pints ÷ 8 for gallons and pints ÷ 2 for quarts.

Calculating Dilutions

Some liquid pesticide formulations are diluted and sold at application strength. These often are labeled "ready-to-use." Granules, pellets, and dusts are also ready-to-use. Fumigants and ultra-low-volume formulations are concentrates that are applied full strength.

However, many pesticide formulations are concentrates, which are sold at strengths many times that needed for application. You must dilute most concentrated products before you can apply them. They are usually powders, water-dispersible granules/dry flowables, or liquids.

Water is the most common diluent. However, some labels may instruct you to use mineral oil or another liquid. Concentrated pesticides may be diluted in a mix tank and then loaded into the application equipment. Or, they may be loaded directly into the application equipment and diluted there.

To prepare a pesticide mixture for application, you must carefully calculate how much concentrated pesticide to use and how much diluent to add to the concentrate. Otherwise, you might apply the wrong amount of pesticide to the target site – even if using properly calibrated equipment.

Determine if the application you plan to make requires you to use calibrated equipment. If so, the first step is to calibrate your equipment to match what the label tells you to apply to a given area or space. Next, when mixing, you will need to do some simple calculations based on the capacity of your sprayer, how much area you want to treat, and the application rate or output of your calibrated equipment. If the application does not require calibrated equipment, the label will tell you how to make an end-use dilution. In many such cases, labels provide charts telling you how much concentrate and how much diluent to use to make a dilution of a specific strength

Table 10-1. Sample dilution table

Total volume of finished spray	Amount of product					
	0.5%	1%	1.5 %	2%	5%	10%
1 gal	0.67 fl oz	1.33 fl oz	2 fl oz	2.67 fl oz	6.5 fl oz	13 fl oz
25 gal	1 pt	1 qt	1.5 qt	2 qt	5 qt	10 qt
100 gal	1 qt	1 gal	1.5 gal	2 gal	5 gal	10 gal

NOTE: 2 tablespoons = 1 fluid ounce.

(ex. a 2% solution or suspension). Table 10-1 is an example.

The following formulas and examples will help you to figure dilutions in most ordinary situations. Use your common sense, estimating what you would expect the calculated amount to be.

The pesticide label or other sources will tell you:

- What diluent to use.
- How much to dilute the formulation.
- How much of the dilute pesticide to apply per unit area.

NOTE: Never EXCEED the label application rate or the number of treatments permitted per season or cycle. In Virginia (except for termiticide pretreatments), it is legal to use less than the labeled rate. However, you should reduce the application rate or number of treatments ONLY if you have research-based information to support your decision.

After you determine how much you need to dilute the pesticide concentrate, calculate how much pesticide and diluent to combine to achieve the correct amount of dilute pesticide mixture. Depending on the situation, you may need to know:

An effective pesticide application depends on accurate calculations.

- How much your equipment holds when full or how much mixture you will need to complete the job.
- How much mixture your equipment applies per unit area.
- The size of the site you need to treat.

Guides available from many sources contain formulas and examples to help you make necessary calculations.

Diluting Dry Formulations

Dry Weight of Formulated Product per Volume of Total Mix (Ex. Pounds per 100 Gallons)

Directions for dry formulations, such as wettable or soluble powders, may be given as pounds of pesticide formulation per 100 gallons of diluent. Determine one of the following:

- How many gallons your sprayer tank holds.
- The number of gallons you will add to the tank if the job requires only a partial tank load.

Then, use this ratio:

$$\frac{\text{label rate for product}}{\text{diluent volume given on label}} = \frac{\text{amount of product needed for job}}{\text{volume of total mix (or tank volume)}}$$

Multiply the total volume of finished spray mix you need (in gallons) by the label rate (in pounds) and divide by 100 gallons. This will give you the amount of formulated product you need to add to the tank.

Example: Your spray tank holds 500 gallons. The label tells you to use 2 pounds of formulated product per 100 gallons of water. How many pounds of product should you add to the tank to make a full tank load?

HINT: Your tank holds five times more water than the 100 gallons per diluent volume given on the label. So, you will need five times more product.

Solution:

$$\frac{2 \text{ lb}}{100 \text{ gal}} = \frac{? \text{ lb}}{500 \text{ gal}}$$

(500 x 2) ÷ 100 = lb to make a full load

1,000 ÷ 100 = lb to make a full load

10 = lb needed to make a full load

Dry Weight of Formulated Product per Area

Amount of Product per Acre

The label may list the recommended rate as pounds of pesticide formulation per acre.

If the job requires a full tank, you must know how many gallons your equipment applies per acre and the spray tank capacity. Using the formulas below, follow these steps:

Step 1:

$$\frac{\text{gal in tank}}{\text{gal per acre}} = \text{acres sprayed per tankful}$$

Step 2:

$$\text{acres sprayed per tankful} \times \text{lb per acre} = \text{lb needed in tank}$$

Example: Your sprayer applies 15 gallons per acre and your tank holds 400 gallons. The label rate is 3 pounds of formulated product per acre. How much product should you add to the tank to make a full tank load?

Step 1:

$$\frac{\text{gal in tank}}{\text{gal per acre}} = \text{acres sprayed per tankful}$$

400 ÷ 15 = 26.7 acres sprayed per tankful

Step 2:

$$\text{acres sprayed per tankful} \times \text{lb per acre} = \text{lb needed in tank}$$

26.7 x 3 = 80.1 lb needed in tank

If the job requires LESS than a full tank, you must know how many acres you want to treat and how many gallons your sprayer is delivering per acre. You need to calculate both the number of gallons of finished spray mix needed and the pounds of formulated product to use. Using the formulas below, follow these steps:

Step 1:

$$\text{acres to be treated} \times \text{lb per acre} = \text{lb of product needed in tank}$$

Step 2:

$$\text{gal per acre} \times \text{acres to be treated} = \text{gal of finished spray needed in tank}$$

Example: You want to spray 3.5 acres. Your equipment has a 100-gallon tank and is calibrated to deliver 15 gallons per acre. The label rate is 3 pounds per acre. How much pesticide should you use? How much finished spray mix do you need?

Step 1:

$$3.5 \text{ acres} \times 3 \text{ lb per acre} = \text{lb of product needed in tank}$$

3.5 x 3 = 10.5 lb of product needed in tank

Step 2:

$$15 \text{ gpa} \times 3.5 \text{ acres} = \text{gal of finished spray needed}$$

15 x 3.5 = 52.5 gal of finished spray needed

Amount of Product per 1,000 Square Feet

Use the same procedure to calculate the number of pounds or dry ounces of product per 1,000 square feet:

$$\frac{\text{amount in tank} \times \text{rate per 1,000 sq ft}}{\text{amount equipment applies per 1,000 sq ft}} = \text{amount of product to use}$$

Example: Your sprayer, as configured, applies 2 quarts (0.5 gallon) of finished spray mix per 1,000 square feet. The sprayer holds 3 gallons. The product label tells you to apply 4 dry ounces of formulated product per 1,000 square feet. How much product do you need to make a full tank of spray mix? How many square feet can you treat with a full load?

GIVEN:

1 gallon = 4 quarts; 1 pound = 16 dry ounces.

HINT: To apply this product at the label rate, using 4 dry ounces of product per 1,000 square feet, you will need six times more product to make a full load.

Solution:

$$\frac{\text{12 qt in tank x 4 dry oz per 1,000 sq ft}}{\text{2 qt applied per 1,000 sq ft}} = \text{amount of product to use}$$

(12 x 4) ÷ 2 = 24 dry oz

$$\text{24 dry oz} \div \text{16 dry oz per lb} = \text{1.5 lb needed in tank}$$

To figure how many square feet you can treat with one full (3-gallon) load, cross multiply and divide:

$$\frac{\text{2 qt}}{\text{1,000 sq ft}} = \frac{\text{12 qt}}{\text{? sq ft}}$$

(1,000 x 12) ÷ 2 = number of sq ft

12,000 ÷ 2 = number of sq ft

$$\text{6,000} = \text{number of sq ft you can treat with a full load}$$

Dry Weight of Active Ingredient per Area (Ex. Pounds per Acre)

If the label rate is given in pounds of a.i. per acre, you must first convert that figure to pounds of formulation per acre. Use this formula:

$$\frac{\text{lb of a.i. per acre x 100}}{\text{percent of a.i. in formulation}} = \text{lb of formulated product per acre}$$

Then follow the steps described above in "Dry Weight of Formulated Product per Area" to figure how many pounds or dry ounces of formulated product to add to your tank.

Example: You want to apply 2 pounds of active ingredient per acre. Your formulation is an 80% wettable powder. How much formulated product should you apply per acre?

HINT: Because your product contains less than 100% a.i., you will need more than 2 pounds of formulated product. However, since this product is fairly concentrated (80%), you will not need much more.

$$\frac{\text{2 lb of a.i. per acre x 100}}{\text{80\% a.i. in formulation}} = \text{lb of formulated product per acre}$$

$$(2 \times 100) \div 80 = \text{2.5 lb of formulated product per acre}$$

Diluting Liquid Formulations

Volume of Formulated Product per Total Volume of Finished Spray Mix

Application rates for liquid formulations (ex. emulsifiable concentrates, flowables, and liquid concentrates) may specify the number of fluid ounces, pints, quarts, or gallons to use to make a specific volume of total solution or suspension. For example, a label may instruct you to use 2 gallons of product and enough diluent to make 100 gallons of end-use mix. To make these calculations, use the same formulas you use to calculate dilutions for dry formulations. However, substitute the proper liquid measure for pounds in the formulas:

$$\frac{\text{label rate for product}}{\text{diluent volume given on label}} = \frac{\text{amount of product needed for job}}{\text{volume of total mix (or tank volume)}}$$

Example: The label rate is 2 pints of formulated product per 100 gallons of water. Your spray tank holds 30 gallons. How much product do you need to mix up a full tank?

HINT: Since your tank holds about one-third of 100 gallons, you will need about one-third of the 2 pints per 100-gallon rate.

$$\frac{\text{2 pt (label rate)}}{\text{100 gal (diluent volume)}} = \frac{\text{amount of product needed for job}}{\text{30 gal (tank volume)}}$$

(30 x 2) ÷ 100 = 0.6 pt of product needed in tank

$$0.6 \text{ pt} \times \frac{16 \text{ fl oz}}{\text{per pt}} = \frac{9.6 \text{ fl oz of product needed}}{\text{to make 30 gal of finished spray}}$$

Volume of Formulated Product per Area

Label application rates for liquid formulations often tell you how many units of liquid measure (fluid ounces, pints, quarts, or gallons) to apply per unit area (ex. per acre or per 1,000 square feet). In this case, you have to know how much liquid your application equipment is applying to a known area. Using the formulas below, follow these steps:

Step 1:

$$\frac{\text{gal in tank}}{\text{gpa}} = \text{acres sprayed per tankful}$$

Step 2:

$$\frac{\text{acres sprayed per tankful}}{\text{rate of product per acre}} = \text{amount of product needed in tank}$$

Example 1: Your sprayer applies 25 gallons per acre and your tank holds 400 gallons. The label rate is 2 quarts per acre. How much product should you use to mix up a full tank?

HINT: If your sprayer applies 25 gpa, it will apply 100 gallons to 4 acres. So, 400 gallons will treat 4 times that much. If you use 2 quarts for 1 acre, you will use 16 times that much to treat 16 acres.

Step 1:

$$\frac{400 \text{ gal in tank}}{25 \text{ gpa}} = \text{acres sprayed per tankful}$$

$400 \div 25 = 16$ acres per tank

Step 2:

$$\frac{16 \text{ acres sprayed per tankful}}{\text{per acre}} \times 2 \text{ qt} = \text{amount of product needed in tank}$$

$16 \times 2 = 32$ qt needed to mix a 400-gal tank

$$32 \text{ qt} \div 4 \text{ qt per gal} = 8 \text{ gal needed to mix a full tank}$$

Example 2: Your backpack sprayer holds 4 gallons. When you use it as configured, you apply 1 gallon of liquid to 1,000 square feet. A product's label tells you to apply it at a rate of 4 fluid ounces per 1,000 square feet. How much of this product do you need to make a tankful of spray?

HINT: Because your sprayer is set up to apply 1 gallon of finished spray per 1,000 square feet, 4 gallons will treat four times that (4,000 square feet). If the label rate is 4 fluid ounces per 1,000 square feet, you will use 4 times that much (16 fluid ounces of product) to treat 4,000 square feet.

Step 1:

$$\frac{1 \text{ gal}}{1{,}000 \text{ sq ft}} = \frac{4 \text{ gal (full tank)}}{? \text{ sq ft}}$$

$(1{,}000 \times 4) \div 1 = 4{,}000$ sq ft per tankful

Step 2:

$$\frac{4 \text{ fl oz of product}}{1{,}000 \text{ sq ft}} = \frac{? \text{ fl oz of product}}{4{,}000 \text{ sq ft}}$$

$$(4{,}000 \times 4) \div 1{,}000 = 16 \text{ fl oz of product per full tank}$$

Weight of Formulated Product per Unit Area

Some labels give an application rate as pounds of active ingredient per acre. For these, you must first calculate how many gallons of formulated product you need per acre to achieve that rate. The label of a liquid formulation product states how many pounds of active ingredient are in a gallon of the concentrated formulation. For example, 4 EC usually has about 4 pounds of active ingredient per gallon.

The label of your product may provide a chart telling you how much product to use. You can also calculate the application rate using this formula:

$$\frac{\text{lb of a.i to apply per acre}}{\text{lb of a.i. per gal of product}} = \text{gal of formulated product per acre}$$

Then, use the formulas and steps described above in "Volume of Formulated Product per Area" to figure the dilution.

Example: The label rate of a liquid product is 1 pound of active ingredient per acre. You purchased an 8 EC that contains 8 pounds of active ingredient per gallon. Your tank holds 500 gallons and is calibrated to apply 25 gallons per acre. How many acres per tankful can you treat? How much formulation would you need for a full tank?

Step 1:

$$\frac{\text{1 lb of a.i per acre (label rate)}}{\text{8 lb of a.i. per gal of product}} = \text{amount of formulated product per acre}$$

$1 \div 8 = 1/8 = 0.125$ (1/8) gpa

Step 2:

$$\frac{\text{500 gal in tank}}{\text{25 gpa}} = \text{acres per tankful}$$

$500 \div 25 = 20$ acres per tankful

Step 3:

20 acres per tankful x 0.125 gpa = gal of product to add to tank

20 x 0.125 = 2.5 gal to add to tank

Determining the Size of the Target Site

To determine how much pesticide you need for a job, you must measure or calculate the size of the site you will treat. Global positioning system (GPS) devices and applications are very useful for this task. Many GPS handheld units include an area surface measurement function. Google Maps and other Internet tools are also available. Use an app on your smartphone or tablet to map field boundaries and target areas.

If the target site is a rectangle, circle, or triangle, you can use simple measurements and formulas. Irregularly shaped areas are more challenging. However, you can calculate their size by dividing them up into basic shapes.

The following examples will help you calculate the area of both regularly and irregularly shaped surfaces, as well as the volume of some enclosed spaces.

Determine the size of your target site before making a pesticide application.

Regularly Shaped Areas

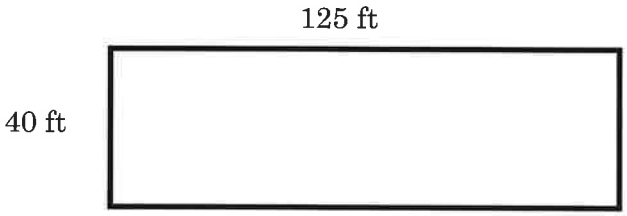
Rectangles and Squares

To find the area of a rectangle or square, multiply the length by the width.

Area = length x width

Example: If the length of a rectangular field is 125 feet and the width is 40 feet, what is its area?

Solution: area = 125 ft x 40 ft = 5,000 sq ft



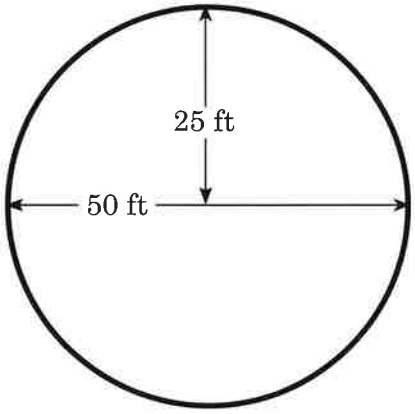
Circles

To calculate the area of a circular site, you must know:

- The radius of the circle or its diameter.
- The value of pi (~ 3.14), also written as "ϖ."

The radius of a circle is the length of a straight line that goes from the center of a circle to any given place on the circle's edge. The radius is equal to half of a diameter.

The diameter of a circle is the length of the longest possible straight line across a circle. Any such line passes through the center of the circle.



Calculate the area of a circular site by multiplying pi by the radius squared:

Area of a circular site = ϖ x length of the radius^2 (3.14 x radius x radius)

Example: If the diameter of a circle is 50 feet and the radius is 25 feet, what is the area of the circle?

Solution:
area = 3.14 x 25 ft x 25 ft = 1,962.5 sq ft

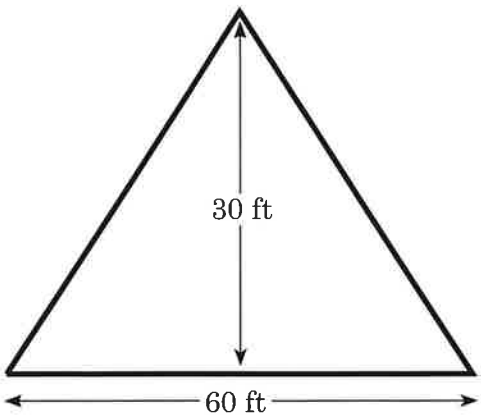
Triangles

To find the area of a triangle, multiply the length of the longest side (base) by the width at the widest point (height). Then divide by 2. (This formula works for any triangular shape.)

Area = base x height ÷ 2

Example: If the base of a triangle is 60 feet and its height is 30 feet, what is the area of the triangle?

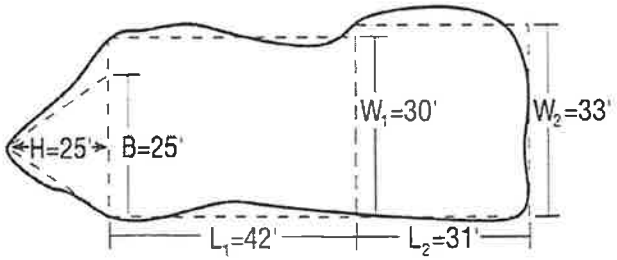
Solution: area = 60 ft x 30 ft ÷ 2 = 900 sq ft



Irregularly Shaped Areas

Irregularly shaped sites often contain a combination of rectangles, circles, and triangles. Calculate the area of each and add them together.

Example 1: Divide the site below into a triangle and two rectangles, and figure its approximate area.



(There may be some overlap to compensate for areas not included.)

The triangular region on the left side is 25 feet at the base (B) and 25 feet high (H).

The center area rectangle is 42 feet long (L_1) and 30 feet wide (W_1).

The rectangle on the right side measures 31 feet long (L_2) and 33 feet wide (W_2).

B = 25 ft

H = 25 ft

L_1 = 42 ft

W_1 = 30 ft

L_2 = 31 ft

W_2 = 33 ft

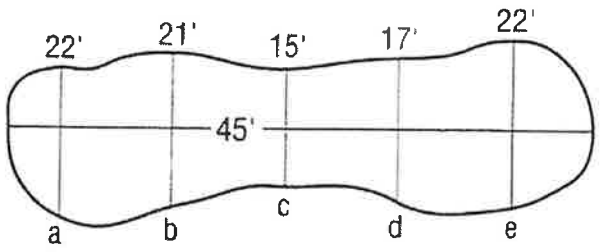
Solution: area = triangle, left (B x H ÷ 2) + rectangle, center (L_1 x W_1) + rectangle, right (L_2 x W_2)

(25 ft x 25 ft ÷ 2) + (42 ft x 30 ft) + (31 ft x 33 ft)

= (312.5 sq ft) + (1,260 sq ft) + (1,023 sq ft)

= 2,595.5 (~ 2,600) sq ft

Example 2: Some target areas are roughly rectangular, like the one shown below:



In such cases, use the transect method. Establish a line down the middle of the site for the length. Then, measure from side to side at several points along this line. Average the side-to-side measurements and use this figure as the width. Use the length and the estimated width to figure the area as a rectangle (L x W).

L = 45 ft

W = transect a (22 ft) + transect b (21 ft) + transect c (15 ft) + transect d (17 ft) + transect e (22 ft) ÷ 5

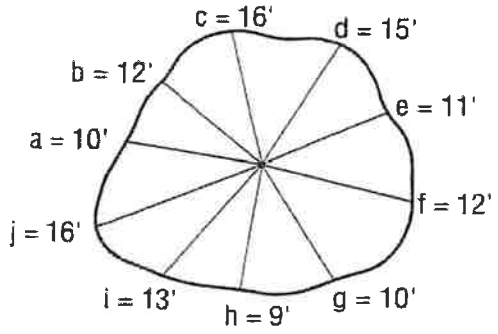
$$\text{area} = \frac{\text{L x (a + b + c + d + e)}}{\text{number of transects}}$$

$$45 \text{ ft x } \frac{(22 \text{ ft} + 21 \text{ ft} + 15 \text{ ft} + 17 \text{ ft} + 22 \text{ ft})}{5}$$

= 45 ft x 19.4 ft

= 873 sq ft

Example 3: If the site is more or less round, treat it as if it were a circle. From a center point, measure distance to the edge of the area 10 or more times. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.



$$\text{Average radius} = \text{sum of all measurements} \div \text{number of measurements}$$

Solution:

$$\text{average radius} = \frac{(a + b + c + d + e + f + g + h + i + j)}{\text{number of measurements}} =$$

$$\frac{10 \text{ ft} + 12 \text{ ft} + 16 \text{ ft} + 15 \text{ ft} + 11 \text{ ft} + 12 \text{ ft} + 10 \text{ ft} + 9 \text{ ft} + 13 \text{ ft} + 16 \text{ ft}}{10}$$

= 12.4 ft

Area = 3.14 x radius x radius

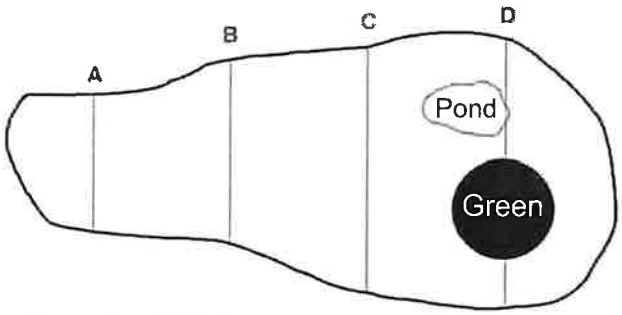
= 3.14 x 12.4 ft x 12.4 ft

= 482.8 sq ft

Partial Areas

In some cases, you may wish to treat only part of an area (ex. a residential lot or a playground). Usually, you will measure and calculate the total area. Then, calculate the areas of the sections that will NOT be treated. (For a residential lot, these might include driveways and walkways, landscaped beds, and the area the house sits on.) Add the areas of each untreated section together and subtract this total from the total area.

Example: Using the figure below, calculate the approximate area of a fairway (not counting the green or the pond) with the following dimensions:



Length = 900 ft

Width at point A = 198 ft

Width at point B = 270 ft

Width at point C = 360 ft

Width at point D = 390 ft

Diameter of the green = 144 ft (radius = 72 ft)

Length of the pond = ~ 114 ft

Width of the pond = ~ 66 ft

Diameter of the pond = ~ 90 feet (radius = ~ 45 ft)

Solution: First, using the transect method, figure the average width of the fairway:

198 ft + 270 ft + 360 ft + 390 ft ÷ 4 = 304.5 ft

Next, calculate the approximate area by multiplying the average width (304.5 feet) by the length (900 feet):

304.5 ft x 900 ft = 274,050 sq ft

Finally, compute the surface area of the green and the pond, and subtract these values from the total area of the fairway:

Area of the green = 72 ft x 72 ft x 3.14 = ~ 16,278 sq ft

Area of the pond = 45 ft x 45 ft x 3.14 = ~ 6,358.5 sq ft

Total area to subtract = 16,278 + 6,358.5 = 22,636.5 sq ft

274,050 sq ft (total area of the fairway) – 22,636.5 sq ft (combined area of the green and the pond) = 251,413.5 sq ft

251,413.5 sq ft ÷ 43,560 sq ft per acre = 5.8 acres

Several sources can help you find the dimensions and the area of a site you wish to treat. These include city and county planners, the Farm Service Agency, the Soil and Water Conservation District, and the Natural Resources Conservation Service (NRCS) for rural sites. NRCS has a tool available on the Internet (Web Soil Survey) you can use to locate, mark off, and compute the area of a given site:

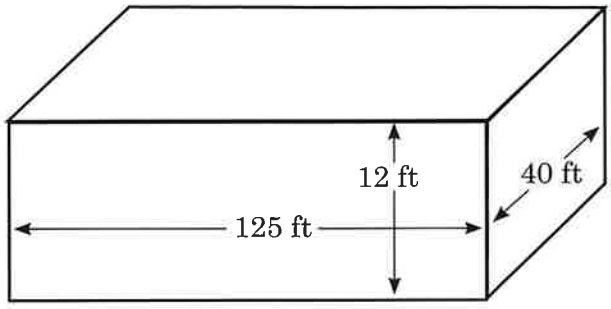
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Volume of Enclosed Spaces

To treat an enclosed space, you must determine its volume.

Cubes or Boxes

If the space is shaped like a cube or box (ex. a room or a closet), use this formula for three dimensions:



Volume = length x width x height

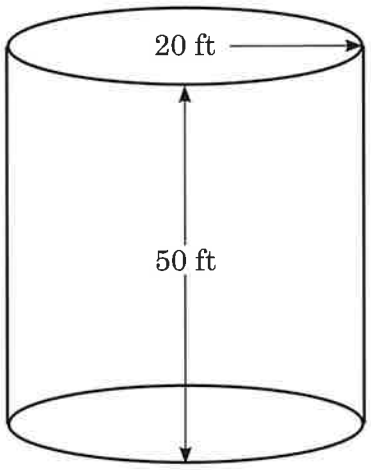
Example: A target area has a length of 125 feet, a width of 40 feet, and a height of 12 feet. What is its volume?

Solution: volume = 125 ft x 40 ft x 12 ft

= 60,000 cubic feet (cu ft)

Cylinders

If the space is cylindrical (ex. a grain bin), you find the volume by multiplying the height by the area of the circle that forms the base (radius x radius x 3.14):



Volume = height x radius x radius x 3.14

Example: A target area has a height of

50 feet and a radius of 20 feet. What is its volume?

Solution:

volume = 50 ft x 20 ft x 20 ft x 3.14 = 62,800 cu ft

Other Spaces

To apply fumigants and other pesticides (ex. fogs) that must fill the entire inside of a structure or other enclosed space, calculate the volume (in cubic feet) of the structure (ex. building, greenhouse, truck, or railroad car). To apply pesticides to bodies of water (other than surface treatments), calculate the volume of the water. Sometimes the structures or bodies of water are regular in shape. The calculations for these are fairly simple. For irregular shapes, calculate the areas for parts of the structure separately and add them together to find the total volume. For water bodies, other methods (ex. transect) may also be used.

Test Your Knowledge

Q. When measuring dry formulations, why must you use the measuring device that came with the product?

A. Dry products vary in density. The graduation lines on measuring devices also vary from product to product and batch to batch. Therefore, the devices may not be accurate for products other than the ones they came with.

Q. When measuring liquid formulations, which is more accurate: a tall, thin cylinder or a short, wide jug of the same capacity?

A. A tall, thin cylinder. More indicator marks fit on this type of container and will give a more precise measure.

Q. List two ways you can measure the true capacity of your tank.

A. 1. Fill the tank by hand using a container of known capacity.

2. Attach a flow meter to a hose and measure the quantity of water as it flows into the tank.

Q. In what Virginia Cooperative Extension (VCE) resources could you find equivalents and conversions useful in pesticide application work?

A. **Pest Management Guide: Horticultural and Forest Crops** and **Pest Management Guide: Field Crops**. In each book, look in the "Calibration Tables and Information" subsection of "Regulations and Basic Information."

Q. How can you find out how much pesticide to apply?

A. Look at the directions for use section of the pesticide label. Some labels have charts listing a range of application rates. Consultants, industry organizations, Extension agents, university specialists, and pesticide dealers may be able to help you determine the use rate, based on label directions.

Q. List five ways that a product label may state application rates.

A. 1. Amount of active ingredient (a.i.) per unit area or volume. Example: 1 pound of active ingredient per acre.

2. Amount of active ingredient per volume of finished spray. Example: 2 pounds of active ingredient per 100 gallons of spray mix.
3. Amount of formulated product per unit area or space. Example: 5 gallons of an emulsifiable concentrate per acre.
4. Amount of formulated product per volume of mixture. Example: 1 pint of product per 1,000 square feet, applied in 1 to 2 gallons of finished spray.
5. Percentage of the final dilution. Example: 0.5% by volume.

Q. How do you know when you must calibrate application equipment?

A. If label directions tell you to apply a specified amount of pesticide or active ingredient per unit area (or space). Here is an excerpt of label instructions that require calibration:

- "2 pints of a liquid pesticide product in 1-2 gallons of finished spray mix per 1,000 ft^2."

Q. Give an example of label directions that require mixing but no calibration.

A. "For hard-to-control perennial weeds, apply a 2% solution on a spray to wet basis, with complete and uniform coverage of the foliage of the plant to be controlled." These instructions simply tell you to mix up a solution of a specific strength and apply to target pests.

Q. What types of formulations may need calibration and loading but no mixing?

A. Ready-to-use (RTU) formulations with label directions that require calibration. These include most granular and dust formulations; some liquid formulations (such as dilute, end-use solutions); and certain fumigants.

Q. What is a ratio and proportion equation? Give an example.

A. A fraction that allows you to find a value by using basic arithmetic.

Example: If there are 12 inches in 1 foot, how many inches are there in 5 feet?

Solution: 1 foot is to 12 inches as 5 feet is to ? inches:

$$\frac{1 \text{ ft}}{12 \text{ in}} = \frac{5 \text{ ft}}{? \text{ in}}$$

To solve, cross multiply and divide:

(12 x 5) ÷ 1 = number of inches in 5 ft

60 = number of inches in 5 ft

Q. The label rate of your product is 2 pints per 1,000 square feet, but you have calibrated your equipment in acres. How do you convert the label rate (pints per 1,000 square feet) to the rate per acre?

A. Your ratio will be:

$$\frac{\text{pt per acre}}{43{,}560 \text{ sq ft}} = \frac{2 \text{ pt}}{1{,}000 \text{ sq ft}}$$

(43,560 x 2) ÷ 1,000 = number of pt per acre

87,120 ÷ 1,000 = number of pt per acre

87.12 (~ 87) = number of pt to apply per acre

Q. What pesticide formulations must you dilute before application?

A. All except those sold as ready-to-use products or those designed to be applied full strength (ex. fumigants).

Q. What information do you need from the pesticide label or other sources before you can dilute pesticides correctly?

A. What diluent to use, how much to dilute the formulation, and how much of the dilute pesticide to apply per unit area.

Q. What information about your equipment and the application site

do you need in order to calculate how much pesticide and diluent to combine in your application equipment?

A. 1. How much your equipment holds when full or how much mixture you will need to complete the job.

2. How much mixture your equipment applies per unit area.

3. The size of the site you need to treat.

Q. Your spray tank holds 300 gallons. The label of a wettable powder product tells you to use 3 pounds of formulated product per 100 gallons of water. How many pounds of product should you add to the tank to make a full load?

A.

$$\frac{3 \text{ lb}}{100 \text{ gal}} = \frac{? \text{ lb}}{300 \text{ gal}}$$

$(3 \times 300) \div 100 =$ 9 lb needed to make a full load

Q. A label tells you to use 0.2 ounce of dry product per 1,000 square feet. The area you plan to treat is 5,000 square feet. How much product will you need to use?

A. Your ratio will be:

$$\frac{0.2 \text{ dry oz}}{1{,}000 \text{ sq ft}} = \frac{? \text{ dry oz}}{5{,}000 \text{ sq ft}}$$

$(0.2 \times 5{,}000) \div 1{,}000 =$ 1 dry oz needed to treat the total area

Q. You want to apply 3 pounds of active ingredient per acre. Your formulation is a 60% wettable powder (WP). How much formulated product should you apply per acre?

A.

$$\frac{3 \text{ lb of a.i. per acre} \times 100}{60\% \text{ a.i. in formulation}} = \text{lb of formulated product per acre}$$

$(3 \times 100) \div 60 =$ 5 lb of formulated product per acre

Q. As calibrated, your spray equipment applies 50 gallons per acre. A label tells you to use 5 pounds of formulated product per 100 gallons of water. How much product should you add to the tank to make 50 gallons of finished spray?

A. Your ratio will be:

$$\frac{5 \text{ lb}}{100 \text{ gal}} = \frac{? \text{ lb}}{50 \text{ gal}}$$

$(5 \times 50) \div 100 =$ 2.5 lb needed to mix up a 50-gal load

Q. As calibrated, your spray equipment applies 50 gallons per acre. Based on label directions, you calculated that you need 2.5 pounds of product to make 50 gallons of finished spray mix, which will treat 1 acre. You need to spray 10 acres. How much product and water will you need?

A. Product:

$$\frac{2.5 \text{ lb}}{1 \text{ acre}} = \frac{? \text{ lb}}{10 \text{ acres}}$$

$(2.5 \times 10) \div 1 = 25$ lb of product

Water:

$$\frac{50 \text{ gal}}{1 \text{ acre}} = \frac{? \text{ gal}}{10 \text{ acres}}$$

$(50 \times 10) \div 1 = 500$ gal of water

You will need 25 pounds of pesticide to make 500 gallons of finished spray.

Q. Your sprayer tank holds 4 gallons and applies 2 quarts of liquid per 1,000 square feet. The label directions of an emulsifiable concentrate (EC) formulation tell you to apply 3 fluid ounces of product per 1,000 square feet. How much product do you need to make a full tank of finished spray?

GIVEN:
128 fluid ounces = 4 quarts = 1 gallon.

A. Step 1:

$$\frac{\text{2 qt}}{\text{1,000 sq ft}} = \frac{\text{16 qt (full tank)}}{\text{? sq ft}}$$

(16 x 1,000) ÷ 2 = 8,000 sq ft per tankful

Step 2:

$$\frac{\text{3 fl oz of product}}{\text{1,000 sq ft}} = \frac{\text{? fl oz of product}}{\text{8,000 sq ft}}$$

(3 x 8,000) ÷ 1,000 = 24 fl oz of product per full tank

Q. Your sprayer applies 30 gallons per acre, and your tank holds 300 gallons. The label rate of a 6 EC product is 2 pounds of active ingredient per acre. How many acres per tank can you treat? How much product should you add to the tank to make a full load?

GIVEN: A 6 EC product contains 6 pounds of active ingredient per gallon.

A. Step 1:

$$\frac{\text{300 gal in tank}}{\text{30 gpa}} = \text{acres sprayed per tank}$$

300 ÷ 30 = 10 acres per tank

Step 2:

$$\frac{\text{2 lb a.i. per acre}}{\text{6 lb a.i. per gal}} = \text{amount of product per acre}$$

2 ÷ 6 = 0.33 (1/3) gpa

Step 3:

10 acres per tankful x 0.33 gpa = gal of product to add to tank

10 x 0.33 = 3.3 gal of 6 EC product needed

Q. The label rate of a liquid formulation is 1.5 pints of formulated product per 100 gallons of water. Your spray tank holds 25 gallons. How much product do you need to mix up a full tank?

A.

$$\frac{\text{1.5 pt (label rate)}}{\text{100 gal (diluent volume)}} = \frac{\text{amount of product needed for job}}{\text{25 gal (tank volume)}}$$

(1.5 x 25) ÷ 100 = 0.38 pt of product needed in tank

0.38 pt x 16 fl oz per pint = 6.1 fl oz of formulation needed

Q. Your sprayer applies 25 gallons per acre, and your tank holds 500 gallons. The label rate is 3 quarts per acre. How many acres can you treat with a full load? How much formulated product should you add to make up a full tank?

A. Step 1:

$$\frac{\text{500 gal}}{\text{25 gpa}} = \text{acres sprayed per tankful}$$

500 ÷ 25 = 20 acres per tank

Step 2:

20 acres sprayed per tankful x 3 qt per acre = amount of product needed in tank

20 x 3 = 60 qt needed to mix a full tank

60 qt ÷ 4 qt per gal = 15 gal needed to mix a full tank

Q. How do you calculate the area of a square or a rectangle?

A. Multiply the length (L) by the width (W). Area = L x W.

Q. You need to treat a floor that measures 15 feet by 12 feet. What is the area?

A. Area of a rectangle = L x W = 15 ft x 12 ft = 180 sq ft.

Q. How do you calculate the area of a circle?

A. Radius (half the diameter) times the radius times 3.14 (pi). Area = r^2 x 3.14 (radius x radius x 3.14).

Q. You plan to apply a pesticide to a circular plant bed with a 20-foot diameter. What is the area of the bed?

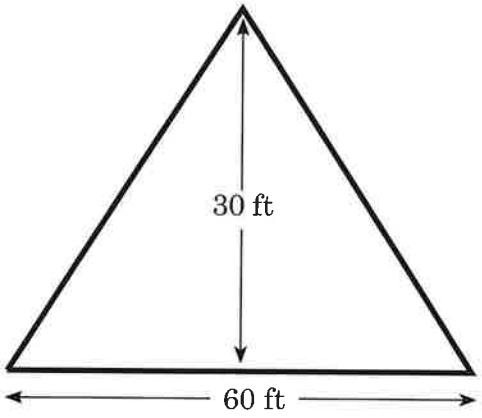
A. If the diameter of the plant bed is 20 feet, then the radius is 10 feet (radius of a circle = half its diameter). Area of the circular bed = 10 ft x 10 ft x 3.14 = 314 sq ft.

Q. How do you calculate the area of a triangle?

A. Multiply the length of the longest side (base) by the width at the widest point (height) and divide by 2. Area = base x height ÷ 2.

Q. You want to treat a triangular area. The base of the triangle measures 60 feet and its height is 30 feet. What is the area?

A. Area of the triangle = base x height ÷ 2. In this case, 60 ft x 30 ft ÷ 2 = 900 sq ft.



Q. How do you calculate the area of an irregularly shaped site?

A. There are three ways:

1. Convert the site into a combination of rectangles, circles, and triangles. Calculate the area of each and add them together.
2. If the site is roughly rectangular, use the transect method. Establish a line down the middle of the site for the length. Then, measure from side to side at several points along this line. Average the side-to-side measurements and use this figure as the width. Use the length and the estimated width to figure the area as a rectangle (L x W).
3. If the site is round, convert it into a circle. From a center point, measure distance to the edge of the area 10 or more times. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

Q. How do you calculate the volume of a space shaped like a cube or box (such as a room or closet)?

A. Multiply the length (L) by the width (W) by the height (H). Volume = L x W x H. Your answer is in cubic dimensions (cubic feet).

Q. How do you calculate the volume of a space shaped like a cylinder (such as a silo)?

A. Multiply the height by the area of the circle at the base. Volume = height x radius x radius x 3.14. Your answer is in cubic dimensions (cubic feet).

Unit 11. Transportation, Storage, Containment, Disposal, and Spill Management

Learning Objectives

After studying this unit, you should be able to:

- Discuss the major safety precautions for transporting pesticides and their containers in a vehicle.
- Discuss how to establish and maintain a safe and secure storage site.
- Describe what to do when a pesticide container is damaged.
- Name the advantages of collection trays and pads.
- Explain what to do with excess pesticides that are still usable.
- Describe what to do with rinsates from equipment cleanup.
- List alternatives to disposing of pesticide containers as wastes.
- Explain how to deal with empty pesticide containers, both rinsable and nonrinsable.
- Name several types of empty, rinsable containers and describe rinsing methods.
- Name the "three C's" of spill management and the steps to take in each.
- List sources of assistance for managing a spill.
- List the materials needed to respond to a pesticide spill.

Terms to Know

NOTE: The "Terms to Know" are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

Active Ingredient (a.i.) – A chemical in a pesticide product that affects or controls the target pest.

Chemical Resistant – Able to prevent movement of a pesticide through material during the period of use.

Collection Pad or Tray – A safety system designed to contain and recover spills, leaks, rinsates, and other pesticide-containing substances.

Decontaminate/Decontamination – To remove (or the removal of) pesticide from exposed surfaces or organisms to prevent further harm or damage.

Diluent – Any substance used to dilute a pesticide (for liquid formulations, usually water).

Drift – The movement of pesticides away from the release site in air.

Exposed/Exposure – Contacting or touching (or subjected to contact with) a pesticide; getting a pesticide on a surface, or in or on an organism. Exposures may be oral, inhalation, dermal, or ocular.

Groundwater – Water beneath the earth's surface. It collects in pore spaces among soil layers, gravel, and rock.

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

Nonporous – Having no openings or pores to allow liquid to be absorbed or pass through (ex. surfaces).

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

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Rinsate – Pesticide-containing water (or other liquid) that results from rinsing a pesticide container, pesticide equipment, or other pesticide-containing materials.

Runoff – The movement of pesticide away from the release site in water or another liquid flowing laterally across the surface.

Surface Water – Water on top of the earth's surface, such as in lakes, streams, rivers, irrigation ditches, and stormwater drains.

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

Transportation of Pesticides

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. A cell phone should be available in all vehicles transporting pesticides.

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 are easier to clean if a spill occurs.

NEVER carry pesticides in the passenger section of your car, van, or truck. Hazardous vapors may escape 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. Spilled pesticide can cause future contamination if it is not cleaned up properly. If you must transport pesticides in the back of a station wagon, open the side windows and do not allow anyone to ride in the back.

NEVER allow children, other passengers, or pets to ride with pesticides.

NEVER transport pesticides with food, clothing, or other things that people or animals might eat or touch. 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 harmed by the pesticides. Whenever possible, transport pesticides in a locked compartment or enclosed cargo box.

Consider transporting highly **volatile** pesticides separately from other chemicals. Spills, or even fumes from opened containers, can contaminate other chemicals. These chemicals may then become unusable and require special handling and disposal.

Transport pesticides safely in the back of a truck.

Vehicle Operator

Both the owner and the operator (driver) of a transport vehicle may be liable for damages that occur when transporting a pesticide. The driver is often the first person to respond to any incident that occurs while transporting a pesticide. Drivers should be trained in spill-control procedures described later in this unit.

The U.S. Department of Transportation (DOT) classifies certain pesticides (ex. fumigants) as hazardous materials. This means there are many regulations regarding transportation of such pesticides – even empty pesticide containers. Examples of DOT regulations include vehicle placarding, inspecting vehicles each day before use, training and licensing drivers to transport hazardous materials, background checks on drivers, and extensive recordkeeping. These

regulations are subject to change. Check with pesticide suppliers and registrants as well as the Virginia Department of Transportation for updates. For more information on transporting hazardous materials, contact the Hazardous Materials Information Center (800-HMR-4922).

Transporting Pesticide Containers

Transport pesticides only in containers with intact, undamaged, and readable labels. Inspect containers before loading to ensure that all caps, plugs, and other openings are tightly closed. Make sure there are no pesticides on the outside of the containers. Handle containers carefully to avoid rips or punctures.

Anchor all containers securely to keep them from rolling or sliding. Packing or shipping containers provide extra cushioning. Protect paper and cardboard containers from moisture – they become soggy and split easily when wet.

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.

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 xxx-xxx-xxxx 24 hours a day.*

Do not transport in or on vehicles containing foodstuffs or feeds.

Storage and Containment of Pesticides

Many **pesticide handlers** use existing buildings or areas within such buildings for pesticide storage. However, for storage of large amounts of pesticides, it is best to build a special storage building just for pesticide needs.

Establish a Storage Site

A well-designed and -maintained pesticide storage site is essential. Such a 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 intruders out is an important function of the storage site. Whether the 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.

Keep pesticide storage areas off limits to the public.

Every pesticide storage site should have a security plan. Pesticides, vehicles, application equipment (especially aerial), bulk storage tanks, and other facilities may otherwise be at risk from intruders. Follow these steps:

1. Secure storage areas, related buildings, and surrounding property. Use fencing, lighting, guards, and/or locks to keep intruders out.

2. Secure pesticide application equipment and vehicles. Disable equipment in the field to prevent theft or misuse. For example, this might mean removing the battery from a truck. Check handlers for identification and proper authorization.

3. Protect confidential information. Keep computer systems secure by monitoring access to electronic data.

4. Develop procedures that enhance security. Implement good hiring and labor policies to find and retain reliable employees. Limit the amount of hazardous pesticides stored on site. Plan what to do in case of emergency, including vandalism and terrorist activity.

5. Coordinate with local and federal authorities. Be prepared to contact local police or the FBI if a breach of security occurs. You can find out the location of the nearest FBI office at www.fbi.gov.

6. Post emergency contact information. Include the name and telephone number of a person to call in an emergency.

Make sure security measures are in place when transporting, storing, applying, or disposing of any pesticide.

Prevent Water Damage

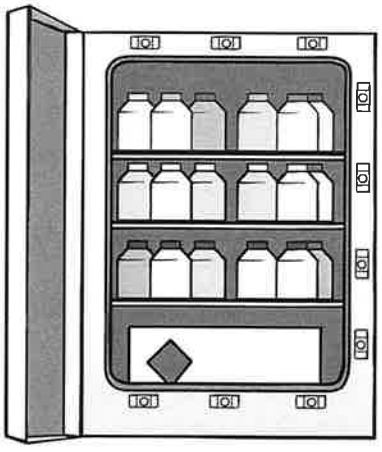
Choose a storage site where water damage is unlikely. Water from burst pipes, spills, overflows, excess rain or irrigation, or flooding streams can damage pesticides and their containers. Water or excess moisture can cause:

- 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 exposed to the weather or may become damp, consider placing metal, cardboard, and paper containers in sturdy plastic bags or cans for protection. If feasible, place large, rust-prone metal containers 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 to store the product. 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.



Pesticide Storage Cabinet

Know the Law

Some pesticide applicators, applicator businesses, and dealers may be affected by Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III), administered by the Environmental Protection Agency (EPA). SARA Title III has many sections; the three that follow relate to the storage of pesticides.

Emergency Planning and Notification

Under certain conditions, the law requires you to notify state and local officials about the location and amount of hazardous chemicals at your site. EPA has assigned a threshold planning quantity (TPQ) for a number of **active ingredients** (not total weight of formulated product). When the stored product is at or above the TPQ, you must notify the State Emergency Response Commission (SERC) in writing. Each facility must designate a coordinator to work with the Local Emergency Planning Committee (LEPC). The state will notify the LEPC that your operation is covered under SARA. This is a one-time notification.

Refer to the most recent Pest Management Guides for guidelines on reporting stored pesticides.

Safety Data Sheet (SDS) Reporting

Employers are required to obtain and keep Safety Data Sheets (SDSs). They must submit copies of each SDS (or a listing of each SDS that must be maintained) to their local fire department, the LEPC, and the SERC. There is one exclusion: if a chemical is used solely for household, consumer, or agricultural purposes, notification is not required. However, under Occupational Safety and Health Administration (OSHA) regulations, pesticide users (except homeowners) must have the SDS for each pesticide they handle.

Annual Inventory Reporting

All regulated facilities must submit an annual chemical inventory to their local fire department, the LEPC, and the SERC. This inventory must include:

- All hazardous chemicals stored at the facility in quantities of 10,000 pounds or more.
- All extremely hazardous chemicals stored in quantities of 500 pounds (or 55 gallons) or more, or in a quantity that exceeds the TPQ, whichever is less.

Agricultural producers are exempt from this section.

Provide Adequate Lighting

The storage site should be well-lit. 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

Construct the floor of the storage site using sealed cement, glazed ceramic tile, no-wax sheet flooring, or another 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 using wood or fiberboard

materials, coat or cover them with plastic or polyurethane or epoxy paint. Put open containers in boxes with newspaper or absorbent material.

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 firefighting or floods. Pesticide movement away from the site could contaminate sensitive areas, including **surface water** or **groundwater**. If your storage site includes large amounts of pesticides, you may need to use a **collection pad or tray** to contain pesticide runoff. See "Use Pesticide Containment Systems" below for more information on collection pads and trays.

Provide Clean Water

Each storage site must have an immediate supply of clean water. Potable (drinkable) running water is ideal. If running water is not practical, use a large, sealable container with clean water. Change the water in the container at least weekly to ensure that it remains safe for use on skin and eyes. Keep an eyewash dispenser on hand for emergencies.

Maintain the Storage Site

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** (PPE) at the site. Vapors, dusts, or spills could contaminate them and accidentally expose people or animals to pesticides. (PPE for site or spill cleanup should be stored near but not in the storage area to prevent contamination.)

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. Exposure to moisture, dripping pesticide, **diluents**, or dirt may damage or destroy labels. To prevent this, 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 formulator immediately.

Keep Containers Closed

Keep pesticide containers securely closed whenever they are in storage. 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.
- The escape of potentially toxic vapors.
- Dust, dirt, and other contaminants getting into and ruining the pesticide.

Use Original Containers

Store pesticides in their original containers. Never put pesticides in containers that might cause anyone to mistake them for food or drink. You are legally responsible if a person or animal 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 PPE and act immediately. If the damaged container is an aerosol can or fumigant tank that contains pesticides under pressure, do not release the pesticide into the air. When a container is damaged, you have several options:

- Use the pesticide immediately at a site and rate allowed by the label.

- Transfer the pesticide into another pesticide container that originally held the same pesticide and has the same label still intact.

- Transfer the contents to a sturdy (plastic or other nonporous) container that can be tightly closed. If possible, remove the label from the damaged container and use it on the new one. Otherwise, temporarily mark the new container with the name and EPA registration number of the pesticide.

If the pesticide in temporary storage is a concentrate that will be further diluted before use, securely attach the following information to the container:

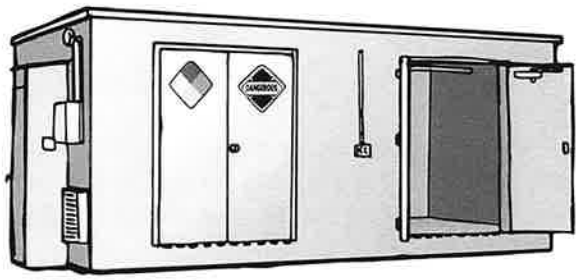
- Product or brand name.
- EPA registration number.
- Name and percentage of active ingredient.
- Signal word.

See "Virginia Service Container Labeling Requirements" in Unit 3 for more information. Get a copy of the label from the pesticide dealer or formulator (whose telephone number is often on the label) as soon as possible.

It is usually not advisable to transfer the entire damaged container and its contents into a larger container. Many times the label on the leaking container becomes illegible. The pesticide is useless and becomes a disposal problem unless you know the product name and registration number and can get a copy of the label.

Store Volatile Products Separately

Store volatile pesticides, such as some types of 2,4-D, apart from other types of pesticides and other chemicals. A separate room is ideal. Vapors from opened containers of these pesticides can contaminate other nearby pesticides and chemicals and ruin them. The labeling of volatile herbicides usually will direct you to store them separately from seeds, fertilizers, and other types of pesticides.



Store volatile pesticides apart from other chemicals.

Isolate Waste Products

If you are holding pesticides and/or pesticide containers for disposal, store them in a special section of the storage site. Accidental use of pesticides meant for disposal can be a costly mistake.

Rinse containers immediately as you empty them. If possible, use the **rinsate** as part of your diluent. Clearly mark containers that have been triple-rinsed or cleaned by an equivalent method.

Know Your Inventory

Keep an up-to-date inventory of the pesticides you have in storage. Each time a pesticide is added to or removed from the storage site, update the inventory list. It will help you keep track of your stock and will be essential in a fire or flood emergency. The list will also aid in insurance settlements and in estimating future pesticide needs.

Do not store unnecessarily large quantities of pesticides for long periods. 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 stored pesticides worthless. Some pesticides have a relatively short shelf life and cannot be kept from year to year.

Keep a copy of an SDS for each product you store. An SDS is an excellent source of information about handling and storage, as well as the procedures to follow in case of an accident.

Know the Law

EPA regulates wastes under the Resource Conservation and Recovery Act (RCRA). EPA issues a list of materials 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's. Contact your state or tribal authority for applicable requirements.

"Wastes" include unrinsed containers, excess pesticides and pesticide dilutions, and rinse and wash water that contains a listed chemical and is unusable. Triple-rinsed pesticide containers, however, are not considered hazardous waste under RCRA. 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, a state, or a tribe; and follow certain disposal requirements.

To find out if a pesticide is listed in RCRA, call:

EPA RCRA hotline: 800-424-9346, 8:30 a.m. to 7:30 p.m. ET, Monday through Friday.

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 clues 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.

Keep track of the purchase date of all stored pesticides.

Use Pesticide Containment Systems

If you often mix and load pesticides or clean equipment in one place, a pesticide collection pad or tray may be a good investment. These pads and trays will catch spills, leaks, overflows, and wash water. These "leftover materials" can then be recovered for reuse or disposal. You may permanently install larger pads, but smaller pads and trays are often more portable.

Containment systems can save time and money by making spill cleanup easier. They also reduce pesticide waste by allowing the reuse of the rinse water and spill cleanup water. These systems help prevent the harm that spills and runoff can cause to the environment or to people.

Collection Trays

You can use a collection tray 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. It should also 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 warehouse or 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 have curbs or walls high enough to hold the largest amount of spillage, leakage, or equipment wash water likely to occur at the site. It also must be equipped with a system to remove and recover spilled, leaked, or released material – either an automatic sump system or a manually operated pump.

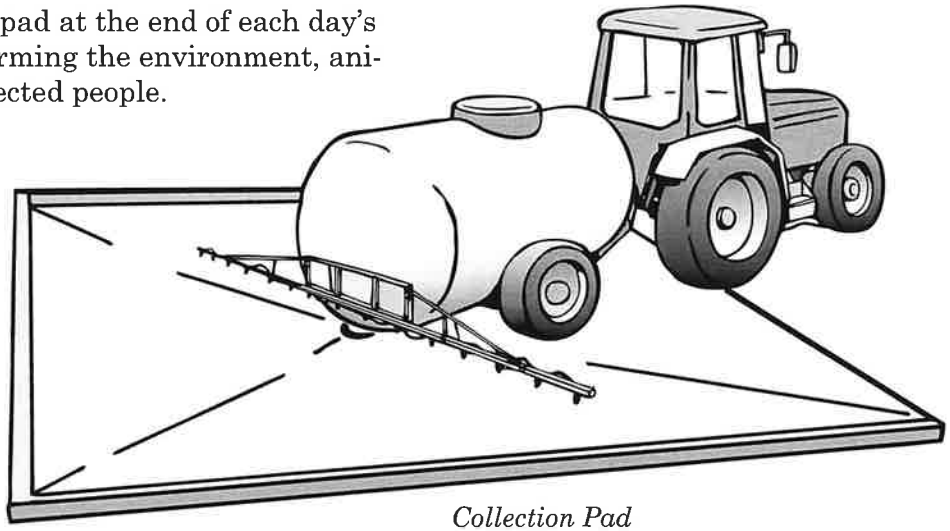
Locate the collection pad where rainwater, irrigation water, and floodwater cannot flow over it. Wash the pad at the end of each day's use to prevent harming the environment, animals, and unprotected people.

Prevent Pesticide Fires

Some pesticides are highly flammable; others do not catch fire easily. The labeling of pesticides that require extra precautions will often contain a warning statement in either the physical or chemical hazards section or the storage and disposal section. The SDS will also have useful information about the product's chemical and physical properties. Pesticides that contain oils or petroleum-based solvents are the ones most likely to have these warning statements. However, some dry products also present fire and explosion hazards.

Store combustible pesticides away from open flames and other heat sources, such as steam lines, heating systems, kerosene or other space heaters, gas-powered equipment, or incinerators. Do not store glass containers in sunlight where they can focus the heat rays and possibly explode or ignite. Install fire detection systems in large storage sites, and equip each storage site with a working fire extinguisher that is approved for all types of fires – including chemical fires.

If you store highly toxic pesticides or large amounts of any pesticides, inform your local fire department, hospital, public health officials, and police of the location of your pesticide storage building BEFORE a fire emergency occurs. Tell fire department officials what types of pesticides are regularly stored at the site, give them a floor plan, and work with them to develop an emergency response plan.



Collection Pad

Labeling Statements about Storage

Typical pesticide labeling instructions about storage include:

Store at temperatures above 32°F.

Do not contaminate feed, foodstuffs, or drinking water during storage.

Store in original container only.

In outside storage areas, store drums on sides to avoid accumulation of rainwater in top or bottom of recessed areas.

Do not store near ignition sources, such as electrical sparks, flames, or heated surfaces.

Flammable. Do not use, pour, spill, or store near heat or open flame. Do not cut or weld container.

Disposal of Pesticides

Pesticide users are responsible for correctly dealing with empty pesticide containers, excess usable pesticides, and waste materials that contain pesticides or their residues. Improper disposal of pesticide wastes can seriously damage human health and the environment. For information on disposal options available in your area, contact your state or tribal pesticide authority.

Excess Pesticides

The best solution to the problem of what to do with excess pesticides is to avoid having them. Follow these steps:

1. Buy only the amount needed for a year or a season.
2. Calculate carefully how much diluted pesticide you need for a job and mix only that amount.
3. Be sure your application equipment is calibrated and in good working order.
4. Use all the mixed pesticide in accordance with labeling instructions.

If you have excess usable pesticides, 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 labeling, under these conditions:

- 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 labeling.
- You must comply with other application instructions specified on the labeling.

If you have pesticide products in their original containers that you cannot use, you may be able to find another pesticide handler who can. Or you may be able to return them to a dealer, formulator, or manufacturer. If you have exhausted other options, look for a pesticide disposal program in your area. Contact the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services (VDACS-OPS), at 804-371-6561 for more information on pesticide disposal.

Rinsates

Most container rinsates should not become excess pesticides because you can add them into the tank with the diluent during the mixing process. Remember that the rinsates you create when you rinse containers and/or clean your equipment contain pesticides and can harm people and the environment. Do not allow rinsates to flow into water systems, including sink or floor drains, rainwater culverts, wells, streams, lakes, and rivers. Do not create puddles that children, other unprotected persons, or animals could get into.

You may use equipment rinsate as a diluent for future pesticide mixtures if:

- The pesticide in the rinsate is labeled for use on the target site where you will apply the new mixture.

- The amount of pesticide in the rinsate plus the amount of pesticide product in the mixture do not exceed the labeling rate for the target site.
- The rinsate is used to dilute a mixture containing the same pesticide or a compatible pesticide.
- You comply with other application instructions on the labeling, including any specific instructions for application as an excess pesticide.

You cannot add rinsate to a pesticide mixture if:

- The pesticide labeling does not list the rinsate as an acceptable diluent (ex. if the rinsate contains a strongly acidic or alkaline neutralizing agent).
- The rinsate contains strong cleaning agents (ex. bleach or ammonia) that might harm the plant, animal, or surface to which it will be applied.
- The rinsate would alter the pesticide mixture and make it unusable (ex. if the pesticides are physically or chemically incompatible).

If you have any rinsates that you cannot use, dispose of them as you would excess pesticides.

Pesticide Wastes

Unusable excess pesticides and unusable rinsates must be disposed of as wastes. Other pesticide wastes include contaminated spill cleanup material and PPE that cannot be cleaned and reused. Whenever possible, avoid creating pesticide wastes that require disposal.

Sometimes, you can take pesticide wastes to a landfill operating under EPA, state, tribal, or local permit for hazardous wastes. Most sanitary landfills are not suitable. Some regions have pesticide incinerators to dispose of pesticide wastes. Never burn on site (open burn), bury, or dump excess pesticides. Never dispose of them in a way that will contaminate public or private groundwater, surface water, or sewage treatment facilities.

If you cannot dispose of pesticide wastes right away, contain, mark, and record their contents. Store them safely and properly 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 law. If these wastes cannot be disposed of by use according to label instructions, contact your state pesticide or environmental control agency or the hazardous waste representative at the nearest EPA regional office for guidance.

Empty Pesticide Containers

"Empty" pesticide containers are usually not truly empty. The pesticide that clings to the inside of the container can be dangerous to you, other people, and the environment. Take care of empty containers at once. Dispose of them in accordance with label directions and with federal, state, tribal, and local laws and regulations.

Return all pesticide containers to the pesticide storage area or the container-holding area when you finish your task. Do not leave containers unattended at the mixing, loading, or application site. Never give pesticide containers to children to play with or to adults to use.

Try to avoid disposing 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.

Refillable Containers

Some types of containers can 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, the pesticide dealer or chemical company will clean them 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 30- and 55-gallon drums can be returned to the dealer, manufacturer, or formulator to be reconditioned and reused.

Soluble Containers

Soluble containers may be placed, unopened, into the mixing tank. The container dissolves in the solvent (usually water) in the tank. Only the overpackaging remains, which can be discarded as nonhazardous waste in a sanitary landfill.

Rinsable Containers

When you are diluting pesticides, rinse the empty pesticide containers (unless the labeling directs you not to). Rinse containers as soon as they are empty. The remaining residues can dry quickly and become difficult to remove. Such rinsing often saves money. This is because each rinse removes pesticide from the sides and bottom of the container and allows you to add it to the pesticide mixture.

Triple Rinsing Containers

Triple-Rinsed or Pressure-Rinsed Containers

Glass, metal, and plastic containers; plastic-lined paper or cardboard containers; and even unlined paper or cardboard containers that can withstand the rinsing process should be triple-rinsed or pressure-rinsed. Use the diluent (water, high-grade oil, or another liquid) listed on the pesticide labeling as the liquid for rinsing.

Containers that have been correctly triple-rinsed or pressure-rinsed may often be placed in a sanitary landfill as regular trash. Make sure that the pesticide labeling and/or government authorities (state, tribal, or local) do not prohibit this. Mark the containers to show that they have been rinsed. There are stickers commercially available for this purpose.

Pressure rinsing is an alternative to triple rinsing. Some studies have shown that pressure rinsing is as effective as triple rinsing and can take less time. Wear protective clothing, especially gloves and goggles or a face shield, while doing this procedure.

To triple rinse a container:

1. *Empty the container into the tank. Let it drain an extra 30 seconds.*
2. *Fill it about 20% full of water.*
3. *Replace the lid and shake the container so that all interior surfaces are rinsed.*
4. *Drain the rinse water from the container into the tank. Let the container drain for 30 seconds.*
5. *Repeat the procedure two more times.*

Some pesticide equipment, including some closed-system mixing and loading equipment, is equipped with a mechanism to pressure rinse pesticide containers when they are emptied. The system usually operates by:

- Inserting a high-pressure nozzle and hose into the container.
- Rotating the nozzle and rinsing for at least 30 seconds.
- Draining the container thoroughly into the mix tank.

Some systems puncture the base or side of the container to insert the nozzle. Other systems insert the nozzle into the container's regular opening.

Labeling Statements about Triple Rinsing

Typical pesticide labeling instructions about triple rinsing containers include:

Triple rinse containers and dispose of rinsate in area just treated or by other approved means.

Triple rinse (or equivalent). Then dispose of in a sanitary landfill or by other approved state and local procedures.

Nonrinsable Containers

Nonrinsable containers include bags and boxes of dry pesticides and aerosol cans and cylinders. Empty them as completely as possible. Some containers are designed to be returned to the pesticide dealer or manufacturer for refilling.

If empty pesticide containers cannot be refilled, reconditioned, or recycled, crush, break, or puncture them (except for aerosol cans). This will make the containers unusable and may save storage space.

You can also take unrinsed containers to an incinerator or landfill operating under EPA, state, or tribal permit for hazardous waste disposal. If this is not possible, check with your state, tribal, or local authorities for guidance.

Burnable Containers

The labeling of some paper and cardboard containers may list "burning, if allowed by state and local authorities" as a disposal option. However, open burning of pesticide containers and waste pesticides is a questionable practice. It may also violate state regulations that may supersede the instructions on the pesticide labeling. Because of possible air pollution hazard and liability risks, it is best to use another disposal method for these containers.

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. Ideally, all spills could be prevented by careful pesticide handling and proper maintenance of vehicles and equipment. However, 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 properly respond 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, seek assistance.

The faster you can manage 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 before the end of the workday to keep unprotected persons or animals from pesticide exposure.

Pesticide spills demand immediate attention.

A good way to remember the steps for a spill emergency is the three C's: **C**ontrol, **C**ontain, **C**lean up.

Control the Spill

If a spill occurs, take control of the situation by doing the following:

1. Protect yourself.
2. Stop the source of the spill.
3. Protect others and secure the area.
4. Stay at the site.

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 PPE to wear, do not take a chance! Wear a long-sleeved shirt, long pants, **chemical-resistant** apron, footwear, gloves, eye protection, and a respirator.

Stop the Source

If a bag tears, try to position it so no more material will escape. If a spray tank is overflowing, stop the inflow and try to cap off the tank. If a container tips over, set it upright. 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 and Secure the Area

Isolate the spill site by keeping all unprotected people and animals well back. Rope off the site if necessary. If you suspect the spill contains a highly volatile or explosive pesticide, keep people back even farther. Warn everyone 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 properly protected person arrives. Someone should be at the spill site at all times until the spill is cleaned up. Use a cell phone if you need to call for help.

Contain the Spill

Once you have stopped the spill and removed people from the danger area, you must contain the spill. This involves confining the spill to a small area, protecting water sources, absorbing liquids, and covering dry materials.

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 tubes ("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. If pesticide does get into a stream, pond, or other waterway, contact VDACS-OPS. Ask them what other state agencies to contact.

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, pet 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. It will also make the dry material more difficult to clean up.

Clean up the Spill

After you have contained the spill, you must pick up the spilled material and decontaminate the spill site and any contaminated items or equipment. You must also neutralize the spill site (if required) and clean yourself thoroughly.

Pick up Spilled Materials

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.

WARNING

Be careful with pesticides that are oxidizers such as calcium hypochlorite, a common sanitizer (ex. Clorox®), and some herbicides and desiccants containing chlorites. Do not contain such pesticides with sawdust, shredded paper, or sweeping compounds. These absorbent compounds combine with the oxidizer to create a fire hazard and could burst into flames. Instead, use pet litter, clay, dry lime, sand, soda ash, or other nonflammable absorbent material.

Clean up spilled pesticide using appropriate tools and materials.

Dispose of this material as explained above in "Pesticide Wastes."

Sweep up dry pesticide spills for reuse if possible. Avoid contaminating the spilled materials with soil or other debris. This will allow you to use the materials in the usual application equipment without clogging the nozzles or hopper openings. However, if the dry spill has become wet or full of debris, sweep it up and place it 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 con-

tainment tray or pad, and you can collect and deal with the rinsate generated.

If the surface on which the pesticide has spilled is **nonporous** (ex. 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 spill residues 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 completely soaked up. Then sweep up the absorbent material and place it in a plastic drum or bag for disposal as excess pesticide.

If the spill surface is porous (ex. soil, unsealed wood, or carpet), you may have to remove the contaminated surface and dispose of it as excess pesticide. Depending on the size of the spill and the toxicity of the pesticide, however, you may be able to neutralize the site. For help in determining whether it is feasible to neutralize the site of a pesticide spill, contact the pesticide manufacturer (registrant) or the Chemical Transportation Emergency Center (CHEMTREC; see below).

Neutralize the Spill Site

The labeling of a few pesticides will instruct you to neutralize a spill of that pesticide. Sometimes the pesticide manufacturer, CHEMTREC, or other authority (such as EPA or OSHA) will also require you to neutralize the spill site. Follow the instructions carefully.

Neutralizing a spill may involve using full-strength bleach, lime or ammonia, or weak acid (ex. vinegar) and working this mixture into the spill site with a coarse broom. Consult the label, SDS, or manufacturer for information on what to use. Next, spread fresh absorbent material over the spill site to soak up the neutralizing liquid. Finally, sweep up this material and place it in a plastic drum or bag for disposal. You may need to repeat the process several times to make sure that the site is thoroughly neutralized.

Do NOT mix bleach with lime or with products containing ammonia, acids, or other household cleaners.

One way to neutralize soil is to remove and dispose of the top 2 to 3 inches. Then, mix activated charcoal into the remaining soil, or cover the spill site with 2 or more inches of lime and cover the lime with fresh topsoil.

Sometimes, the label may instruct you to cover minor spills with activated charcoal. The activated charcoal can adsorb or tie up enough pesticide to avoid harming plants and animals that may contact the soil. However, activated charcoal is not effective for large spills.

Decontaminate Equipment

Clean any vehicles, equipment, and PPE that were contaminated by the spill or during the containment and cleanup process. Use chlorine bleach, liquid laundry detergent, and water to clean the vehicles and equipment. Wash PPE thoroughly, following manufacturers' instructions and the guidelines in Unit 7 of this manual. Remember that you cannot effectively clean porous materials (ex. brooms, leather shoes, and clothing) if they are thoroughly saturated with pesticide. Discard them.

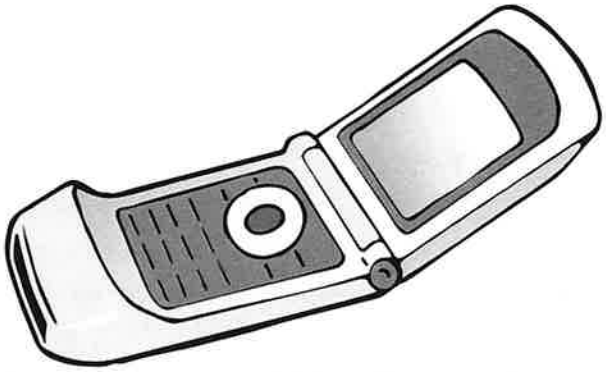
Decontaminate Yourself

As soon as you are finished with the spill and equipment cleanup, wash yourself thoroughly with soap and water. Wash any part of your skin that might have been exposed, and always wash your face, neck, hands, and forearms.

Spill Follow-Up

For all large spills – and any spills that take place off your property (or that of your employer or client) – keep records of your containment and cleanup activities. Also record your conversations with authorities and the public about the spill. Photographs help to document any damage as well as the cleanup process.

Report all spills that may endanger people or the environment to VDACS-OPS (804-371-6561). Someone in the Office of Pesticide Services will help you determine whether you must report the release – and to what agency



Promptly report a pesticide spill on a roadway.

– to comply with other regulations. See "Reporting Pesticide Accidents" in Unit 1 for specific information on reporting spills.

Spill Assistance

If you need help managing a spill, contact VDACS-OPS. Virginia Cooperative Extension agents can also offer advice or technical assistance. In an emergency, call CHEMTREC. CHEMTREC is a public service of the Chemical Manufacturers Association. Located in Washington, D.C., CHEMTREC is staffed 24 hours a day by trained personnel who can advise you on how to manage chemical emergencies. The telephone number for CHEMTREC emergency response information is on the product label. Call CHEMTREC in the event of a large pesticide spill or exposure hazard, or if you need immediate help. The local fire department and emergency medical technicians can also help control the spill and provide first aid.

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 allows you to reach the manufacturer and others who know how to manage emergencies for that product.

If the spill occurs on a highway, call the highway patrol or the Virginia Department of Transportation right away. If the spill occurs on a county road or city street, call the county sheriff, city police, or fire department. These authorities are trained for such emergencies and can help you in your cleanup. Many local and state authorities require you to notify them of a pesticide spill.

If you suspect that a large spill is flammable, call the fire department for assistance. Do not let them hose down the spill unless an authority directs them to do so.

If anyone is poisoned by contacting the spill, or if you suspect that an exposure may lead to poisoning, take the affected person(s) to the nearest hospital emergency room. Call ahead and provide emergency room personnel with the brand name and active ingredient(s) of the pesticide. Also mention any other labeling and SDS 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-length 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.

Contact the [chemical company] emergency response team for decontamination procedures or any other emergency assistance at xxx-xxx-xxxx.

Spill Kit

Keep a spill cleanup kit on hand whenever you work with 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:

- A cell phone and emergency numbers.
- Chemical-resistant gloves, footwear, apron, and coveralls or suit.
- Protective eyewear.
- An appropriate respirator, if required by any of the pesticide labeling.
- Containment tubes to confine the leak or spill.
- Absorbent materials, such as spill pillows, absorbent clay, sawdust, pet litter, activated charcoal, vermiculite, or paper for liquid spills.
- A sweeping compound to keep dry spills from drifting or wafting during cleanup.
- A shovel, broom (both preferably foldable), and dustpan.
- A heavy-duty detergent.
- A fire extinguisher rated for all types of fires.
- Any other spill cleanup items specified on the labeling of any products you use regularly.
- A sturdy plastic container that will hold the quantity of pesticide from the largest pesticide container in use and that can be tightly closed.

Other useful items to have on hand are water in a mist or spray bottle (to moisten the surface of fine-textured dry material) and warning tape, cones, or signs (to keep people out of the spill area).

Store all of these items in a plastic container or drum so that they will be clean and in working order when needed.

Know the Law

If you are involved in a pesticide spill, you may need to comply with the provisions of two laws administered by EPA.

Title III of the Superfund Amendments and Reauthorization Act of 1986 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 Virginia Emergency Response Council, c/o the Virginia Department of Emergency Management Operations Center (800-468-8892).
- Notify the Local Emergency Planning Committee.
- Report the release to the National Response Center (800-424-8802).

In addition, any spill that could 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 VDACS-OPS (804-371-6561) or the EPA Region 3 office (800-553-2509) for help.

Test Your Knowledge

Q. What precautions should you take when transporting pesticides in a vehicle?

A. 1. NEVER carry pesticides in the passenger section.

2. NEVER allow people or pets to ride with pesticides.

3. NEVER transport pesticides with food, clothing, or other things that people or animals might eat or touch.

4. NEVER leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck.

5. Consider transporting highly volatile pesticides separately from other chemicals.

Q. Name several Department of Transportation (DOT) regulations concerning transportation of hazardous materials (ex. fumigants).

A. Vehicle placarding, inspecting vehicles each day before use, training and licensing drivers to transport hazardous materials, background checks on drivers, and extensive recordkeeping.

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.

Q. List at least four good ways to establish a safe storage site.

A. 1. Secure the site.

2. Prevent water damage.

3. Control the temperature.

4. Provide adequate lighting.

5. Use nonporous materials.

6. Prevent runoff.

7. Provide clean water.

Q. Why is a well-designed and properly maintained storage site so important?

A. A good storage site protects people and animals from accidental exposure and is environmentally friendly. It also protects pesticides from temperature extremes, excess moisture, theft, vandalism, and unauthorized use. This reduces liability risks.

Q. Why should a pesticide storage site have a security plan?

A. To protect pesticides and related equipment from theft, misuse, and other unlawful conduct. Keeping intruders out is an important part of a good security plan.

Q. Name several ways to protect storage areas, related buildings, pesticide application equipment, and vehicles from intruders.

A. Use fencing, lighting, guards, and/or locks to keep intruders out. Disable equipment in the field. Check handlers for identification and proper authorization. Stay in close touch with local and federal authorities.

Q. While you are inspecting a pesticide storage site, you notice that some metal containers are rusting and several cardboard containers have split or crumbled. On other containers, the labeling is smeared and hard to read. What is the likely cause of the damage?

A. Water or excess moisture.

Q. What sorts of materials are best for the floor of a pesticide storage site? Why?

A. Sealed cement, glazed ceramic tile, and no-wax sheet flooring. These nonporous materials are relatively easy to clean and/or decontaminate.

Q. Why should a pesticide storage site be temperature-controlled and have adequate lighting?

A. Temperature extremes (both heat and cold) can destroy the potency of some pesticides. Good lighting is essential to allow pesticide handlers to read the container labels, notice any leaks, and clean up spills.

Q. List at least four good ways to maintain a safe storage site.

A. 1. Prevent contamination.

2. Keep labels legible.

3. Keep containers closed.

4. Use original containers.

5. Watch for damage.

6. Use pesticide containment systems.

7. Store volatile products separately.

8. Isolate waste products.

9. Know your inventory.

10. Consider shelf life.

Q. Why is it important to keep pesticide containers tightly closed while in storage?

A. To prevent spills, cross contamination with other products, evaporation (liquid pesticides), and clumping or caking (dry pesticides). Tightly closed containers will also keep toxic vapors from escaping and protect pesticides from dust and dirt.

Q. When a pesticide container is damaged, what options do you have?

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 (plastic or other nonporous) container that can be tightly closed, and fasten the label to the outside of the new container.

Q. What are pesticide containment systems? When might you use them?

A. Collection pads or trays that catch spills, leaks, overflows, and wash water. These devices may be useful if you often mix and load pesticides or clean equipment in one place.

Q. Name several 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 damage to the environment and to people from spills and runoff.

Q. Describe a collection pad suitable for use at a mixing/loading site.

A. It should be made of a waterproof material such as sealed, smooth concrete; glazed ceramic tile; or no-wax sheet flooring. The pad must be concave or have curbs or walls high enough to hold a large amount of spillage, leakage, or equipment wash water. It should also have a system to remove and recover spilled, leaked, or released material – either an automatic sump system or a manually operated pump.

Q. Name several reasons to keep an up-to-date inventory of stored pesticides.

A. 1. To keep track of your stock, especially in a fire, flood, or other emergency.

2. To aid in insurance settlements.

3. To help estimate future pesticide needs.

4. To prevent overstocking of pesticides by purchasing only what is needed for the current year.

Q. Describe how to store pesticides to minimize fire and explosion hazards.

A. Store combustible pesticides away from open flames and other heat sources. Do not store glass containers in sunlight where they can focus the heat rays and possibly explode or ignite. Install fire detection systems in large storage sites. Additionally, equip each storage site with a working fire extinguisher approved for all types of fires.

Q. List several ways to avoid having excess pesticides.

A. 1. Buy only the amount needed for a year or a season.

2. Calculate carefully how much diluted pesticide you need for a job and mix only that amount.

3. Be sure your application equipment is calibrated and in good working order.

4. Use all the mixed pesticide in accordance with labeling instructions.

Q. What can you do with excess pesticide materials that are still usable?

A. 1. Apply them to a site listed on the labeling. Be sure the total amount of active ingredient applied to the site does not exceed the rate and frequency allowed on the labeling.

2. Find someone else who can legally use them.

3. Return them to the dealer, formulator, or manufacturer.

4. Look for a pesticide disposal program in your area.

Q. What should you do with the rinsate created when cleaning your pesticide equipment?

A. Collect and apply it if possible. Otherwise, dispose of the rinsate as excess pesticide.

Q. After cleaning your application equipment, you collect rinsate that contains ammonia. Can you add the rinsate to a future pesticide mixture?

A. No. The ammonia in the rinsate might harm the application surface.

Q. How should you dispose of unusable pesticide wastes (other than empty containers)?

A. Take them to a hazardous waste landfill or pesticide incinerator or store them until safe and legal disposal is possible.

Q. What should you do with empty pesticide containers?

A. 1. If containers are rinsable, rinse them as soon as they are empty.

2. Return all empty pesticide containers to the pesticide storage area or the container-holding area.

3. Recycle containers if possible.

4. Crush, break, or puncture empty containers (except for aerosol cans) that cannot be refilled, reconditioned, or recycled.

5. Dispose of containers in accordance with labeling directions and with any laws or regulations that apply.

Q. List three ways to avoid having to dispose of empty pesticide containers as wastes.

A. 1. Use refillable containers.

2. Recycle or recondition the containers.

3. Use soluble packaging.

Q. What types of empty pesticide containers can be rinsed?

A. 1. Glass, metal, and plastic.

2. Plastic-lined paper or cardboard.

3. Unlined paper or cardboard that can withstand the rinsing process.

Q. What two methods of rinsing can you use? Briefly describe each.

A. Triple rinsing and pressure rinsing. Triple rinsing involves filling an empty container about 20% full of water, then shaking the container to rinse all interior surfaces. Drain the rinse water into the tank, letting the container drain for about 30 seconds. Repeat the procedure two more times.

Pressure rinsing involves inserting a high-pressure nozzle and hose into the container, rotating the nozzle, and rinsing. Drain the container thoroughly into the mix tank.

Q. True or false: Pesticide containers that have been properly triple-rinsed or pressure-rinsed may be placed in a sanitary landfill as regular trash.

A. True. Mark the containers (or use a sticker) to show that they have been rinsed.

Q. How should you dispose of nonrinsable containers?

A. Empty them as much as you can. If possible, return to the pesticide dealer or manufacturer for refilling. If empty pesticide containers cannot be refilled, reconditioned, or recycled, crush, break, or puncture them (except for aerosol cans). You may also take unrinsed containers to an incinerator or landfill operating under EPA, state, or tribal permit for hazardous waste disposal.

Q. Describe how to respond to any pesticide spill, no matter what size.

A. 1. Act promptly. The faster you can manage and dispose of a spill, the less chance there is that it will cause harm.

2. If you cannot manage a spill by yourself, get help.

3. Never leave a spill unattended.

Q. What are the three C's of spill management?

A. **C**ontrol, **C**ontain, **C**lean up.

Q. What should you do to control a spill situation?

A. Protect yourself, stop the source of the spill, protect others and secure the area, and stay at the site.

Q. Describe how to stop the source of a pesticide spill.

A. If a bag tears, try to position it so no more material will escape. If a spray tank is overflowing, stop the inflow and try to cap off the tank. If a container tips over, set it upright. 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.

Q. How should you contain a spill?

A. Confine the spill to a small area, protect water sources, absorb liquids, and cover or dampen dry materials.

Q. Describe how to contain a large spill of a liquid pesticide.

A. Use a shovel, a rake, or other tool or equipment to make a dike of soil, sod, or absorbent material. If necessary, cover the entire spill site with absorbent materials (ex. fine sand, sawdust, or pet litter). Be careful not to use flammable materials (ex. sawdust or shredded paper) when cleaning up spilled pesticides that contain calcium hypochlorite.

Q. What does cleaning up a spill entail?

A. Picking up spilled materials, decontaminating the spill site, neutralizing the spill site (if required), decontaminating equipment, and decontaminating yourself.

Q. Describe how to decontaminate and neutralize a sealed concrete spill site.

A. Decontaminate: Use water and detergent to remove spill residues. Place fresh absorbent material over the wash solution. Then, sweep up the absorbent material and place it in a plastic drum or bag for disposal.

Neutralize: Work full-strength bleach, ammonia, or a weak acid into the spill site with a coarse broom. Consult the label, SDS, or manufacturer for information on what to use. Spread fresh absorbent material over the site to soak up the neutralizing liquid. Then, sweep up the material and place it in a plastic drum or bag for disposal.

Q. Whom should you notify in case of a pesticide spill?

A. If the spill may endanger people or the environment, first call VDACS-OPS (804-371-6561). Someone in the Office of Pesticide Services will help you determine whether to report the release – and to what agency – to comply with other regulations. Under some circumstances, you may have to report the spill to other authorities, such as the Virginia Emergency Response Council, the Local Emergency Planning Committee, and the National Response Center.

Q. Whom should you call to get help in managing a spill?

A. The Office of Pesticide Services. Virginia Cooperative Extension agents can also offer advice or technical assistance. In an emergency, call CHEMTREC; the fire department and/or emergency medical technicians; the emergency numbers on pesticide labeling; the city police, county sheriff, or highway patrol; or the Virginia Department of Transportation.

Q. When should you have a spill kit on hand?

A. Every time you handle a pesticide or its container.

Q. Where could you store the items in your spill kit?

A. In a sturdy plastic container or drum.

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Glossary

Glossary

NOTE: These terms are defined according to their meaning in the context of this manual. These definitions may not be accurate in other contexts.

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

Absorption – The process of taking in (soaking up) a substance.

Acaricide – A chemical that controls mites, spiders, and/or ticks. See also miticide.

Accumulation – Buildup (ex. increasing amounts of pesticides in animals or soil over time).

Acidic – The opposite of alkaline; having a pH less than 7.

Active Ingredient (a.i.) – A chemical in a pesticide product that affects or controls the target pest.

Acute Effects – Illnesses or injuries that appear soon (within 24 hours) after exposure to a pesticide or combination of pesticides.

Acute Toxicity – The measure of harm caused by a single pesticide exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity.

Adjuvant – A substance added to a pesticide formulation or tank mix to increase its effectiveness or safety (ex. emulsifier or wetting agent).

Adsorption – The process of adhesion; coating a particle or binding something to a surface.

Agitate/Agitation – To stir or mix; the process of stirring or mixing.

Air-Purifying Respirator – A type of personal protective equipment that removes particulates and toxic vapors. It traps and removes contaminants from the surrounding atmosphere using a cartridge, canister, or particulate filter.

Air-Supplying Respirator – A type of personal protective equipment that provides breathing air from a source independent of the surrounding atmosphere.

Alkaline – The opposite of acidic; having a pH more than 7.

Allergic Effects – Harmful effects, such as skin rash or asthma, that some people develop when exposed to a substance that does not cause the same reaction in others. An allergy causes a hypersensitivity to a specific substance, often called the allergen.

Annual – A plant that completes its life cycle in one year.

Appendage – An animal body part or organ that projects from the main part of the body.

Application Rate – The amount of pesticide applied to a given area.

Aquifer – A naturally occurring underground stratum that collects and holds large volumes of groundwater.

Arthropod – An animal with jointed legs and a segmented, jointed, outer skeleton.

Avicide – A chemical used to control birds.

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

Bactericide – A chemical that kills bacteria.

Band Application – Application of a pesticide to a long, narrow strip (ex. over or between crop rows).

Biennial – A plant that completes its life cycle in two years. The first year it germinates and grows. The second year it continues to grow, produces fruit and seeds, and then dies.

Biological Control – The use of living organisms (or their products) to control pests.

Biological Diversity – The variety and differences among living things, usually within an ecosystem.

Biorational Pesticide – A chemical substance with pesticidal properties obtained from a natural enemy or disease; a chemical with

pesticidal properties patterned on one that occurs naturally. See also microbial pesticide.

Brand Name – The trademarked name given to a pesticide product by the manufacturer. It often includes information about the formulation and percentage of active ingredient (ex. Sevin 50% WP).

Broadcast Application – Uniform application of a pesticide to a wide or large area.

Buffer Zone – A strip of land that separates pesticide-treated areas from untreated areas. Buffer zones act as barriers to keep pesticides out of nontarget areas, such as streams or playgrounds.

Calibrate – To measure the delivery rate and distribution of application equipment; to adjust application equipment so the desired amount of pesticide is applied uniformly to a given area or space.

Calibration – The process of measuring and adjusting the amount of pesticide a piece of equipment applies to a target.

Canister Respirator – A type of personal protective equipment that has a cylindrical container (canister) filled with gas- and vapor-removing material. The canister is either connected directly to the facepiece or worn on a harness and connected to the facepiece by a flexible hose. Canister respirators are often called gas masks.

Carrier – The primary material used to allow a pesticide to be dispersed effectively. Examples include talc in a dust formulation, water mixed with a wettable powder before a spray application, and air that disperses the pesticide in an air-blast application.

Cartridge Respirator – A type of personal protective equipment that contains gas- and vapor-removing material. Cartridge respirators may be either one-piece units with cartridges permanently attached to the facepiece, or two-piece units with removable cartridges.

Certified Applicator – Any commercial applicator, registered technician, and/or private applicator who has met the certification requirements in Virginia.

Chemical Control – The use of chemicals to destroy pests, control their activity, or prevent them from causing damage.

Chemical Name – The technical name that identifies the chemical formula and structure of a pesticide active ingredient (ex. 1-naphthyl N-methyl carbamate).

Chemical Resistant – Able to prevent movement of a pesticide through material during the period of use.

Chemigation – Application of a pesticide through an irrigation system.

Chlorophyll – The green pigment that allows plants to manufacture food.

Chronic Effects – Illnesses or injuries that appear a long time (usually several years) after exposure to a pesticide. Often, chronic effects are due to repeated exposures.

Chronic Toxicity – The measure of harm caused by repeated, prolonged exposure to small amounts of pesticide.

Closed Mixing and Loading System – A safety system designed to prevent pesticides from contacting handlers or other persons during mixing and loading.

Cocoon – A silken case in which an insect pupa develops into an adult.

Collection Pad or Tray – A safety system designed to contain and recover spills, leaks, rinsates, and other pesticide-containing substances.

Commercial Applicator – A certified applicator who uses pesticides on the job, other than for agricultural production on private property.

Commercial Applicator for Hire – Any commercial applicator who uses or supervises the use of any pesticide commercially, on the property of others. Commercial applicators for hire in the commonwealth must have a pesticide business license or work for someone who does.

Commercial Applicator Government Employee – Any local, state, or federal government employee who uses or supervises the use of any pesticide for any purpose, regardless of the site, while performing his or her official duties.

Commercial Applicator Inactive – Any commercial applicator who is not currently employed in a pesticide-related job and is thus not covered by the required insurance. Inactive applicators must still satisfy renewal and recertification requirements.

Commercial Applicator Not for Hire – Any commercial applicator who uses or supervises the use of pesticides as part of his or her job duties only on property owned or leased by the applicator or by his or her employer.

Common (Chemical) Name – A short name given to a pesticide active ingredient that the Environmental Protection Agency (EPA) has officially accepted (ex. carbaryl).

Compatible – A combination of ingredients in which no component of the mixture reacts with or adversely affects any other.

Concentrated – Having a high percentage of active ingredient.

Concentrates – Pesticides that have a relatively high percentage of active ingredient.

Concentration – Content of pesticide in a liquid or a dry material; for example, pounds per gallon of liquid or percentage by weight for a dust.

Conductivity – A measure of water's ability to conduct electricity. Dissolved substances (ex. soluble salts) increase the conductivity of water.

Contact Pesticide – A pesticide that kills pests by touching them. A contact herbicide affects only treated plant parts. A contact insecticide does not need to be eaten to control insect pests.

Control – To kill, to prevent or lessen the harmful effects of, to destroy, or to repel an undesirable organism.

Cultural Control – Changing the habitats where pests flourish to decrease pest pressure.

Curative Fungicide – A product that inhibits or eliminates a disease-causing organism after it has become established in or on a host.

Cuticle – (1) Protective outer covering of insects; (2) waxy coating on the leaves of plants.

Decontaminate/ Decontamination – To remove (or the removal of) pesticide from exposed surfaces or organisms to prevent further harm or damage.

Defoliant – A chemical that causes leaves to drop from plants.

Delayed Effects – Illnesses or injuries that appear more than 24 hours after exposure to a pesticide or combination of pesticides.

Delayed Systemic Effects – Illnesses or injuries to a system in the body that appear more than 24 hours after exposure to a pesticide or combination of pesticides.

Desiccant – A chemical that causes rapid water loss.

Developmental Effects – Injuries to or illnesses of a fetus in the womb of a woman who has been exposed to a pesticide.

Dicot – Plant with two seed leaves (cotyledons) and broad, net-veined leaves. As a rule, flower parts are in multiples of four or five (ex. four, five, or 10 petals).

Diluent – Any substance used to dilute a pesticide (for liquid formulations, usually water).

Dilute – To make less concentrated.

Direct Onsite Supervision – The act or process by which a competent person, acting under the instructions and control of a certified commercial applicator who is responsible for the actions of that person, applies a pesticide. The certified commercial applicator must be present at the application site and be able to see the person applying the pesticide at all times.

Direct Supervision – The act or process by which a competent person, acting under the instructions and control of a certified commercial applicator who is responsible for the actions of that person, applies a pesticide. The certified commercial applicator must be either near or in close telephone or radio contact with the person applying the pesticide.

Directed Application – Precise application to a specific area or site (ex. underleaf, fence line, or guard

rail spraying), often using specialized equipment.

Disease – An abnormal, unhealthy condition caused by an invading organism, such as a bacterium or virus.

Disinfectant – A substance used to kill or deactivate disease-producing microorganisms; chemicals used to clean or surface-sterilize objects.

Distributor Products – End-use pesticides produced and registered by a manufacturer or formulator and sold under a different name by a distributor.

Dormant – Inactive or sluggish.

Drift – The movement of pesticides away from the release site in air.

Drop Spreader – A type of granular applicator with an adjustable sliding gate that opens holes in the bottom of the hopper. Granules flow out by gravity feed.

Ecosystem – A system formed by the interaction of a community of organisms with their environment.

Effective Swath Width – The span of spray or granules with enough pesticide to control the pest.

Efficacy – Effectiveness.

Emergency Exemption from Registration – An emergency (Section 18) exemption that allows the sale and use of a certain pesticide product for a specific nonregistered purpose for a specified period. EPA grants emergency exemptions at the request of a state regulatory agency. EPA will issue a Section 18 exemption ONLY when there is no other feasible way to respond to a pest emergency.

Emulsifier – A chemical that allows petroleum-based pesticides (such as emulsifiable concentrates) to mix with water.

Emulsion – A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other, and each retains its identity and properties. Agitation may be necessary to prevent separation.

Endangered Species – Plants or animals whose survival has been designated by a federal or state agency as endangered or threatened. These species have small populations that are vulnerable to extinction, most often due to habitat destruction, disease, or overharvesting.

Environment – The world around us: all physical, chemical, and biological surroundings, such as climate, soil, water, air, and living organisms. It also includes manmade elements.

Environmental Hazard Statements – Statements on pesticide labeling that list possible environmental hazards that may result from using a pesticide. These statements may also include specific actions to take to avoid or reduce hazards.

Eradication – Elimination of an entire pest population.

Erosion – The movement of sediment, soil, and rock from the ground surface.

Establishment Number – The number assigned by EPA to each pesticide production facility.

Estuary – An area of water that occurs where a river meets the tide of an ocean.

Exposed/Exposure – Contacting or touching (or subjected to contact with) a pesticide; getting a pesticide on a surface, or in or on an organism. Exposures may be oral, inhalation, dermal, or ocular.

Eyewash Dispenser – Commercially available system to flush contaminants out of the eyes.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) – A law that established the basis of U.S. pesticide regulation to protect applicators, consumers, and the environment.

Filtering Facepiece Respirator (FFR) – A disposable air-purifying device that protects the user by filtering particles (particulates) from the air. The filter is an integral part of the facepiece. There are seven classes of filters for NIOSH-approved FFRs currently available. FFRs are one type of particulate-filtering respirator.

Fit Check – An on-the-spot test to make sure a respirator

is working correctly and is positioned properly on the face.

Fit Test – A procedure to evaluate the fit of a respirator on an individual. This may be a qualitative or a quantitative test.

Flow Rate – Volume of material released per unit time; for example, the amount of fluid that passes through a nozzle's orifice in one minute.

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

Fumigant – A pesticide that is or forms a toxic vapor or gas when applied.

Fungicide – A chemical or mixture of chemicals that controls plant disease(s) caused by fungi.

Gall – Abnormal plant growth caused by stimuli from an insect or other organism.

Gallons per Acre (gpa) – The volume of liquid applied to an acre unit area.

Gallons per Minute (gpm) – The volume of liquid released by a spraying system or from a specific nozzle in one minute (60 seconds).

General-Use Pesticide – An unclassified pesticide that can be purchased and used both by certified applicators and by the public.

Groundwater – Water beneath the earth's surface. It collects in pore spaces among soil layers, gravel, and rock.

Growth Regulator – A chemical substance that alters the growth and development of a plant or animal. See also insect growth regulator (IGR) and plant growth regulator (PGR).

Habitat – The place(s) where an animal or plant lives.

Hazard – The risk of harmful effects from pesticides.

Hazard Communication Standard (HCS) – A regulation under the Occupational Safety and Health Act. The HCS requires employers to provide information and protections to workers who may be exposed to hazardous chemicals under normal operating conditions or in foreseeable emergencies.

Heat Stress – A potentially life-threatening illness that occurs when the body is subjected to more heat than it can adjust to.

Herbicide – A chemical used to control weeds.

Heterogeneous – Having unlike or dissimilar ingredients or nature. The ingredients in a heterogeneous mixture are not dispersed uniformly.

Homogeneous – Having the same or similar ingredients or nature. The ingredients in a homogeneous mixture are dispersed uniformly.

Host – An organism infected by a parasite; a plant or animal on or in which a parasite lives.

Impregnates – Solid materials with one or more pesticide active ingredients incorporated into them (ex. livestock ear tags, plastic pest strips and adhesive tapes, and pet collars).

Incompatible – A combination of ingredients that is not usable, stable, safe, or effective.

Inert Ingredient – Inactive component of a formulated pesticide product added to dilute the pesticide or to make it safer, more effective, and/or easier to handle. Inert ingredients have no direct effect on target pests.

Insect Growth Regulator (IGR) – A chemical substance that interferes with insect hormones controlling normal growth and development. See also growth regulator.

Insecticide – A chemical used to control insects.

Insoluble – Does not dissolve in a liquid.

Integrated Pest Management (IPM) – A system that uses all suitable pest control measures together in a way that keeps pest populations below the levels that cause economic injury.

Invertebrate – An animal without a backbone (ex. an insect or a slug).

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

Key Pest – A pest that is nearly always present, often causes major damage, and requires regular control.

Label – All printed material attached to or part of the pesticide container.

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

Larva (Plural = Larvae) – Immature stage of insects that undergo complete metamorphosis. Most larvae look like segmented worms with legs; a caterpillar is an insect in the larval stage.

Leaching – The movement of pesticide in water or another liquid downward through soil or other planting medium.

Liability – Legal responsibility.

Mechanical Control – The use of various devices and machines to control pests or alter their environment.

Metamorphosis – Change in body form during the life cycle of an organism. There are two different types: complete and gradual.

Microbe – An organism (such as a bacterium or protozoan) that cannot be seen without the aid of a microscope.

Microbial Pesticide – A pest control product formulated with microorganisms, such as bacteria and fungi. See also biorational pesticide.

Minimum-Risk Section 25(b) Pesticides – Products judged to present a low risk to humans and the environment. These pesticides are exempt from the federal registration process.

Miticide – A chemical used to control mites.

Mixture – Two or more substances that are not chemically bound to one another. Mixtures may be uniform and homogeneous (ex. a dilute solution of saltwater) OR non-uniform and heterogeneous (ex. a piece of granite, a bag of M&Ms, or oil and vinegar salad dressing).

Mobility – The tendency of a pesticide to run off in water, become a vapor, or otherwise change form or leave the target site.

Mode of Action – How a pesticide works; the way it controls a pest.

Molluscicide – A chemical used to control snails, slugs, or pest shellfish.

Mollusk – A soft-bodied, invertebrate animal, usually protected by a shell. Clams, snails, and slugs are mollusks.

Monitoring – Determining the size and distribution of a pest population in an area. See also scouting.

Monocot – Plant with one seed leaf (cotyledon) and narrow, parallel-veined leaves. As a rule, flower parts are in threes or multiples of three (ex. three, six, or nine petals).

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

N, R, and P Series – Filters classified by NIOSH based on oil degradation resistance. N-series filters are not oil-resistant, R-series filters have limited oil resistance (typically eight hours of use), and P-series filters have indefinite oil resistance (oil proof). The filter efficiency level for each classification may be 95%, 99%, or 99.97%.

National Institute for Occupational Safety and Health (NIOSH) – The federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH tests and sets standards for respiratory protection devices, such as filtering facepiece respirators and cartridge respirators, as well as other personal protective equipment.

Nematicide – A chemical used to control nematodes.

Nematode – A microscopic, eel-like roundworm.

Nonpoint Source Pollution – Contamination from pesticides that comes from a wide, nonspecific area or from broadcast applications. Weather events often contribute to this type of pollution.

Nonporous – Having no openings or pores to allow liquid to be absorbed or pass through (ex. surfaces).

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

Nymph – Immature stage of insects that undergo gradual metamorphosis. A nymph

looks like a small, wingless version of the adult.

Occasional Pest – A migratory or cyclical pest that may require intermittent control.

Occupational Safety and Health Administration (OSHA) – The federal agency responsible for regulating and enforcing labor laws, including the safe use of hazardous chemicals in the workplace (as outlined in the Hazard Communication Standard [HCS]).

Offsite – Outside the area of the pesticide application, handling, mixing, and loading.

Organic Matter – Materials and debris in the soil that began as living plants or animals.

Organism – Any living thing (ex. plants, animals, fungi, and bacteria).

Orifice – A precisely sized opening in a spray nozzle, duster, or granular applicator through which the spray, dust, or granules flow.

Oxidizer – A highly reactive chemical that may explode and is a fire hazard under certain conditions.

Parasite – An organism that gets all or part of its food from another living organism. In so doing, it harms that organism (its host).

Particle Drift – The airborne movement of particles of (or containing) pesticide, such as spray droplets or dusts.

Particulate-Filtering Respirator – A disposable, air-purifying device that protects the user by filtering dusts, mists, powders, and particles from the air.

Pathogen – An organism that causes disease in other organisms.

Penetrant – A chemical that helps a pesticide active ingredient get through a surface and into an object or organism.

Perennial – A plant that lives for more than two years.

Permeability – The ability of a substance (ex. rock or soil) to allow liquids or gases to pass through. The more permeable a substance is, the faster water will flow through it.

Persistence – The ability of a pesticide to remain effective over time and not break down.

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

Pest – Any living thing that is undesirable or harms people, property, or the environment.

Pesticide – Any substance used to control a pest, or to reduce the unwanted or harmful effects of a pest.

Pesticide Business License – A document required of persons in the business of selling, storing, distributing, mixing, recommending the use of, or applying pesticides. For a complete explanation of conditions and exemptions, see Unit 1.

Pesticide Handler/Handling – A person who works (or the process of working) directly with pesticides, performing routine tasks such as mixing, loading, and applying; transporting, storing, and disposing; and/or working on pesticide equipment.

Pesticide Use – Application or supervision of an application of a pesticide. "Use" includes all the routine activities that are part of a pesticide application, such as mixing, loading, cleanup, and disposal. Handling, transfer, or transport after the manufacturer's original seal is broken is considered use. (Pesticide handling typically managed by persons other than the mixer/loader/applicator, such as long-distance transport, long-term storage, or ultimate disposal, is not considered routine use.)

Petroleum Based – Made from petroleum products (ex. xylene, refined oil, and kerosene).

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

Physical Control – Changing certain environmental conditions to suppress or control pests.

Phytotoxicity – Injury or damage to a sensitive plant caused by a chemical exposure.

Plant Growth Regulator (PGR) – A chemical substance that interferes with normal plant growth and development. See also growth regulator.

Point Source Pollution – Contamination that comes from a specific, identifiable place (ex. a leaking container of herbicide).

Pollution – Environmental contamination. The improper release of pesticides into the environment may cause pollution.

Porous – Having tiny openings that allow liquid to be absorbed or to pass through. Porous surfaces may absorb pesticides readily.

Postemergent Herbicide – A pesticide applied to weed foliage; usually more effective if the weed is actively growing.

Precautionary Statement – Pesticide labeling statement that warns of possible hazards from use of the pesticide product and that may indicate specific ways to avoid the hazards.

Precipitate – An insoluble, solid substance that forms because of a chemical change.

Precipitation is the formation of a solid in a solution resulting from a chemical reaction.

Predator – An animal that attacks, kills, and feeds on other animals.

Preemergent Herbicide – A pesticide applied before weed seeds germinate and begin to grow.

Prefilter – An accessory item placed in front of an approved filter that removes coarse particles from the air. Prefilters do not meet NIOSH guidelines for particulate filters. Respirators with prefilters must still meet these requirements.

Prevention – Keeping a pest from becoming a problem.

Private Applicator – A certified applicator who uses or supervises the use of any restricted-use pesticide (RUP) to produce an agricultural commodity. Applications must be made on property owned or rented by the user, or by his or her employer. A certified private applicator may also apply an RUP to the property of another agricultural producer. However, he or she must receive no compensation except for trading personal services between them. Uncertified applicators employed by agricultural producers may use RUPs only when under the direct supervision of a certified private applicator.

Protectant Fungicide – Pesticide applied to prevent the development of some plant diseases caused by fungi.

Pupa – The immature "resting" stage of insects that undergo complete metamorphosis.

During the pupa stage, an insect will change from the larval to the adult body form.

Recertification – The demonstration of continued competency to apply pesticides safely by participation in appropriate, approved education courses or by reexamination.

Registered Technician – A certified applicator who renders services similar to those of a certified commercial applicator. Such a person has completed training and demonstrated competency as required for registered technicians but has not met the requirements for commercial certification. Registered technicians may apply general-use pesticides on the job without supervision. They may apply RUPs only under the direct supervision of a certified commercial applicator. Like commercial applicators, registered technicians may be for hire, not for hire, government employees, or inactive.

Registration Number – The identification number assigned to a pesticide product when it is registered by EPA.

Release – To discharge pesticide from its container or the equipment or system used to apply it. Release can be intentional (as in an application) or accidental (as in a spill or leak).

Reproductive Effects – Injuries to the reproductive system of exposed men or women.

Reregistration – Review of a labeled pesticide to assess its risks and benefits. EPA conducts reregistration reviews to verify the safety and efficacy of registered pesticides.

Residue – An amount of pesticide that remains in the environment (ex. on a plant, an animal, or in the soil) after an application or a spill.

Resistance – The natural or genetic ability of an organism to tolerate toxic effects and/or pest attack.

Respirator – A device that protects the respiratory tract from irritating and poisonous gases, fumes, smoke, and dust. Some respirators have equipment that supplies oxygen or clean air.

Restricted-Entry Interval (REI) – The length of time specified on the pesticide label between the time of the pesticide application and the time it is safe for a person to enter the treated area without label-required personal protective equipment.

Restricted-Use Pesticide (RUP) – Any pesticide classified for restricted use by the administrator of EPA. The "restricted-use" classification restricts a product, or its uses, to use by a certified pesticide applicator (commercial or private) or under the direct supervision of a certified applicator.

Revolutions per Minute (rpm) – Number of full rotations completed in one minute around a fixed axis, used as a measure of rotational speed of a mechanical component. Often, rpm is the best way to gauge or set the operating speed of a tractor.

Rhizome – A horizontal plant stem that grows on or under the soil. It produces leaves and buds along its upper surface and roots along its lower surface.

Rinsate – Pesticide-containing water (or other liquid) that results from rinsing a pesticide container, pesticide equipment, or other pesticide-containing materials.

Rodenticide – A chemical used to control rodents, such as rats, mice, or voles.

Rotary Spreader – A type of granular applicator that distributes granules to the front and sides of the spreader, usually with a spinning disk or fan.

Runoff – The movement of pesticide away from the release site in water or another liquid flowing laterally across the surface.

Safety Data Sheet (SDS) – Occupational Safety and Health Administration (OSHA) Form 20, designed to contain important safety information about a chemical that is hazardous to handlers due to toxic, fire, or reactive properties. The SDS is a source of information for employees and employers. It contains details about chemical properties, toxicity, first aid, and emergency procedures to follow in case of an accident.

Sanitation – Managing pests by removing food or hiding places that would attract pests. Other types of sanitation include removing garbage or litter around a house, removing and destroying pests and diseased plant materials, disinfecting tools, and sterilizing soil.

Scouting – Regularly searching for, identifying, and assessing numbers of pests and the damage they are causing. See also monitoring.

Secondary Pest – A pest that requires control only under certain circumstances, such as the elimination of a key pest or the absence of a natural host.

Secondary Poisoning – When a predator or scavenger ingests pesticide by eating an animal killed by a pesticide. Secondary poisoning may cause sickness or death.

Sensitive Areas – Sites or organisms that are particularly vulnerable to harmful effects from pesticides.

Sensitization – The process by which a person develops an allergic response to a substance after repeated exposures.

Sign – A visible indication of pesticide poisoning or injury in a person or animal.

Signal Word – An indication of the acute human toxicity of a pesticide product. All pesticides must carry a signal word, in large letters, on the front panel of the pesticide label. Signal word options are DANGER—POISON (with a skull and crossbones symbol ☠), DANGER, WARNING, and CAUTION. The signal word is based on the acute toxicity and properties of the entire contents of a formulated pesticide, not just the toxicity of the active ingredient.

Slurry – A thick liquid mixture (suspension) of solids in a liquid. An example is making a "paste" with a wettable powder and water before further dilution.

Soil Permeability – A property of soil that allows liquids or gases to pass

through. The more permeable a soil is, the faster water will flow through it.

Soluble/Solubility – The ability of a pesticide to dissolve in another substance, usually a liquid. Highly water-soluble pesticides are more likely to move in solution into water systems.

Solution – Homogeneous (uniform) mixture of two or more substances. Liquid solutions are transparent and do not separate (ex. form layers) if allowed to sit.

Solvent – A liquid that will dissolve a substance and form a true solution. Common solvents include water, acetone, refined oil, and alcohol.

Special Local Need (SLN) Registration – A registration, also known as a 24(c) registration, that allows states to expand or limit the uses of federally registered pesticides within their jurisdictions. It is a good option to allow the use of pesticides on regional crops, to manage localized pest problems, or both. Some SLNs permit you to use a pesticide on a site not listed on the federal label. Others may alter the use directions of federally registered products to accommodate conditions in a certain area.

Spot Treatment – An application to a small, localized area. In some cases, spot treatment involves treating individual pests, such as thistles in a pasture or a yellow jacket nest, while avoiding nontarget organisms.

Spray Volume – The amount of finished pesticide mixture to be applied per unit area.

Stolon – An aboveground runner or rooting structure found in some species of plants. Many grasses spread by stolons.

Supplemental Labeling – A term used by EPA for labeling that describes newly approved uses or other changes, such as reduced and/or increased preharvest intervals, added since the last accepted master label was reviewed and approved by the agency. These are partial labels distributed with the product by a registrant or a distributor. Since supplemental labels are partial labels, they must bear a statement referring the user to the product label for complete directions, precautions, and a statement notifying the user that the labeling must be in his or her possession. Both the product label and the supplemental labeling are required to safely and effectively apply the product for its supplemental use.

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

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

Surfactant – A surface-active ingredient that alters the dispersing, spreading, or wetting properties of spray droplets. Surfactants are one type of adjuvant.

Suspension – A substance that contains undissolved particles mixed throughout a liquid. Suspensions are cloudy or opaque. They will usually separate (ex. form layers) without agitation or some other treatment. An emulsion is a type of suspension.

Swath – The area treated by application equipment in one pass.

Swath Width – Side-to-side measurement of the band or strip of pesticide released by application equipment.

Symptom – An undetectable reaction to pesticide poisoning or injury in a person or animal.

Systemic Pesticide – Pesticide that is absorbed and circulated by a plant or animal. For example, a systemic insecticide may be applied to soil, be absorbed by plant roots, be transported throughout a plant, and kill insect pests that feed on its leaves. A systemic herbicide applied to plant leaves will circulate to all parts of the treated plant. It will control biennial and perennial plants with large root systems and food reserves.

Tank Mixing – Combining two or more crop production products (pesticides or fertilizers) in one tank in order to apply them at the same time.

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

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

Temperature Inversion – A weather occurrence in which a layer of warm air traps a layer of cool air near the ground surface. Spray drift under these conditions can be severe.

Threshold – A pest population level that requires action to prevent unacceptable injury or harm.

Tip-and-Pour Dispenser – A built-in measuring device that fills with a given amount of pesticide when the container is tilted.

Tolerance – The maximum amount of pesticide residue that may remain on food or feed at harvest or slaughter.

Toxic – Poisonous.

Toxicity – The measure of a pesticide's ability to cause acute, delayed, or allergic effects.

Turbidity – A measure of water cloudiness caused by suspended particles (ex. undissolved chemicals and soil sediments). Turbid water often appears brown or muddy.

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

Vapor Drift – The airborne movement of pesticide in a gaseous state.

Vascular Plant – A plant that contains conducting tissue, called xylem and phloem, for moving water and nutrients.

Vector/Disease Vector – An organism that carries pathogens (disease organisms) from one host to another.

Vertebrate – An animal with a backbone (ex. a mammal, bird, or reptile).

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

Water-Based Products – Pesticides or other chemicals that use water as the only diluent or carrier.

Water Table – The dividing line between the saturated zone of water underground and the unsaturated rock or soil above it.

Watershed – The land on which water drains into one particular waterway.

Weed – Any plant growing where it is not wanted.

Worker Protection Standard (WPS) – An EPA regulation requiring growers who employ agricultural workers and pesticide handlers to protect them from pesticide exposure. WPS impacts pesticides used in agricultural plant production on farms, in greenhouses and nurseries, and in forestry operations.