General Knowledge: Guidelines for the Safe Use of Pesticides

Guidelines for the Safe Use of Pesticides Learning Objectives

THIS CHAPTER IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR BOTH PRIVATE AND NON-PRIVATE CERTIFIED APPLICATORS GENERAL EXAM.

After studying this section, you should be able to:

- ✓ **Define what a pesticide is and the different types of pesticides.**
- ✓ **Identify the routes of entry for pesticides into the body.**
- ✓ **Describe and follow the components of a pesticide label.**
- ✓ **Give examples of protective clothing and personal protective equipment (PPE) for use by pesticide applicators.**
- ✓ **List the steps necessary to avoid heat stress during pesticide applications.**
- ✓ **Explain what to do in the event of a poisoning.**
- ✓ **Explain procedures for safely mixing, applying, disposing, storing and transporting pesticides.**
- ✓ **Explain how to clean up a pesticide spill.**
- ✓ **Describe pesticide security measures.**
- ✓ **List record-keeping requirements for pesticide applications.**
- ✓ **Explain pesticide stewardship.**
- ✓ **Describe pesticide application equipment and how to calibrate it.**

Introduction to Guidelines for the Safe Use of Pesticides

No one really knows what would happen if farmers were denied the use of pesticides. Agricultural experts and some scientists believe that without pesticides, the production of crops would decrease about 35 percent almost immediately and livestock production would drop at least 25 percent. Even with currently available pesticides, losses in agricultural production and marketing caused by all kinds of pests are estimated at $30 billion annually in the United States, and much more worldwide.

Pests not only adversely affect agricultural productivity, but they impair the health of humans, as well as domestic and wild animals, and they damage the environment.

Pesticides are an important management tool and we must use them wisely, properly and safely.

Pesticide labeling includes the printed material attached to the pesticide container and all supplemental pesticide information that the label references but may not be attached to the pesticide container. The law requires that you read, understand and follow all pesticide labeling.

Without pesticides, we could not commercially produce the high-quality fruits and vegetables that we now enjoy in abundance. Pests not only adversely affect agricultural productivity, but they impair the health of humans, as well as domestic and wild animals, and they damage the environment.

Pesticides efficiently control most public health pests. Scientists estimate that about 30 major human diseases have been reduced or eliminated altogether through the use of insecticides to control pests that carry or transmit disease-causing organisms. Among the diseases suppressed in control campaigns are malaria, equine encephalitis, yellow fever, bubonic plague, Rocky Mountain spotted fever, African sleeping sickness, Lyme disease, West Nile virus and dengue fever. Mosquitoes, biting flies, fleas or ticks spread these major diseases.

Pesticides aid in the commercial production of food, feed and fiber. They are equally important in the control of home garden and landscape pests. In the home, they protect against termites, cockroaches, fleas, bed bugs, lice, mice and rats. We even use pesticides to control fleas, ticks and other pests that attack our pets.

The correct use of pesticides is critically important. Too much of a chemical may damage or kill the plants or animals it was intended to protect, while too little may not provide adequate pest control. Many desirable plants and animals, including humans, can be harmed by the incorrect or careless use of pesticides. We must use them wisely, properly and safely.

Pesticides must be used in strict accordance with the instructions on the product label, which is the printed material that is attached to the container. In some cases, the label may require that applicators refer to additional instructions that are not attached to the container. The label will instruct users where to find the information. The pesticide label and information it references are legal documents according to federal and state laws. Any deviation from the label directions constitutes a misuse and subjects the user to either civil or criminal penalties. These laws also require that all pesticides be classified as either restricted-use or general use products. **Restricted-use pesticides may be used only by certified applicators or by persons working under the direct supervision of a certified applicator.** Certified applicators have demonstrated, by written or oral examination, competence in using and handling pesticides. General use materials are available to anyone without restrictions unless otherwise designated on the label.

Section 408 of the Federal Food, Drug and Cosmetic Act authorizes the EPA to set tolerances or maximum residue limits for pesticide residues for each

pesticide on each edible crop. These tolerances vary for different crops, even with the same pesticide. Safe residue tolerances are determined through extensive residue analyses for every pesticide applied to a food or feed crop.

Strict pesticide laws and regulations allow the widespread use of synthetic chemicals to produce food and fiber, while protecting our health, preserving the structures we live in, and preventing damage to the environment. Pesticide laws and regulations are designed to protect the general public, crops, livestock, users, workers, and the environment from the negative side effects of pesticides.

What is a Pest?

Pests are living organisms that compete with people for food supply or fiber, damage structures or personal property, injure ornamental plants, damage livestock or pets, or transmit diseases to people or animals. Pests include animals such as insects, spiders, ticks, mites, rats, birds, snails, slugs and nematodes, or plants, such as weeds, or fungi, such as rusts and mildews. Micro-organisms, such as bacteria and viruses, can be pests as well.

What is a Pesticide?

A pesticide is any substance or mixture of substances intended to prevent, destroy, repel or mitigate any pest or any substance or mixture of substances used as a plant regulator, defoliant or desiccant.

Pesticides are split into two main categories by FIFRA:

- **General Use Pesticides (GUP)** are those pesticides which will not generally cause unreasonable adverse effects on the environment when used in accordance with its labeling. They are available to everyone.
- **Restricted-Use Pesticides (RUP)** are those which may generally cause unreasonable adverse effects on the environment, including injury to the applicator. Applications of these pesticides must be made by a certified applicator or under the direct supervision of a certified applicator.

Pesticide products contain both active and inert ingredients.

Active ingredients are the chemicals in a pesticide product that act to control the pests. Active ingredients must be identified by name on the pesticide product's label, together with its percentage by weight. There are several categories of active ingredients:

- **Conventional**, which are all ingredients other than biological pesticides and antimicrobial pesticides.

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certified applicator.

Active ingredients are the chemicals in a pesticide product that act to control the pests.

Inert ingredients are chemicals, compounds and other substances that play key roles in pesticide effectiveness and product performance.

- **Antimicrobial**, which are substances or mixtures of substances used to destroy or suppress the growth of harmful micro-organisms, whether bacteria, viruses or fungi on inanimate objects and surfaces.
- **Biopesticides**, which are types of ingredients derived from certain natural materials.

Pesticide products contain at least one active ingredient and other intentionally added inert ingredients. The inert ingredients are chemicals, compounds and other substances, including common food commodities (e.g., certain edible oils, spices, herbs) and some natural materials (e.g., beeswax, cellulose).

Inert ingredients play key roles in pesticide effectiveness and product performance. These functions include:

- Acting as a solvent to help the active ingredient penetrate a plant's leaf surface.
- Improving the ease of application by preventing caking or foaming.
- Extending the product's shelf-life.
- Improving safety for the applicator.
- Protecting the pesticide from degradation due to exposure to sunlight.

The name “inert” does not mean non-toxic. All inert ingredients must be approved by EPA before they can be included in a pesticide.

Under federal law, the identity of inert ingredients is confidential business information. In general, only the total percentage of all inert ingredients is required to be on the pesticide product label. The law does not require manufacturers to identify inert ingredients by name.

Types of Pesticides

Pesticides can be classified according to their function. A common classification for pesticides is based on the pests they control.

- **Avicides:** Control pest birds.
- **Algicides:** Control algae in lakes, canals, swimming pools, water tanks and other sites.
- **Antifouling agents:** Kill or repel organisms that attach to underwater surfaces, such as boat bottoms.
- **Antimicrobials:** Kill micro-organisms, such as bacteria and viruses.
- **Attractants:** Materials that attract pests; for example, by luring an insect or rodent to a trap or bait. Food is not considered a pesticide when used as an attractant.
- **Bactericides:** Destroy bacteria.

- **Biopesticides:** Biopesticides (also called biorational pesticides) are a certain type of pesticides derived from natural materials such as animals, plants, bacteria and certain minerals.
- **Biocides:** Kill micro-organisms.
- **Disinfectants and sanitizers:** Kill or inactivate disease-producing micro-organisms on inanimate objects.
- **Fumigants:** Produce gas or vapor intended to destroy pests in buildings or soil.
- **Fungicides:** Kill fungi, including blights, mildews, molds and rusts.
- **Herbicides:** Kill weeds and other undesirable plants that are growing where they are not wanted.
- **Insecticides:** Kill insects and other arthropods, such as ticks, spiders or centipedes.
- **Miticides (also called acaricides):** Kill mites that feed on plants and animals.
- **Microbial pesticides:** Micro-organisms that kill, inhibit or outcompete pests, including insects or other microorganisms.
- **Molluscicides:** Kill snails and slugs.
- **Nematicides:** Kill nematodes (microscopic, worm-like organisms that feed on plant roots).
- **Ovicides:** Kill eggs of insects and mites.
- **Pheromones:** Biochemicals used to disrupt the mating behavior of insects.
- **Piscicides:** Control pest fish.
- **Predacides:** Control vertebrate predator pests.
- **Repellants:** Repel pests, including insects, such as mosquitoes, and birds.
- **Rodenticides:** Control mice, rats and other rodents.

Pesticides can be categorized by the pests they control.

Although not usually thought of as pesticides, the following classes of chemicals are considered pesticides and are also regulated under both federal and state pesticide laws:

- **Defoliants:** Chemicals that cause leaves or foliage to drop from a plant, usually to facilitate harvest.
- **Desiccants:** Chemicals that promote drying of living tissues, such as unwanted plant tops.
- **Insect growth regulators:** Chemicals that disrupt the molting, maturity from pupal stage to adult stage, or other life processes of insects.
- **Plant-growth regulators (PGRs):** Substances (excluding fertilizers and other plant nutrients) that alter the normal or expected growth, flowering or reproduction rate of plants.

Defoliants, desiccants and growth regulators are also considered pesticides.

Biopesticides, although "natural," can still be just as harmful to humans, animals, plants and the environment as chemical pesticides.

Even slightly toxic pesticides can be hazardous to humans, non-target animals and the environment, if used in a manner inconsistent with the label directions.

Some pesticides, such as fumigants (gases), give nonspecific control of a wide variety of pests. Others may kill a pest at a certain stage of its development. Ovicides, for example, kill only the eggs of insects and related arthropods. Manufacturers of pesticides spend considerable time and money developing and testing new products before releasing them. Companies commonly test as many as 20,000 different compounds before finding a marketable product. Costs of developing a new pesticide and bringing it to market often exceed $80 million and may take more than 10 years.

Biopesticides are certain types of pesticides derived from such natural materials, as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations. Biopesticides fall into three major classes:

- Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances that interfere with mating, such as insect sex pheromones, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.
- Microbial pesticides consist of a micro-organism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds and other fungi that kill specific insects.

  The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bt ingredients control moth larvae (caterpillars) found on plants, other Bt ingredients are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.
- Plant-Incorporated-Protectants (PIPs) are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein

and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

Conventional pesticides, also referred to as **chemical pesticides**, are all active ingredients other than biological pesticides and antimicrobial pesticides. Conventional active ingredients are generally produced synthetically, and like all pesticides they prevent, mitigate, destroy or repel any pest or act as a growth regulator, desiccant or defoliant.

Pesticide resistance occurs when a population of pests no longer responds to the proper application of a pesticide. Repeated applications of the same pesticide may result in a pest population that is resistant to the active ingredient. Resistance reduces pesticide choices and increases pest management costs. The following tactics are used to manage and prevent pesticide resistance:

- Rotate pesticides with different modes of action.
- Tank-mix pesticides with different modes of action.
- Don't apply pesticides at rates below the recommended label rate.
- Use IPM. Use other management methods when appropriate, including mechanical or physical removal of pests.

Chemical Insecticides: Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors. They are classified based on their structure and mode of action. Many chemical insecticides are derived from a common source or production method. The most common insecticides are:

- **Organophosphate Insecticides:** These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they are usually not persistent in the environment.
- **Carbamate Insecticides:** These insecticides also affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates.
- **Organochlorine Insecticides:** These substances were commonly used in the past, but many have been removed from the market due to their

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Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors.

Herbicides are pesticides used to kill or control vegetation.

Synthetic auxins are more effective at controlling broadleaf weeds and trees than grasses.

health and environmental effects and their persistence in the environment (examples are DDT, chlordane).

- **Pyrethroid Insecticides:** These pesticides were developed as synthetic versions of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system.

Chemical Herbicides: Herbicides are pesticides used to kill or control vegetation. To be effective, herbicides must reach a living site to disrupt a vital process or structure. Herbicide mode of action is the way the herbicide affects a vital metabolic plant process. There are a number of modes of action, and they occur at the tissue or cellular level in the plant. Using the same herbicide over and over can result in resistance to that herbicide. To prevent herbicide resistance, it is important to alternate herbicides with different modes of action when making multiple herbicide applications.

- **Synthetic auxins** interfere with cell division and cell enlargement. The symptoms of these types of herbicides are downward twisting and curving stems and puckered, twisted or curling leaves, called epinasty. The plant dies as growth stops and mature tissues undergo cell division, choking the vascular tissues. While the symptoms may appear within hours, the plant dies slowly, usually in three to four weeks. Synthetic auxins are translocated through the plant and are usually applied to the foliage. Control occurs at low volumes of spray. Drift is a concern with these herbicides, as very low volumes can cause damage. Synthetic auxins are more effective at controlling broadleaf weeds and trees than grasses. Some are persistent in the soil.
- **Photosynthesis inhibitors** cause the plant leaves and stems to stop producing food. The plant turns white and dies. They may be applied to the soil or directly onto foliage. They do not appear to affect the roots. Photosynthesis inhibitors can persist in the soil, depending on the formulation.
- **Cell membrane disruptors** cause the cell contacts to leak. Plants wilt, dry, yellow and eventually die. Most of these herbicides are nonselective, contact herbicides. Good coverage is required for control. Injury can be visible in few hours to a few days, depending on the formulation.
- **Cell division disruptors** inhibit new cell formation. This causes the plant to stop growing and prevents the development of a seed head, which prevents reproduction. These herbicides do not readily translocate from the leaves on which they are applied. They are not persistent in soils.

- **Root and shoot inhibitors** prevent the growth of roots and shoots or germinating seeds and small seedlings by disrupting cell division. These herbicides have a very limited ability to translocate in plants, so they do not control established weeds. They are generally soil applied and have limited mobility in the soil. They require precipitation or irrigation water to activate in the soil.
- **Bud development inhibitors** prevent bud development when applied to woody plants late in the growing season, but before leaves start changing colors. The effects are not seen until the following spring, when the woody plants fail to resume growth. These herbicides move only from the leaves to the buds, so they do not translocate in the plants. They have no soil activity and do not injure grasses at normal application rates.
- **General metabolic inhibitors** are those herbicides that interfere with enzyme production or activity. The enzymes normally help in amino acid production, which form proteins in the plants. The elimination of protein production eventually eliminates the plant. Symptoms show up slowly in the targeted plants, sometimes taking a week or more to manifest. Some of these types of herbicides have residual soil activity and some are not active in the soil at all.
- **Pigment inhibitors** cause the destruction of chlorophyll in the plants. Plants die because the leaves can no longer produce food. These herbicides are sometimes applied as preemergence herbicides and have limited soil mobility. They are considered nonselective herbicides, but may not control deep-rooted, established plants due to limited soil mobility.

Herbicide effectiveness is dependent on both herbicide uptake rate and quantity and herbicide movement in the plant.

Herbicide uptake rate and quantity: Herbicides are applied either to the soil, where they interact with the roots, or applied to the foliage of the plant (the above-ground stems, leaves, etc.).

- **Herbicide application rates** influence the effectiveness of an herbicide application. Different weed species and stages of growth may require different rates for the product to be effective. Pesticide labels list the rate requirements. Read and follow them.
- **Equipment must be properly calibrated** in order to deliver the proper amount of herbicide to the target plant.
- **Soil-applied materials**, such as preemergence herbicides, generally dissolve in the soil water and enter the plant via the plant's roots. Absorption of the herbicide takes place across the cell walls of the root hairs. The plant must be actively growing, so non-germinating seeds are

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The cuticle is the waxy covering found on all leaves. The thickness of this waxy coating varies for each plant species and can be thicker within the same species on plants growing in dry, hot climates.

Contact herbicides kill only the plant parts they touch, so they will kill the leaves and stems, but not necessarily the roots.

Systemic herbicides are absorbed through the leaves or roots and move freely throughout the plant.

not affected by these herbicides. To remain effective, the herbicide barrier formed in the soil must not be disturbed.

- **Foliar-applied herbicides** are sometimes difficult to get into the plant through the shoots and leaves. The major barrier to herbicide uptake is the cuticle. The cuticle is the waxy covering found on all leaves. The thickness of this waxy coating varies for each plant species and can be thicker within the same species on plants growing in dry, hot climates. Many plants have leaf hairs, which may hold the herbicide spray droplets above the surface of the leaves where they are not readily absorbed. Both the leaf cuticle and leaf hairs can cause herbicides to bead up and run off or evaporate. The addition of wetting agents or oils can help spread out herbicide solution, cover the foliage and penetrate the cuticle, but they are an added expense. Often the wetting agents or oils are included in the product. If they are not included, follow label instructions to add them.
- **Spray volume** can affect the effectiveness of an herbicide application. Adjust the spray volume to minimize spray runoff or spray drift while maximizing coverage and penetrating the crop canopy.
- The amount of **foliage or shoot growth** can affect the effectiveness of an herbicide application. There must be enough foliage to intercept the spray application. For grasses, this generally means waiting until there are three to five blades. For broadleaf plants, it means waiting until the leaves are one-half inch to one inch in diameter.
- In general, the **retention time** of water-soluble herbicides on plants must be six to 12 hours to maximize absorption. Oil-soluble herbicides require less time, often as little as one hour. Do not apply herbicides during rain, when rain is expected, or when irrigation will occur before the required retention time has passed.

Herbicide movement in the plant: To be effective, herbicides must reach a living site to disrupt a vital process or structure. Herbicides are subdivided based on how they move in plants.

- **Selective herbicides:** Herbicides that kill specific types of plants.
- **Nonselective herbicides:** Herbicides that kill all types of plants.
- **Contact herbicides:** Herbicides with little to no movement in plants. They kill immediately after penetration, usually within hours. They require thorough coverage. They kill only the plant parts they touch, so they will kill the leaves and stems, but not necessarily the roots. For this reason, they are more effective against annual weeds to kill plants and prevent seed production, and not very effective against biennial or perennial weeds whose roots remain and produce more above-ground plant parts at a later date.

- **Systemic herbicides:** Herbicides that are absorbed through the leaves or roots and move freely throughout the plant. Application to part of the plant will kill the entire plant. Systemic herbicides are effective against most plants and are recommended for perennials. They take time to be effective and may be soil- or foliage-applied. These types of herbicides can move through the plant tissues in two basic ways: through the water-conducting tissues or through the food conducting tissues.
    - Herbicides that move through the water-conducting tissues, called apoplastic movement: Water movement in most plants is upward only. Water generally is not absorbed by the leaves and transmitted down to the roots, but it moves from the roots up to the leaves. These herbicides are generally soil applied. If they are foliar applied, the herbicide will act as a contact herbicide, only killing the plant parts they touch. The older leaves are affected first.
    - Herbicide movement through the food conducting tissues, called symplastic movement: These types of herbicides move through the plant to the points of active growth. They are generally applied to the leaves and move through the plant to the roots. A few are soil applied. They are very effective at killing the roots and can be used on annual, biennial and perennial weeds.
- Preemergence herbicides are applied to the soil and must be incorporated either mechanically or by irrigation or precipitation. Timing is especially important. Most preemergence herbicides are applied at a time of year when precipitation will help incorporate the herbicide and weed seeds are likely to germinate.

Toxicity of Pesticides

All pesticides must be toxic or poisonous to kill the pests they are intended to control and, thus, are potentially hazardous to people and animals, as well as to pests. Since pesticide toxicity varies widely, it is very important for persons who use pesticides, or those who regularly come in contact with pesticides, to have a general knowledge of the relative toxicity of the products that are being used.

The toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits and dogs) to different dosages of the active ingredient in a pesticide product. The active ingredient is that portion of a pesticide formulation that is toxic to the pest. Toxicity may be acute (immediate) or chronic (manifests over time).

The toxicity of each active ingredient is determined by at least three methods:

All pesticides must be toxic or poisonous to kill the pests they are intended to control and thus are potentially hazardous to people and animals as well as to pests.

The lower the LD 50 or LC 50 of a pesticide product, the greater the toxicity of the material to people and animals.

- oral toxicity, in which the chemical is fed to test animals;
- dermal toxicity, in which the skin is exposed to the chemical and the absorption through the skin and accumulation in the bloodstream is measured; and
- inhalation toxicity, in which test animals breathe the chemical's vapors.

In addition, the effect of the chemical as an irritant to the eyes and skin is examined under laboratory conditions.

Acute toxicity is usually expressed as LD 50 (Lethal Dose 50) and LC 50 (Lethal Concentration 50). This is the amount or concentration of a toxicant (the active ingredient) required to kill 50 percent of a test population of animals under a standard set of conditions. Acute toxicity values of pesticides, based on a single dosage, are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LD 50 and LC 50 values are useful in comparing the acute toxicity of different active ingredients, as well as different formulations of the same active ingredient. The lower the LD 50 or LC 50 of a pesticide product, the greater the toxicity of the material to people and animals. Pesticides with high LD 50s have the least acute toxicity when used according to the label directions.

The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Any harmful effects that occur from small doses repeated over time are termed chronic effects. Some of the suspected chronic effects from exposure to certain pesticides include birth defects, production of tumors, blood disorders, and neurotoxic effects (nerve disorders). The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than acute toxicity.

Pesticide products are categorized on the basis of their LD 50 or LC 50 values. Those pesticides that are classified as having high acute toxicity, either oral, dermal or inhalation toxicity, must have the signal words DANGER and POISON (in red letters) and a skull and crossbones symbol prominently displayed on the package label. Effective December 31, 1984, the Spanish equivalent for the word DANGER, PELIGRO, must also appear on the labels of highly toxic chemicals. As little as a few drops of such a material taken orally could be fatal to a 150-pound person. Acute (single dosage) oral LD 50s for pesticide products in this group range from a trace to 50 mg/kg.

Pesticide products considered to have moderate acute toxicity must have the signal word WARNING (AVISO in Spanish) displayed on the product label. Acute oral LD 50s range from 50 to 500 mg/kg. From 1 teaspoon to 1 ounce of such a material could be fatal to a 150-pound person.

Pesticide products classified as having slight acute toxicity or that are relatively nontoxic are required to have the signal word CAUTION on the pesticide label. Acute oral LD 50 values for CAUTION signal word pesticides are greater than 500 mg/kg.

Pesticides formulated in petroleum solvents or other combustible liquids must also include the precautionary word FLAMMABLE on the product label.

Despite the fact that some pesticide products are considered to be only slightly toxic or relatively nontoxic, all pesticides can be hazardous to humans, non-target animals and the environment if used inconsistently with the instructions on the product label. Use the pesticide only as recommended by the manufacturer. ***As the applicator, you are legally responsible if a pesticide is misused in any way*.**

Signal Word	Level of Acute Toxicity
Caution	The pesticide is **slightly toxic** if eaten, absorbed through the skin or inhaled, or it causes **slight** eye irritation.
Warning	The pesticide is **moderately toxic** if eaten, absorbed through the skin or inhaled, or it causes **moderate** eye irritation.
Danger	The pesticide is **highly toxic** through **at least one route** of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.
Danger-Poison (with skull and crossbones)	The pesticide is **highly toxic** through **more than one route** of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.

Routes of Entry

There are three principal ways a pesticide can enter the human body:

- through the skin (dermal)
- through the lungs (inhalation)
- through the mouth (oral)

Dermal route: The skin is the most important entry route of most pesticides into the body. Approximately 97 percent of all exposure to pesticides during a spraying operation is dermal. To protect yourself, keep pesticides away from the underarms and groin. These areas absorb pesticides very rapidly. Always wash your hands BEFORE using the restroom if you are applying pesticides. Don't sit on pesticide containers or contaminated seats. A small amount of chemical allowed to remain on the skin can be absorbed into the

The three most common routes of entry of pesticides into the human body are:

- **Dermal – through the skin**
- **Inhalation – through the lungs**
- **Oral – through the mouth**

Approximately 97 percent of all exposure to pesticides during a spraying operation is dermal.

After applying pesticides, always wash your hands and face before eating, drinking chewing gum, putting on makeup, using tobacco, smoking or vaping.

Protect your eyes and cover any open wounds when handling pesticides to prevent pesticides from entering the body through these routes.

It is your legal responsibility to read, understand and follow pesticide label directions.

body and cause pesticide poisoning. Wear protective clothing when handling pesticides. Follow application and equipment cleanup procedures, and always wash thoroughly immediately after an application to remove all traces of a pesticide and prevent further absorption through the skin. It is also important to change into clean clothing.

Inhalation route: Protect the lungs from toxic dusts, vapors, gases (fumigants) and spray particles while handling and applying pesticides, especially in confined areas. Once breathed into the lungs, pesticides enter the bloodstream very rapidly and completely. Cartridge or canister-type respirators provide respiratory protection for most types of outdoor applications when fitted correctly. When fumigants or highly toxic pesticides are used in confined areas, it may be necessary to use a self-contained air supply for safety.

Oral route: The most serious oral exposure occurs when liquid concentrates splash into the mouth during mixing, or someone unknowingly consumes a pesticide. A certain amount of chemical may be swallowed when you eat, drink or smoke with contaminated hands, or you rub your mouth on contaminated clothing, or you lick your lips. Since the intestinal tract rapidly and completely absorbs many pesticides, always wash your hands and face thoroughly before eating, drinking, chewing gum, putting on makeup, using tobacco, smoking or vaping.

There are several other routes of entry that are generally not as important as the dermal, inhalation and oral routes. However, under certain conditions and with certain pesticides, absorption through the eyes or through skin abrasions can be significant and particularly hazardous. Eyes are very sensitive to many pesticides and can absorb surprisingly large amounts of pesticide, considering their size. The eyes and any open wounds should be protected when handling pesticides.

Reading the Pesticide Label

Pesticides are poisons designed to kill or repel animals or plants that are considered pests. Pesticides can have unintended effects on people, pets, wildlife, desirable plants and the environment. Most pesticide accidents result from careless use. Lack of knowledge about pesticides and improper handling are very serious. When using pesticides, do everything possible to limit your exposure, and that of other employees and the environment, to an absolute minimum.

All pesticides must bear labels that provide the pesticide user with information about the product. In fact, the information on the label is a legal

requirement. Read and make sure that you understand the information presented on a product label before you use it. Explore alternatives to applying pesticides and select the least toxic methods available. If pesticides are necessary, select the least toxic products first.

Pesticide manufacturers are required by law to put specific information on the label. The label must include the brand or trade name of the product; a common chemical name, if one has been approved; and the full chemical formula of the active ingredient. The percentage or amount of active ingredient in the formulation must also be included, as well as information on the pests to be controlled, the crops or areas to be treated, the rate or amount of material to be used, mixing and application instructions, safety information (including signal words, proper equipment and clothing, first aid instruction and antidotes), possible hazards to wildlife and the environment, storage and disposal instructions, re-entry intervals following application, days to harvest if the pesticide will be used on an edible crop, a restricted-use statement if applicable, a statement of net contents, EPA registration and establishment numbers, and the name and address of the manufacturer.

There are two types of statements on a pesticide label: **mandatory statements** and **advisory statements**. Statements that include the words "**must**, **do** or **do not** are mandatory directions for use. These statements direct the user to a specific action. Other examples of mandatory statements are "apply immediately after mixing" or "wear chemical-resistant gloves." Advisory statements are more descriptive. They describe actions that will keep pesticide application risks low and effectiveness of the application high. For example, "applying the product immediately after preparation will help ensure that it is in suspension. If application is delayed, agitate to remix the product."

The pesticide label provides a wealth of information: **READ IT CAREFULLY!** The following gives an overview of the label requirements.

Nine Required Parts of a Pesticide Label

1. INGREDIENT STATEMENT: The label of a pesticide must give the name and percentage by weight of each active ingredient and the percentage by weight of all inert (other) ingredients. Labels must list chemical and/or common names of each active ingredient. The chemical name is a complex name that identifies the chemical components of the pesticide ingredients. Common names are shortened versions of the complex chemical names.
2. NAME, BRAND OR TRADEMARK: The name, brand or trademark under which the product is sold must be on the front panel of the label. The brand or trade name is the one used in advertising. The brand name

Explore alternatives to applying pesticides. If pesticides are necessary, select the least toxic products first.

The nine required parts of a pesticide label are:

1. **Ingredient statement**
2. **Name, brand or trademark**
3. **Precautionary statements**
4. **Directions for use**
5. **Name and address of manufacturer**
6. **Net contents**
7. **EPA registration number**
8. **EPA establishment number**
9. **Use classification**

Certain information MUST appear on the <u>front panel</u> of a pesticide label:

- **Brand name**
- **Use classification**
- **List of ingredients**
- **"Keep Out of Reach of Children" statement**
- **Signal word**
- **First aid statement**
- **Net contents or net weight**

Unfortunately, there is no absolute standard for <u>where</u> on the front panel of the pesticide label this information is to be placed.

READ THE LABEL CAREFULLY.

does not give an indication of what active ingredient the product contains and, therefore, is not a good method for identifying a pesticide in case of a poisoning. Refer to the chemical name or common name in case of poisoning or when using a reference manual to seek additional information about the product, how to apply it or about treatment for poisoning by the active ingredient.

3. PRECAUTIONARY STATEMENTS: Precautionary statements inform the user of the proper precautions to take to protect self, others, domestic animals and the environment from harmful effects of pesticide exposure. Hazard statements help the user apply the pesticide correctly. Precautions must include signal words to reduce hazards to humans, as well as child hazard warnings. They may discuss additional precautions.
    a. The **Human Hazard Signal Words** (DANGER, WARNING, CAUTION) indicate the level of acute toxicity of the pesticide: DANGER—A taste to a teaspoonful taken by mouth may kill an average-sized adult. WARNING—A teaspoonful to an ounce taken by mouth may kill an average-sized adult. CAUTION—An ounce to more than a pint taken by mouth may kill an average-sized adult.
    b. The **Child Hazard Warning** (KEEP OUT OF REACH OF CHILDREN) must be on the front panel of the pesticide product label.
    c. The **Statements of Practical Treatment** can include information on:
        i. Signs and symptoms of poisoning
        ii. First aid
        iii. Antidotes
        iv. A note to physicians in the event of a poisoning
    d. The **Hazards to Humans and Domestic Animals** statements provide information about routes of pesticide exposure to humans (i.e. mouth, skin, lungs) and specific actions to take to prevent pesticide exposure (i.e. protective clothing, facial masks).
    e. The **Environmental Hazards** statement helps protect wildlife from a hazardous pesticide. The label must bear special toxicity statements such as "This product is highly toxic to birds" (or to fish). General environmental precautions may include: "Do not apply directly to water," or "Do not contaminate water, food or feed by storage and disposal of the pesticide."
    f. The **Physical or Chemical Hazards** warning statements inform users about the flammability or explosive characteristics of the pesticide.
4. DIRECTIONS FOR USE: Directions for use provide important information about the proper use, storage and disposal of the pesticide product. The directions will indicate:
    a. How much of the product to use and when to use it (MORE IS <u>NOT</u> BETTER!).

b. The crop, animal or site the product claims to protect. You must verify that the pesticide label does not prohibit the use of the product to control the target pest
c. The proper equipment to be used for the application.
d. Mixing directions, if they apply.
e. The proper methods of storage and disposal of the pesticide product that are necessary to follow in order to prevent contamination and accidental exposure.

5. NAME AND ADDRESS OF MANUFACTURER: The name and address of the manufacturer or distributor must be on the label. This is the contact for additional information not provided on the label.
6. NET CONTENTS: The net contents indicate how much of the product is in the container. This can be listed in pounds per gallon, gallons, quarts or pints for liquids, or in pounds and ounces for dry formulations.
7. EPA REGISTRATION NUMBER: Pesticide products must bear an EPA registration number that indicates the federal government has approved the pesticide labeling information.
8. EPA ESTABLISHMENT NUMBER: The establishment number identifies the facility that produced the product. If anything should go wrong, the facility that made the product can be traced and contacted.
9. USE CLASSIFICATION: The EPA classifies pesticides as either "General Use" or "Restricted-Use." Restricted-use pesticides may only be sold to and used by certified pesticide applicators or persons under the direct supervision of a certified applicator. A statement indicating that a pesticide is a "Restricted-Use" product must appear at the top of the front panel of the label. "General Use" pesticides do not require certification or special label designations.

IF YOU CHOOSE TO USE A PESTICIDE PRODUCT—REMEMBER:

- Read the label completely. The label is the legal basis for use of the product. Heed the warnings by taking all precautions listed on the label.
- Use the pesticide only if it is really needed. Purchase and use only the amount of pesticide needed. Apply the pesticide at the lowest rate that is effective. It is against the law to exceed the maximum application rate on the label.
- In the event of a pesticide poisoning, you can call the following hotlines to obtain further information:

NATIONAL POISON CENTER HOTLINE: 1-800-222-1222

NATIONAL PESTICIDE INFORMATION CENTER (NPIC): 1-800-858-7378

TOLL FREE, 24 HOURS A DAY

In the event of pesticide poisoning, call the following for further information:

NATIONAL POISON CENTER HOTLINE: 1-800-222-1222

NATIONAL PESTICIDE INFORMATION CENTER (NPIC): 1-800-858-7378 TOLL FREE, 24 HOURS A DAY.

Failure to follow the instructions on a pesticide label can result in serious pesticide accidents and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document.

It is not uncommon to find some active ingredients formulated in several different ways. This is done to make the chemical more stable, suitable for application with modern equipment, or in some cases, more attractive to a pest (i.e., bait).

Baits may be attractive to non-target animals, including children and pets. Follow label directions to place baits in a manner that will limit non-target

It is essential that the applicator follow all instructions in the use of pesticides to avoid injury or damage to themselves, other persons and the environment. Failure to follow the instructions on a pesticide label can result in serious pesticide accidents and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document. The user is liable for personal injury, crop damage or pollution incurred through misuse of a pesticide.

If you do not understand the directions on the label, ask your supervisor, pesticide dealer or salesperson, vocational agricultural instructor, or the Nevada Department of Agriculture for assistance.

Pesticide Formulations and Packaging

Formulation of a pesticide is the mixing of an active ingredient with some type of carrier or diluent, either a liquid or solid material. Pesticides are available in a wide variety of formulations. It is not uncommon to find some active ingredients formulated in several different ways. This is done to make the chemical more stable, suitable for application with modern equipment, or in some cases, more attractive to a pest (i.e., bait). Undiluted active ingredients are rarely used to control pests. Pesticides are available as aerosols, baits, dusts, emulsifiable concentrates, flowables, fumigants, granules, soluble powders, solutions, water-dispersible granules and wettable powders.

Aerosols (A) are liquids that contain the active ingredient in solution, packaged in a pressurized container. “Bug bombs” contain a small amount of active ingredient mixed with a propellant that forces the contents from the can in a spray or mist. They are available for home garden and household use (12- to 16-ounce cans) and commercial use (4- to 10-pound cylinders). They are convenient to use since no measuring or mixing of ingredients is required. They are ready to use as purchased and are easy to store. **Never attempt to puncture or burn aerosol cans because they may explode and produce shrapnel.**

Baits (B) are composed of an edible substance, or some other attractant, mixed with a poisonous active ingredient. The bait either attracts pests or is placed in a location where the pest animal will find it. The pest must eat the bait to be killed. They are used to control certain insects, snails and slugs, birds, rodents, and other pest mammals. Most bait formulations contain a low percentage of the active ingredient and are often used in kitchens, gardens, granaries, or other food-storage and food-processing facilities and refuse disposal areas. A major advantage is that baits can be placed exactly where, and only when, needed and can be removed after use. However,

baits may be attractive to children and pets. Domestic animals and wildlife may be killed by these formulations. In order to protect non-target species, any bait used for rodent control must be applied below ground in rodent burrows or in bait stations. At times, poisonous baits do not control the target pest because other sources of food are available and more attractive.

damages.

Dusts (D) are ready to use as purchased without additional mixing. They contain an active ingredient plus a finely ground, inert substance such as talc, clay, nut hulls or volcanic ash. The amount of active ingredient usually ranges from 0.5 to 10 percent. Dusts are easy to handle, and low-cost application equipment is available. They are relatively expensive for the amount of active ingredient in the total formulation; there are often problems with drift; they may be more irritating to the applicator than sprays; often little active material reaches the target host; and rain and wind easily remove dust formulations from treated surfaces. Dusts are recommended mainly for use around the home and garden but not for large-scale use on the farm.

Emulsifiable concentrates (EC) are liquid formulations with the active ingredient dissolved in one or more petroleum solvents. An emulsifier is added so that the material will mix readily with water. Emulsifiable formulations usually contain between 2 and 8 pounds of active ingredient per gallon. EC formulations (ideal for the home gardener) are easy to measure and mix. They are not abrasive and will not plug screens and nozzles. There are, however, several shortcomings associated with the use of these materials. Because of the high concentration of active ingredient(s) in EC formulations, there may be considerable hazard to the applicant and other persons if the product is accidentally spilled on the skin or consumed. They should never be stored under excessively high temperatures or where the liquid can freeze. Most of these formulations are highly flammable because of the petroleum solvent. Compatibility with other products, as well as phytotoxicity (toxicity to plants), of EC materials may occasionally be a problem. Most liquid concentrates of this type can cause rubber hoses, gaskets and pump parts to deteriorate, and some formulations are detrimental to painted surfaces.

Most emulsifiable concentrates are highly flammable, as the active ingredient is mixed with a petroleum solvent.

Flowables (F) consist of finely ground solid particles suspended in a liquid carrier. The solid in a flowable is similar to the active ingredient in a wettable powder, except that the solid is formulated to stay in suspension in the liquid. Normally, flowables contain 4 or more pounds of active ingredient per gallon. Flowables can be mixed readily with water and usually do not clog nozzles. They need only moderate agitation to remain in suspension. The principal disadvantage of flowables is the hazard associated with handling

Fumigants are the most hazardous of all pesticide formulations.

Applications of fumigants require a separate category certification for all pesticide applicators.

Granules and pellets are ready to use as purchased and require no further mixing.

and storing undiluted concentrated materials. The same precautions should be observed with flowables as with emulsifiable concentrates.

Fumigants (LG) are poisonous gases. Applications of fumigants require a separate category certification for all pesticide applicators. Many fumigants are formulated as liquids under pressure and become gases when released. They are used to control pests in soil, ship holds and closed structures, such as buildings, granaries and greenhouses. Fumigants kill insects, weed seeds, nematodes, rodents, fungi and other pests. Fumigants are nonselective and can penetrate into any area that is not airtight. They are the most hazardous of all pesticide formulations. Use extreme care and appropriate protective equipment, including respiratory protection, when applying fumigants. Often fumigants are formulated with a foul-smelling or irritating warning gas, but this gas, too, is frequently highly toxic. Most fumigants can severely irritate or burn the skin, eyes and lungs, so they are not recommended for use by the homeowner. Aerosols, smokes, mists and fogs are finely dispersed particles and, thus, are not considered fumigants. All fumigants are classified as Restricted-Use Pesticides.

Granules and pellets (G) are dry, ready-to-use materials normally containing from 2 to 15 percent active ingredient. Most are prepared by applying the active ingredient as a liquid to a coarse, porous, solid material such as clay or ground corn cobs. Granules and pellets are ready to use as purchased and require no further mixing. Since the particles are relatively heavy, granules do not normally present a drift hazard and, thus, are safer to apply than most other formulations. They can be applied with relatively inexpensive equipment, such as seeders and fertilizer spreaders. Granules are applied either directly to the soil, water or over plants. Although granules are more expensive to use than many other formulations, the ease of application more than offsets the added cost. Granular formulations, with few exceptions, cannot be used for treating foliage, because they will not stick to plant surfaces.

Solutions are designed to be used without further dilution or to be diluted with specially refined oil or other petroleum solvents. Some materials in this category can be mixed with water to form true solutions. High-concentrate formulations contain 8 or more pounds of active ingredient per gallon, while low-concentrate formulations usually contain less than 2 pounds active ingredient per gallon. Many are formulated with chemicals that function as spreaders and stickers.

Water dispersible granules are dry, granular materials designed to be mixed with water. Upon contact with water, the granules disperse or break apart. The resulting preparation has all the characteristics of a flowable formulation

or a finely dispersed wettable powder. The granules are easy to handle and are nearly dust-free, which reduces their respiratory hazard. However, since many water-dispersible granules have a fairly high percentage of active ingredient, the same precautions as observed with flowables should be taken.

Wettable powders and soluble powders (WP), (SP) are dry, powdered formulations usually containing from 25 to 80 percent active ingredient. Wettable powders are mixed with water to produce suspensions, whereas soluble powders dissolve in water to form solutions. A wetting agent is often added to keep suspended particles of wettable powders uniformly dispersed. As a rule, wettable powders are safer to use on foliage and usually are not absorbed through the skin as quickly as liquid formulations. They are generally easy to handle, transport, store and mix and are relatively reasonable in cost. Since wettable and soluble powders are dusts, they may be hazardous to workers who breathe in the concentrated dust during mixing. Wettable powder suspensions need to be agitated constantly to avoid settling of the particles. Wettable powders also cause problems by clogging sprayer screens and nozzles. They are very abrasive to spray nozzles and pumps. Very hard or alkaline water may cause some difficulty in mixing wettable powders.

Pesticides are packaged in a variety of containers, from pint containers for the home gardener to 55-gallon drums, and in bulk fiberglass containers holding as much as 1,000 gallons. Dusts, wettable and soluble powders, granules, and other solid formulations are packaged in everything from small cellophane-wrapped bait packs and lined paper bags to cardboard and plastic containers and drums. Liquids are packaged in plastic or metal containers. The choice of container is often dictated by the reactivity or corrosiveness of the liquid materials. Aerosols usually come in reinforced metal containers and cylinders. The variety of packaging materials, shapes and sizes is endless. Glass containers have been replaced by plastic, and corrosive chemicals are no longer put in metal containers. Pesticide recognition by container packaging is helpful, but the final authority on the nature of the contents is the product label itself. Keep the label with the product.

Wettable powders are mixed with water to produce suspensions, whereas soluble powders dissolve in water to form solutions.

Be sure to always store pesticides in their original containers. The original packaging includes the pesticide label, as required by law. Keep additional labeling brochures or leaflets with the pesticide.

This ensures easy access to the information you need to mix, apply, store and dispose of the pesticide and empty pesticide containers properly.

Protective Clothing and Personal Protective Equipment (PPE)

The type of protective clothing and equipment needed depends on the job being done and the type of chemical being used. **READ THE LABEL** on the pesticide container carefully and follow all directions concerning necessary protective clothing and equipment. Many highly toxic pesticides require full

Protective clothing and Personal Protective Equipment requirements may be different for <u>mixing</u> the pesticide versus <u>applying</u> the pesticide.

Read the pesticide label carefully!

Wash all your protective clothing and equipment after each day's use.

Do not wash your clothing with the family wash. Keep it separate to avoid any possibility of cross-contamination.

Maintain all your protective equipment clean and in good operating condition.

Replace worn and cracked equipment promptly.

protection, including a respirator, while mixing, applying and disposing of the pesticide. In some cases, special equipment may be required, such as a self-contained air system when using fumigants. In most cases, the handler is required to wear a chemical-resistant apron while mixing, loading or disposing of a product, in addition to the required personal protective equipment (PPE) designated for the applicator.

At a minimum, the following protective items should be available when using pesticides.

1. Clean clothing, including a long-sleeved shirt, long trousers and/or coveralls or a spray suit made of a tightly woven fabric or a water-repellent material. A cotton T-shirt and shorts do not provide adequate protection when handling or applying pesticides.
2. Waterproof gloves, unlined and without a fabric wristband. Shirtsleeves should be worn over gloves in most instances, not tucked inside, unless you are spraying overhead, when sleeves should be tucked into the gloves.
3. Waterproof boots. Pants legs should be worn over boots, not tucked inside.
4. Wide-brimmed, waterproof hat.
5. Safety glasses with brow and side protection, goggles or full-face shield.
6. Respirator with a clean cartridge or canister. Make sure you use the correct type of cartridge or canister for the chemical being applied. They differ among particular kinds or groups of toxicants. The cartridge or canister is that portion of the respirator that actually removes the harmful gases, mists, vapors, fumes or dusts. It should be changed according to specifications, or anytime there is reason to believe noxious substances are not being removed from the air.
7. Handlers, those that mix, load and dispose of concentrated product, are usually required to wear a chemical-resistant apron over other PPE.

Wash all your protective clothing and equipment after each day's use. Do not wash your clothing with the family wash. Keep it separate to avoid any possibility of cross contamination. Maintain all your protective equipment clean and in good operating condition. Replace worn and cracked equipment promptly.

Avoiding Heat Stress

Heat stress is an illness that occurs when the body builds up more heat than it can cope with. Heat stress is not caused by exposure to pesticides but may affect pesticide handlers and applicators who are working in hot conditions. Wearing personal protective equipment, clothing and devices that protect

the body from contact with pesticides can increase the risk of heat stress by limiting the body's ability to cool down.

Several factors work together to cause heat stress. Before beginning a pesticide-handling task, think about whether any of these factors are likely to be a problem. Consider making adjustments in the task itself or in the workplace conditions to avoid heat stroke, including:

- Heat factors – temperature, humidity, air movement and sunlight
- Workload – the amount of effort a task takes
- Personal protective equipment (PPE)
- Drinking water intake
- Scheduling

Heat and Workload

High temperatures, high humidity and bright sunlight increase the likelihood of heat stress. Air movement from wind or fans may provide cooling. Because hard work causes the body to produce heat, a person is more likely to develop heat stress when working on foot than when driving a vehicle or flying an aircraft. Lifting or carrying heavy containers or equipment also increase the likelihood of becoming overheated.

Use fans, air conditioning, ventilation systems (indoors) and shade whenever possible. A work area or vehicle sometimes can be shaded by a tarp or canopy or provided with fans, awnings or air conditioners. Consider wearing cooling vests, garments with ice or frozen-gel inserts that help keep the body cool.

Allow time to adjust to the heat and workload. People who have become used to working in the heat are less likely to be affected by heat stress. To become adjusted to hot work environments, do about two hours of light work per day in the heat for several days in a row; then gradually increase the work period and the workload for the next several days. An adjustment period of at least seven days is recommended. If the warm weather occurs gradually, handlers may adjust naturally to working in hot conditions.

Personal Protective Equipment (PPE)

Pesticide handling tasks often require the use of extra layers of clothing and other PPE. These items keep pesticides from getting on the skin, but they also interfere with natural body cooling that occurs when sweat evaporates. A person can get overheated quickly when wearing PPE.

Select a level of PPE that is appropriate for the pesticide being used. The pesticide label will indicate the minimum PPE required. Use personal experience and PPE selection guides to help decide whether more protection

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High temperatures, high humidity and bright sunlight increase the likelihood of heat stress.

Allow time to adjust to the heat and workload. People who have become used to working in the heat are less likely to be affected by heat stress.

A person can become overheated quickly when wearing Personal Protective Equipment (PPE). Generally, the more protective the equipment is, the more it adds to the heat load.

The PPE specified on the label is the MINIMUM PPE required.

Drink plenty of water before, during and after work during heat stress conditions.

Schedule the tasks requiring the heaviest workload or the most PPE during the coolest part of the day, usually early morning. When heat stress is high, schedule frequent breaks to allow the body to cool.

is needed. Do not over-protect if heat stress is a concern, but wear whatever is necessary. Generally, the more protective the equipment is, the more it adds to the heat load.

Choose PPE that is designed to be as cool as possible or that provides a cooling effect, such as a powered air-purifying respirator or, when appropriate, back-vented coveralls. Whenever it is practical, choose coveralls that allow air to pass through, such as woven fabrics (cotton, or cotton-polyester blends). Rubber or plastic fabrics and fabric with chemical-resistant barrier layers allow almost no air to pass through. Non-woven polyolefin (TyvekÒ) fabrics allow little air to pass through. Non-woven polypropylene and polyester/wood pulp fabrics vary in their resistance to airflow, depending on how they are constructed.

Drinking Water Intake

Evaporation of sweat cools the body. Under the conditions that lead to heat stress, the body produces a large amount of sweat. Unless the water lost in sweat is replaced, body temperature will rise. Drink plenty of water before, during and after work during heat stress conditions. Do not rely on thirst. A person can lose a dangerous amount of water before feeling thirsty, and the feeling of thirst may stop long before fluids are replaced. Be sure to keep body weight fairly constant. All weight lost because of sweating should be regained every day. People working in heat stress conditions should weigh themselves before work every day and keep their weight constant by drinking plenty of water.

Scheduling

When the combination of temperature, sunlight, humidity, workload and PPE is likely to lead to overheating, use scheduling to avoid heat stress. Schedule the tasks requiring the heaviest workload or the most PPE during the coolest part of the day, usually early morning. When heat stress is high, schedule frequent breaks to allow the body to cool. Consider using a work/rest cycle guide to decide how long to work before taking a break. Remember that people differ in their ability to work in hot conditions. Most work/rest cycle guides are based on an average of many people who are adjusted to the heat and the workload. Workers who have not had time to adjust should work less time than the guide indicates. When using recommended work/rest cycles, continue to be alert for possible heat stress problems. Anyone who gets dangerously hot should stop work immediately and cool down. If necessary, shorten the time between breaks. The above steps will prevent most heat stress problems. Under extremely hot conditions when cooling devices cannot be used, it may be necessary to stop work until conditions improve.

Signs and Symptoms of Heat Stress

Heat stress, even in mild forms, makes people feel ill and impairs their ability to think clearly and do a good job. They may get tired quickly, feel weak, be less alert and be less able to use good judgment. Severe heat stress (heat stroke) is a serious illness. Unless victims are cooled quickly, they can die. Severe heat stress is fatal to more than 10 percent of its victims, even young, healthy adults. Victims may remain sensitive to heat for months and be unable to return to the same work.

Learn the signs and symptoms of heat stress and take immediate action to cool down if they appear. Signs and symptoms may include:

- Fatigue (exhaustion, muscle weakness)
- Headache, nausea and chills
- Dizziness and fainting
- Loss of coordination
- Severe thirst and dry mouth
- Altered behavior (confusion, slurred speech, quarrelsome or irrational attitude)

Heat cramps can be painful. These are muscle spasms in the legs, arms or stomach caused by loss of body salts through heavy sweating. To relieve cramps, drink cool water or sports drinks. Stretching or kneading the muscles may temporarily relieve the cramps. If there is a chance that stomach cramps are being caused by pesticides rather than salt loss, get medical help right away.

First Aid for Heat Stress

It is not easy to tell the difference between heat stress illness and pesticide poisoning. The signs and symptoms are similar. **Don't waste time trying to decide what is causing the illness**. Get medical help right away.

First aid:

- Get the victim into a shaded or cool area.
- Cool the victim as rapidly as possible by sponging or splashing the skin, especially face, neck, hands and forearms, with cool water or, when possible, immersing 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! Cool the victim immediately. Brain damage and death may result if treatment is delayed.

Learn the signs and symptoms of heat stress:

- **fatigue (exhaustion, muscle weakness)**
- **headache, nausea and chills**
- **dizziness and fainting**
- **loss of coordination**
- **severe thirst and dry mouth**
- **altered behavior (confusion, slurred speech, quarrelsome or irrational attitude)**

Take immediate action to cool down if these symptoms appear.

Severe heat stress (heat stroke) is a medical emergency! Cool victim immediately. Get medical help right away.

Know how to recognize the symptoms of pesticide poisoning. Symptoms may include:

- **Headache**
- **Giddiness**
- **Sweating**
- **Blurred vision**
- **Cramps**
- **Nausea**
- **Vomiting**
- **Diarrhea**
- **Numbness**
- **Changes in heart rate**
- **General muscle weakness**
- **Difficulty breathing**
- **Pinpoint pupils**
- **Rashes**
- **Allergic reactions**

If a pesticide has been spilled on the skin or clothing, remove all clothing immediately and thoroughly wash the skin with soap and water.

If the pesticide has been inhaled, get the victim to fresh air.

If the pesticide has been swallowed, get medical attention immediately.

If a Poisoning Occurs

Above all, know how to recognize symptoms of pesticide poisoning. These may appear immediately after exposure or sometimes not for several hours or even days. Symptoms can include headache, giddiness, sweating, blurred vision, cramps, nausea, vomiting, diarrhea, numbness, changes in heart rate, general muscle weakness, difficulty in breathing, pinpoint pupils, rashes and allergic reactions. In advanced poisoning cases, there may be convulsions and coma that ultimately could lead to death. The symptoms may be mistaken for brain hemorrhage, heat exhaustion or heat stroke, pneumonia, asthma, respiratory and intestinal infections, and several other illnesses.

Know the general poisoning symptoms for the pesticides being used in your area. If at any time after exposure to a pesticide a person does not feel well, take them to a doctor or hospital at once. **Take the pesticide label or the container with you if at all possible.** The doctor needs to know what ingredients are in the pesticide. Often an antidote is listed on the label.

If you use pesticides or reside near areas where pesticides are used, have the name and number of the nearest poison control center readily available, or call 1-800-222-1222. There are times when you and the doctor may have to use the services of a center. The centers are staffed on a 24-hour basis. Contact your local hospital, physician, University of Nevada, Reno Extension office, or Nevada Department of Agriculture office to determine the nearest poison control center in your area.

There may be times when immediate action is necessary to prevent serious and often permanent injury to the victim of pesticide poisoning. It could indeed be a life-and-death matter in certain situations. It may be necessary for someone to administer first aid to the victim.

If the pesticide has been spilled on the skin or clothing: Strip off all clothing immediately and thoroughly wash the skin with soap and water. Some pesticides are absorbed through the skin very rapidly. It may be best to dispose of the contaminated clothing, but if you decide to wash the clothing never wash it with the family wash. Keep it separate to avoid any possibility of cross-contaminating the family clothes.

If the pesticide has been inhaled: First, get the victim to fresh air. Have the person lie down and loosen all their clothing. Keep the victim warm and administer first aid if needed. Contact a physician or the nearest poison control center or call 1-800-222-1222 as soon as possible.

If the pesticide has been swallowed: Get immediate medical attention. Keep the victim calm and contact the local emergency response system, the

Poison Control Center (1-800-222-1222) or take the victim to the nearest medical facility. Also take the product label and any Safety Data Sheets you have about the swallowed pesticide.

Every pesticide is different and reacts differently in the body, so first aid treatment will vary. When helping a person who has swallowed a pesticide, read and follow the first aid information on the pesticide label or the Safety Data Sheets (SDS) for the pesticide. Some labels may recommend that you assist the person by making them vomit. Other labels may contain specific warnings AGAINST inducing vomiting. **Induce vomiting ONLY if emergency personnel on the phone or the product label tells you to do so.**

NEVER INDUCE VOMITING if the victim is unconscious or is in convulsions. The victim could choke to death on the vomitus.

NEVER INDUCE VOMITING if the victim has swallowed petroleum products. Many pesticides that are formulated as emulsifiable concentrates are dissolved in petroleum products. The words "emulsifiable concentrate" on the pesticide label are signals NOT to induce vomiting without first consulting the product label or a physician. Petroleum products aspirated into the lungs can cause serious respiratory disorders.

NEVER INDUCE VOMITING if the victim has swallowed a corrosive poison, a strong acid or alkali (base). Determine what the person has ingested. The victim may experience severe pain and have extensive mouth and throat burns. A corrosive poison will burn the throat and mouth as severely coming up as it did going down.

Mixing Pesticides Safely

The concentrated form of many pesticides is relatively poisonous when absorbed through the skin. Always use rubber gloves and eye protection when mixing the concentrated form of any pesticide. For very toxic materials, wear a chemical-resistant apron, a respirator, gloves and a face shield to prevent inhaling the material or splashing it into the face. Home gardeners should never use a pesticide that is so toxic that a respirator is required.

When mixing pesticides, put water in the spray tank until it is about half full before adding the chemical. Accurately measure the proper amount of chemical according to the instructions on the label. Keep all measuring utensils (spoons, cups, etc.) in the areas where pesticides are stored. Wash the utensils thoroughly after each use. Never use these utensils for other purposes.

Never induce vomiting if:

- **the victim is unconscious or having convulsions**
- **the victim has swallowed petroleum-based products**
- **the victim has swallowed a poison that is corrosive, strongly acidic or strongly alkaline**

Only first aid has been discussed here. Take the victim to a doctor or hospital as soon as possible and take the pesticide label with you.

When mixing pesticides, put water in the spray tank until it is about half full before adding the chemical.

Wash all measuring utensils thoroughly after each use and store them with the pesticides. Never use these utensils for other purposes.

Make sure the water supply hose does not come into contact with the pesticide spray preparation to prevent back-siphoning of the pesticide into the water source.

If two or more products are equally effective, select the least toxic material whenever possible.

Wear clean clothing and use protective equipment as needed.

Always keep your head well above the fill hole to avoid inhaling the pesticide. Do not spill or splash when filling the tank. Carefully fill the spray tank with the correct amount of water. Make sure the water supply hose does not come into contact with the spray preparation. This prevents contamination of the hose and avoids the possibility of back-siphoning of the pesticide into the water source.

In certain cases, it is possible for applicators to mix two or more pesticides together to make a single application. Charts are available that show the compatibility of different pesticides. Only materials that are fully compatible should be mixed together. Never mix herbicides with other types of pesticides. The pesticide label may specifically prohibit mixing certain pesticides; read the label carefully.

Applying Pesticides Safely

READ THE LABEL carefully before applying any pesticide. Know something about the dangers of the product you intend to use. Be sure that you have properly identified the insect, weed, disease or other pest that you want to control.

It is unlawful to apply a pesticide to a site not specified on the label. Make sure that both the pest and the host plant or animal are included on the product label, and do not apply a pesticide unless it is actually needed.

Do not permit an irresponsible or careless person to handle, mix or apply any pesticide. They may cause harm to themselves or others. Some workers cannot read the instructions on labels; others may not care. *Ability and attitude are of equal importance in the safe, effective use of chemicals*. Applicators should work in pairs when applying highly toxic pesticides. Immediate assistance is then available if one of the applicators becomes ill.

If two or more products are equally effective, select the least toxic material whenever possible. The Nevada Department of Agriculture can assist you in selecting the proper pesticide product for your particular pest problem.

Most importantly, use pesticides only on the crops for which they are registered. Spraying with the wrong material can destroy an entire crop. You can avoid this type of crop damage by carefully following the instructions on the product label.

Carry fresh water, soap and paper towels with you in a container, protected from the pesticide spray, in case you accidentally spill the chemical on your skin and clothing or are exposed to spray drift.

Guard against drift of sprays or dusts. Drift can be reduced or controlled by making the application when there is no wind. Some chemicals are capable of drifting for miles under certain conditions. The most important factors influencing drift are wind velocity and direction. For more information on reducing drift, go to the General Knowledge: Pesticide Use and the Environment section of this manual.

Cover all feed and water containers when treating an area around livestock and use the same precautions when spraying or dusting around your home. People and animals can be severely injured or killed if directions are not followed. Do not spray or dust close to farm ponds where the chemicals may harm fish or livestock that drink from the ponds. Where a farm pond is used for domestic water supply, be especially careful not to contaminate the water. Stay a safe distance away from any pond and be sure the wind will not carry drift into the water. Consider wildlife as well as humans, domestic animals and plants when applying pesticides. If properly handled, pesticides can control pests without endangering wildlife.

By keeping your application equipment in good condition and operating properly, you can avoid unnecessary hazards to yourself, as well as possible damage to a crop. If, while spraying, you have to fix and adjust equipment that is in poor condition, you may receive excessive exposure to the chemical. Also, be sure that you are using the recommended type of equipment. For example, a powder intended to be dissolved in water should never be used in a dust applicator. The label will explain what types of applications are permissible.

Temperature plays an important role in pesticide applications. Generally, the pesticide label will specify a range of temperatures that are best for pesticide applications or the label will specify a minimum and maximum application temperature range. For example: Do not apply below 50 F or above 85 F. At 40 to 50 F, most pesticides will show reduced activity. Applying them at these low temperatures will be a waste of time and money as they will not be effective. At temperatures of 85 F or above, many pesticides will volatilize, increasing the potential for drift and decreasing their effectiveness.

Use separate equipment for applying herbicides if at all possible. It is not advisable, for instance, to use spray equipment that has contained the herbicide 2,4-D for spraying insecticides or fungicides. If you use the same equipment for applying other pesticides, accidental injury to plants is likely to occur unless the equipment has been very thoroughly cleaned with an approved material.

Never eat, drink or smoke when applying pesticides; do not even carry food or smoking items with you.

Cover all livestock and pet feed and water containers before applying pesticides.

Check the pesticide label for the proper temperature for application. Below 40 to 50 F, many pesticides show reduced activity. Above 85 F, many pesticides will volatilize, increasing the potential for pesticide drift.

Never re-enter a recently sprayed field or greenhouse when the foliage is still wet unless you are wearing proper protective clothing and equipment.

Restricted Entry Interval or REI is the time after the end of a pesticide application during which re-entry is restricted without proper PPE to protect against pesticide residues.

DON'T STOCKPILE PESTICIDES. Registrations change, and new chemicals may be better than old ones.

If you must dispose of a surplus mixture, do so according to label directions.

The steps in cleaning spray equipment are generally detailed on the pesticide label.

Never re-enter a recently sprayed field or greenhouse when the foliage is still wet unless you are wearing proper protective clothing and equipment. Pesticide labels list the Restricted Entry Interval or REI. The REI is the time after the end of a pesticide application during which re-entry is restricted without proper PPE to protect against pesticide residues. These intervals should be strictly observed unless applicators or field personnel are properly protected against residues. Post fields or structures with appropriate warning signs to reduce the possibility of someone accidentally walking into a recently sprayed area. Make sure workers are aware that an application has been made to a field and the length of the Restricted Entry Interval (REI).

Immediately following application and cleaning of equipment, applicators should wash thoroughly and change to clean clothing. All spray residue must be removed from the skin. Applicators who delay bathing and changing to clean clothing can become extremely ill because of toxic residues on the skin and clothing. As many emulsifiable concentrates (ECs) use petroleum-based carriers detergent soap is recommended when washing the hands or bathing. Otherwise, plain soap is satisfactory.

Disposing of Pesticides Safely

Empty pesticide containers, when discarded improperly, are potentially very hazardous. Several deaths and illnesses, particularly among children, have resulted from contact with discarded pesticide containers. An empty can or drum readily entices curious children and animals and, therefore, should never be left where it can become an attractive nuisance.

First, avoid disposal problems associated with excess pesticides by purchasing only the amount you will need for an application or one growing season. DON'T STOCKPILE PESTICIDES. Registrations change, and new chemicals may be better than old ones. Mix only as much pesticide as you will need for a particular application. If you should happen to mix too much, it is best to apply the excess in the recommended manner to another crop or site listed on the label.

If you must dispose of a surplus mixture, dispose of it only according to label directions. Commercial establishments and custom applicators should make sure that they are consistent with the hazardous waste guidelines established under the Federal Resource Conservation Recovery Act (FRCRA), as well as all comparable state statutes, prior to disposing of pesticide wastes and according to label directions. Follow disposal instructions on the

pesticide label and use adequate safety equipment and proper clothing when disposing of pesticide wastes and empty containers.

The Nevada Department of Agriculture (NDA) has a safe pesticide waste disposal program. They can only accept pesticides; they DO NOT accept batteries, motor oil, antifreeze, paint or other substances. They DO NOT accept pesticide rinsate. They DO accept unusable, expired or unwanted pesticides, including pesticides that have been banned for use in Nevada. The program is free.

While wearing the PPE specified on the pesticide label, inventory the pesticides you want to dispose of and fill out the Disposal Pesticide List sheet at https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Environmental/Disposal%20Pesticide%20List.pdf. Call the NDA at 775-353-3717 to set up a time to drop off your unwanted pesticides and your inventory sheet. Do not drop off the pesticides at the NDA office after hours; this is considered illegal dumping, and you will be subject to a fine or other penalties. For more information about this program, go to https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Media/2014-12-Safe-Waste-Pesticide-Disposal.pdf.

Empty containers made of glass, metal or plastic should be rinsed three times with water prior to disposal. Pour the rinsate back into the sprayer and spray out according to the label directions. Disposal of triple-rinsed empty containers in a sanitary landfill is permissible, but the containers must be punctured to prevent reuse. Recycling is the preferred method of empty container disposal. Plastic from pesticide containers is a valuable resource that can be recycled and used as pesticide containers, pallets, waste drums and other items. Per Nevada Administrative Code (NAC) Chapter 445B.22067, it is illegal to burn pesticide containers in Nevada. The NDA, the Ag Container Recycling Council (ACRC), Interstate Ag Plastics (IAP) and the state's pesticide users came together to implement a convenient and effective container recycling pilot program. Containers with pesticide residues are not accepted. Containers should be triple rinsed. Caps and labels should be removed from the containers, as this interferes with the recycling process. Some containers are not acceptable. For more information, go to https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Media/2014-12-Pesticide%20Container%20Disposal(1).pdf.

Follow disposal instructions on the pesticide label and use adequate safety equipment and proper clothing when disposing of pesticide wastes and empty containers.

Recycling is the preferred method of empty container disposal.

Per Nevada Administrative Code (NAC) Chapter 445B.22067, it is illegal to burn pesticide containers in Nevada.

If a leak or spill occurs, clean it up immediately.

You must report a spill that is greater than 1 gallon of liquid or 4 pounds dry weight of unmixed or concentrated pesticides that are detrimental to persons, wildlife, domestic animals, or crops.

If you have a serious accident or have problems during the cleanup phase, contact the Pesticide Accident Hotline (CHEMTREC), 1-800-424-9300 or the National Poison Center Hotline, 1-800-222-1222. Both offices are staffed 24 hours a day.

Dealing with Pesticide Spills

Despite your best efforts, accidents can happen. Accidental spills of pesticides can have severe consequences to human health, pets, livestock, wildlife and the environment. If a pesticide spill occurs, use these four steps:

1. CAUTION: Keep yourself safe. Make sure you are wearing proper Personal Protective Equipment (PPE) before attempting to clean up a spill. If a spill occurs during a pesticide application, you should already be wearing the proper PPE. Try to exclude entry or access to the spill site.
2. CONTROL: Stop the spill from continuing by stopping the source of the spill. For example, if a spill is from a broken hose on a tank, close the valve to the hose. If a pesticide container is leaking, place the container in a secondary container to limit the spill.
3. CONTAIN: Contain the spill so that it does not spread and get into water sources. Build a dike or levy of absorbent material around the spill to keep it from spreading. You can use containment snakes, pads or absorbent material such as cat litter, wood shavings or corn cob litter.
4. CLEAN UP: Add absorbent material to soak up the spilled pesticide. Start at the outside of the spill, next to the containment material you placed down, and work toward the center of the spill. Once the spill has been absorbed, sweep or shovel up the spill-soaked absorbent material and place it in heavy-duty garbage bags or a waterproof container with a tight-fitting lid. Label the container with the date of the spill and the name of the pesticide. Place the broom or shovel and dustpan in a heavy-duty garbage bag for later decontamination or disposal.

The Nevada Department of Agriculture free Pesticide Waste Disposal Program will also take the waste pesticide from a spill and the pesticide-soaked spill clean-up materials and dispose of it properly. You must call ahead to schedule a drop-off of the material. Call Nevada Department of Agriculture at 775-353-3717. Have the name of the pesticide when you call. Do not drop off the spill material at their office after hours. This is considered illegal dumping and you will be fined.

You must report a spill that is greater than 1 gallon of liquid or 4 pounds dry weight of unmixed or concentrated pesticides that are detrimental to persons, wildlife, domestic animals or crops. Report the spill to the Nevada Department of Agriculture at 775-353-3715. Know the name of the spilled pesticide when you call.

If you have a serious accident or have problems during the cleanup phase, contact the Pesticide Accident Hotline (CHEMTREC), 1-800-424-9300, or the National Poison Center Hotline, 1-800-222-1222. Both offices are staffed 24 hours a day by trained personnel who are knowledgeable in emergencies involving the handling of pesticides, including spills and accidents.

You can see that it is important to have a spill kit on hand when you are applying pesticides. You can build your own spill kit or purchase a spill kit. Most service vehicles are required to have a spill kit. Most service vehicles have a shovel.

A purchased spill kit for a service vehicle usually comes in a 5-gallon bucket with a tight-fitting lid. Inside there should be:

- Telephone numbers for emergency assistance
- Containment snakes
- Absorbent material
- Heavy-duty plastic garbage bags
- Dustpan and broom
- PPE, such as gloves, goggles and disposable coveralls

Storing Pesticides Safely

Always store pesticides and other chemicals in their original containers with the label attached and the lid closed securely. Using soda pop bottles, fruit jars or other types of non-pesticide containers can have serious consequences. Small children, as well as most adults, associate the shape of the container with its contents. Consequently, a child or an adult may be seriously poisoned or even killed.

Keep all pesticides out of the reach of children, pets and irresponsible people. Do not store them in your home near food. This will help reduce the exposure hazard and also prevent possible contamination of food. LOCK all chemicals in a building or cabinet. The lock should keep everyone away from the chemicals except those who are qualified to use them. Also, be sure to identify the storage facility with a sign that clearly indicates that pesticides are stored in the structure.

Do not store pesticides near livestock and pet feeds to prevent possible contamination. Livestock and pets may be killed in this manner. Contamination of crop seeds by pesticides can reduce or prevent germination.

Seed that is intentionally treated with a fungicide or an insecticide presents a potential hazard if not stored properly. Such seed is usually treated with a brightly colored dye that serves as a warning that the seed has been treated with pesticide. Unfortunately, the brightly colored seed may be attractive to children. Treated seed should never be used for food or livestock feed or mixed with untreated seed. It should be handled with the same care as the pesticide itself and stored in a locked storage facility away from feed, veterinary supplies, pesticides and other farm chemicals, and farm equipment.

Always store pesticides and other chemicals in their original containers with the label attached and the lid closed securely.

Keep all pesticides out of the reach of children, pets and irresponsible people. LOCK all chemicals in a building or cabinet. Limit access to those who are qualified to use the pesticides.

Do not store pesticides near food, pet feed or livestock feed.

Store all herbicides separately from other pesticides to limit cross-contamination.

Never store respirators, PPE and other safety equipment in the same room with pesticides because of possible contamination.

Check stored pesticide containers often for leaks or cracks.

The label should be readable. All supplemental labeling should also be stored with the pesticide.

Never store pesticides in well houses or near water sources. Never store pesticides in rooms with floor drains.

Herbicides should be stored separately from other types of pesticides as the danger of cross-contamination is too great.

Never store respirators, PPE and other safety equipment in the same room with pesticides because of possible contamination. Maintain all safety equipment in top working condition.

Never leave a portion of a pesticide in an unmarked or unlabeled container. Other people may use the pesticide by mistake and injure themselves or others. Those who use the pesticide do not have the label with directions for its proper, safe use, and relying on verbal directions is a poor practice. Pesticides in large containers that are heavy to handle should be stored on or near the floor to prevent their falling. Place extremely heavy containers on the floor or a pallet, never on shelves. Containers should not extend beyond the shelving or cabinets where they may be bumped, knocked off the shelf, broken open and spilled.

Check containers frequently for leaks and breaks. Pesticides should be stored within a second container of equal or greater volume in order to contain the entire amount of pesticide if a package or container breaks. If a leak or break does occur, transfer the contents to an empty container that originally held the same material. Otherwise, dispose of the contents in the prescribed manner. Clean up spilled pesticides promptly and thoroughly using proper PPE and safety equipment during the cleanup procedure. Dispose of the pesticide waste in a proper manner.

Be especially careful that corrosive materials are stored and handled in containers designed for such materials. A corrosive material in the wrong kind of container may corrode the container and cause serious damage.

Pesticides in glass bottles should not be stored near heat where glass containers can break or explode, spreading the chemical over a large area. Materials in glass containers should be stored in dry, cool areas. However, it is necessary to protect some of them from freezing, so check the label carefully for proper storage information. Storage facilities with temperature regulation are recommended. Excessive heat and freezing often alters pesticides, making them less effective or unusable.

To ensure the label remains on the container in readable condition, protect it with transparent tape or lacquer if the pesticide is to be stored for a long period. Remember, the label is the most important safety factor in the use of a pesticide. *Do not let it become damaged or destroyed*.

Keep an inventory of all pesticides and mark each container with the date of purchase. If a product has an effective shelf life recorded on the label, you will know exactly when expiration occurs if you have marked the purchase date on the label.

It is a good idea to inform your local fire department if you store large quantities of agricultural chemicals, including fertilizers. Chemical fires often cannot be extinguished by ordinary means and the smoke from the fire can be extremely hazardous to firefighters. The fire department must be properly prepared in the event of an agricultural chemical fire.

Post the name of your physician, hospital, and nearest poison control center in a prominent location in the storage facility. Remember to consult the product label for specific storage information.

Transporting Pesticides Safely

Never transport pesticides inside the passenger compartment of any vehicle. No one should be permitted to ride near pesticides. In a vehicular accident, a pesticide spill might result in injury or even death to the occupants. Secure pesticides in the trunk of a car or back of a truck so they cannot roll or slide around. Putting pesticide containers inside a cardboard box will keep them from tipping over. Never carry food, livestock feed, fertilizers or seed together with pesticides. The danger of contamination is too great. It is a good policy to transport weed control chemicals separately from all other pesticides, since a spill could lead to cross-contamination.

Never leave your vehicle unattended when transporting pesticides in an open truck bed. You are legally responsible if curious children or careless adults are accidentally poisoned by pesticides left unattended and exposed in your vehicle. Always haul pesticides in the trunk or in a secure compartment that can be locked to avoid their theft.

Pesticide Stewardship

It is the responsibility of every pesticide applicator to insure good pesticide stewardship. To be a good steward of pesticides, applicators should minimize the risks while maximizing the benefits of a pesticides. This includes the following:

- Maintaining pesticide security. All pesticides should be stored in an area that can be locked to keep out unauthorized people. This locked area can be a storage cabinet or an entire building. Post signs on doors and windows to alert people that pesticides are stored there. Post “no smoking” warnings. Whenever possible, transport pesticides in a locked

Post the name of your physician, hospital and nearest poison control center in a prominent location in the storage facility.

Never transport pesticides inside the passenger compartment of any vehicle.

Secure pesticides in the trunk of a car or in the back of a truck to minimize the potential for breakage or leaks.

It is the responsibility of every pesticide applicator to insure good pesticide stewardship.

All pesticides should be stored in an area that can be locked to keep out unauthorized people. This locked area can be a storage cabinet or an entire building.

If you are a certified applicator supervising non-certified applicators using restricted-use pesticides, you are responsible for the outcome.

Certified applicators that use restricted-use pesticides are required to keep records for two years.

Certified applicators that apply pesticides to public lands are required to keep records of both restricted-use and general use pesticides for two years.

compartment. Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are responsible and liable if curious children or careless adults are accidentally poisoned by the pesticides.

- Develop a method to communicate information on pesticide risks and exposures with the non-certified applicators under your supervision. Pesticide safety training must be presented in a manner that the non-certified applicator can understand. Recognize that cultural and language differences may pose substantial barriers to communication. If you are a certified applicator supervising non-certified applicators using restricted-use pesticides, you are responsible for the outcome. Take these communication requirements seriously to reduce the risk of accidents that could cause serious injury or environmental damage.
- Recognize that, as a pesticide applicator, you are the person people see applying pesticides. Communicating information about pesticide risks and exposures includes your customers and the general public, both of whom might be far less knowledgeable about pesticides, the risks they pose and the actions they can take to reduce those risks. Resources such as the National Pesticide Information Center are helpful for learning how to communicate risk and risk reduction to the general public. Plan all pesticide applications with safety of yourself, your coworkers, the general public, pets, livestock, wildlife and the environment in mind.

Keeping Records

Every person using pesticides should keep careful written records of each application. He/she should record:

1. Date and time of the application
2. Location of the application
3. Type of equipment used
4. Name of the pesticide used
5. The EPA registration number
6. Rate of application (e.g., gallons per acre) and total area treated
7. What crop or site was treated (e.g., corn, ornamentals, house foundation)
8. Size of the area treated and its location
9. Pest controlled
10. Temperature at the start and finish of the application
11. Wind velocity and wind direction at the start and finish of the application
12. Name of applicator and certification number if the pesticide is a restricted material
13. Miscellaneous comments

Certified applicators that use restricted-use pesticides are required to keep records for two years. Certified applicators that apply pesticides to public lands are required to keep records of both restricted-use and general use pesticides for two years. All users of pesticides should keep records for their own protection. Your personal protection is not the only reason for keeping pesticide application records. Many herbicides can be used safely on certain crops but may be fatal to others. Without written records, it is difficult to know what pesticides have been used on a field during the previous few years.

Additionally, keeping records helps ensure that different pesticides with different modes of action are used in situations where multiple pesticide applications are required. This helps reduce the potential for developing a resistant pest population.

More detailed information about record-keeping requirements can be obtained from the Nevada Department of Agriculture at https://agri.nv.gov/Resources/Forms/Division_of_Plant_Health_and_Compliance-Environmental_Services/.

Conclusion

Most pesticides are safe when properly used, but the user must **READ, UNDERSTAND, AND FOLLOW THE LABEL DIRECTIONS**.

The best way to avoid the potential hazards of pesticide use is to read, understand and follow all pesticide label directions.

Equipment and Calibration

Pesticide Application

The skill and accuracy with which you apply a pesticide is just as important as choosing the correct pesticide. Once you select your equipment, you must learn to operate, service and calibrate it.

Selecting Pesticide Application Equipment

Type and size of equipment depends on the intended use, where it will be used, what materials (formulations) will be used, the amount of use (size of area treated and number of times it will be treated), and the need for accessories (booms, drop nozzles, etc.). If selected properly, your equipment can save you time and money in managing pests.

Types of Equipment

Various types of equipment are available for applying pesticides, and applicators must select the proper equipment in order to achieve good results. Equipment must be set up, used and maintained properly. When selecting pesticide application equipment, consider the size of the area to be treated, the crop and site of the application, the accuracy desired, and the cost of the equipment. This section summarizes the most common types of application equipment. New application equipment is constantly being developed.

Hand-operated sprayers:

Hand-operated sprayers may be used indoors or outdoors and are most often used for applying pesticides to small sites. They are useful in locations that are inaccessible to larger equipment. They are inexpensive, simple to operate and easy to clean and store. These sprayers have a manually operated air pump that must be physically pumped, usually with a hand lever. Some are equipped with a small motor that compresses air into the tank and pressurizes the spray mixture. Commonly referred to as buildings and grounds (B & G) or backpack sprayers, this type of equipment generally has small tanks (3 or 4 gallons) and operates at low pressures of 50 psi or less. These sprayers are not suitable for treating large areas.

Motorized sprayers:

Motorized systems may be mounted on tractors, trucks, trailers or aircraft. Motor-powered sprayers are capable of delivering large volumes of spray mix over large areas. This equipment is also capable of driving agitation systems for pesticide formulations that require agitation. These systems are not good for small areas or spot treatments.

High-Volume Hydraulic Sprayers:

A type of directed sprayer, these are generally used in greenhouse or enclosed areas. These application systems are inexpensive to own and operate. They can be used to apply many different pesticides and can be used for spot treatments. They require careful calibration to ensure proper droplet size (not too large or too small) and reduce potential runoff. For larger greenhouse structures, this application system maybe very time consuming.

Low Volume Sprayers and Ultra Low Volume Sprayers:

These systems are used in greenhouses and other enclosed areas. They may be handheld and moveable, or they may be fixed within the structure. These include cold foggers, thermal pulse-jet foggers, air-assisted electrostatic sprayers, mechanical aerosol generators and ready to use aerosols. These low-volume and ultra-low volume sprayers take less time to make an application and have less potential for pesticide runoff. They produce small droplets that can move through the enclosed area. These application methods are not effective in open areas.

Boomless sprayers:

Motorized boomless sprayers are systems that supply spray mix to a hand gun or hand-held boom with several nozzles. Operators are able to cover larger areas than with a hand-operated sprayer. Hand guns are useful for spot treatments and treating small areas. This equipment is suitable for use in rough areas, irregular areas, and along fence lines and roadsides.

Boom sprayers:

Boom sprayers have spray nozzles spaced at regular intervals on a boom. An example is a horizontal boom used on tractor-driven sprayers to apply pesticides to field-grown crops. This type of equipment is also used on aircraft. Good coverage and uniformity is possible when constant spray pressure and travel speed is maintained. In field crops, good coverage is relatively easy to achieve where the target foliage is small and close to the nozzles. These systems are adaptable or adjustable to many different nozzles and application heights. The potential for drift increases the higher the nozzle height is from the ground surface.

Airblast sprayers:

It is difficult to achieve good coverage in fruit trees, especially large trees, with conventional sprayers. With airblast sprayers, a powered fan forces air through an opening, resulting in high air speeds. The opening is adjustable and directs the air stream that carries the pesticide to the target. These systems provide good coverage and penetration and provide high capacity. They also have high drift potential, are unsuitable in windy conditions and in small areas, and can have a high cost.

Granular applicators:

Equipment used to deliver granular pesticides include hand-operated systems that use gravity to spread granules or pneumatic applicators that use a stream of air to carry granules through delivery tubes. The potential for pesticide drift is much lower when granular formulations are used. Application of the granular pesticide material can be inconsistent. Using this application equipment requires calibration to make sure overlap creates an even application with no overapplication or application gaps.

Aerial applicators:

An advantage of aerial applicators, such as airplanes and helicopters, is that pesticide applications can be done quickly over large areas and in locations where ground equipment cannot operate, such as wet fields or large expanses of range or forest land. This application method does not contribute to soil compaction. This method can also take advantage of weather windows; ground equipment may not be able to take advantage of these same weather windows. While pesticide drift is possible with any type of application equipment, drift is one of

the main disadvantages of applying pesticides through an aircraft. There is also potential for incomplete or inconsistent coverage.

Chemigation:

Chemigation is the process of applying pesticides through an irrigation system. Drip and sprinkler irrigation systems are the most common methods used to chemigate. Chemigation has some advantages over applying pesticides with field sprayers, including less damage to plants. Pesticides may be applied to crops or soil when conditions prohibit entry into the field with other spray equipment. Chemigation reduces the potential for drift and is safer for non-target species. Applications are not influenced by wind or many other environmental factors. Chemigation also has disadvantages: if not done properly, pesticides may backflow into the water source, either groundwater or surface water, resulting in significant environmental damage. To prevent backflow, several specific devices must be installed in the chemigation system. This hardware is required by the pesticide label.

Injection:

Injections and implants that place pesticides, usually systemic insecticides, directly inside of ornamental and forest trees are becoming more common. Tree injections have advantages over sprays because they use lower volumes of pesticides, there is less equipment needed and application may be done in adverse weather conditions. In addition, the potential for drift onto a non-target site is eliminated. It can be used where soil treatments are not possible, such as wet, sandy, compacted or restricted soils. There is the potential to damage the bark-cambium interface. The application site can create damage that later becomes an entry point for disease or other pests. Applications of these pesticides should only be done to actively transpiring trees. Pesticide labeling may not allow systemic-injected pesticides to be used on many trees that produce fruit or nuts that will be consumed; read the label carefully. It may take some time for the application to move throughout the tree or shrub.

Types of pesticide mix tanks:

Pesticide mix tanks are tanks attached to application equipment where pesticide formulations and concentrates are mixed with water and other additives, such as adjuvants, surfactants, anti-foaming agents or drift reducers. Tanks may be constructed of a variety of materials, including stainless steel, fiberglass or plastic.

Some pesticide product labels do not allow for the product to be mixed in tanks made of certain materials. Therefore, it is essential to read product labeling in order to determine whether your tank is acceptable for the specific pesticide you wish to apply.

Pesticide spray nozzles:

Pesticide spray nozzles are an integral part of pesticide application equipment. Good uniformity of the application is dependent on proper nozzle selection. Nozzles help control the amount of pesticide applied and the size of droplets. Droplet size depends not only on the nozzle but on the pressure as well. Droplet size decreases with high pressure and increases with low pressure. The bigger the droplet, the less likely it is to drift.

Nozzles may be constructed of a variety of materials, including stainless steel, nylon, aluminum, brass or ceramic. Some materials are very durable, such as stainless steel. Nozzles made from brass wear out quickly, especially when using wettable powders.

Some basic nozzle types include:

- **Fan or flat fan nozzles:** These nozzles are used for herbicide and insecticide applications. They put out the spray in a fan-shaped pattern with less material applied at the edge of the pattern, so the spray pattern must overlap in order to obtain uniform coverage.
- **Hollow cone nozzles:** These nozzles produce a cone-shaped spray pattern, with the liquid on the outside of the cone. Hollow cone nozzles generally produce the smallest droplets and are used when penetration and coverage are critical.
- **Full cone nozzles:** This type of nozzle produces a cone-shaped spray pattern with liquid being applied throughout the cone. They are often used for soil-applied herbicides.

Other equipment:

- **Site gauges** are necessary if you can't see the level of pesticide mix in your tank.
- **Pressure gauges and pressure regulators** allow for management of pressure during application.
- An **unloading valve** may be used for quick unloading of chemicals.
- **Strainers** located in the supply line and in individual nozzles remove debris and prevent clogging of nozzles.
- **Control valves** are used for on and off operation.
- **Hoses, pipes and tubing** must be corrosion-proof, capable of withstanding high pressure, and U.V. light resistant. Changing hose diameter will increase or decrease pressure.

Equipment Calibration

Modern pesticide formulations need to be applied at very specific rates to obtain desired results and to minimize potential health, safety and environmental problems. Over- or under-application will result in less than desirable control of the target pest and increase the risk of causing problems. Both waste time and money. Applying pesticides is NOT a case where "*if a little is good, a lot is better*," especially with herbicides. Accurate application rates are essential for best results.

Calibration information is often presented using many mathematical calculations, which tends to impress us only with the difficulty of the calibration process. In order to simplify the process, the method described below has minimal math needed. This section is subdivided into sections based on the application method used:

- Boom sprayer equipment
- Backpack sprayer equipment
- Granular application equipment
- Chemigation equipment
- Stationary sprinkler system calibration

Because of various field conditions, different application equipment and different speeds crossing a field, EACH person must calibrate their application equipment before using a sprayer for pesticide applications. This way, the pesticide mixture can be adjusted for individual and field differences and the appropriate pesticide application rate can be obtained.

Calibrating Boom Sprayer Equipment

Calibration information provided in this section is designed to be used with tractor or pickup-mounted application equipment when applying emulsifiable concentrates or other liquid pesticide formulations.

FOLLOW THESE INSTRUCTIONS:

1. Clean your sprayer thoroughly with soap and water, sudsy ammonia, or a commercial tank cleaner. Dispose of the rinse material properly. Make sure all of the equipment is working properly. Fill sprayer with clean water.
2. Measure a specific distance, such as 88, 100, 200 or 300 feet, in a typical area of the field you will be spraying. If using a tractor, set your tractor RPM and select the gear that will be used in the field. If using a truck, decide upon a gear and speed or RPM. Record the time needed to cover the distance.
3. Place a measured container under each nozzle to collect the spray. Turn on the spray bar the same length of time it took to spray the distance measured in step 2. Because of variability among nozzles, it is best if each nozzle is collected separately. Record the amount of spray collected in each container from each nozzle and add the numbers together. Divide the total by the number of nozzles to get an average spray quantity per nozzle. If any nozzle sprays 10 percent over or under the average, clean it or replace it and repeat step 3 until all the measurements are within 10 percent of the average.
4. Convert the total amount collected in step 3 to gallons per acre. Multiply the distance in feet originally measured (traveled) by the width of the spray pattern in feet to obtain the area of the plot sprayed in square feet. Divide the area of the plot sprayed by 43,560 (number of square feet in an acre) to obtain the fraction of an acre sprayed. Now you know the plot area sprayed and the liquid volume sprayed on the plot. Divide the area into the quantity of liquid to obtain the number of gallons of water applied per acre.
5. To determine the amount of pesticide you need to mix in a gallon of water, see Table 3 below. You only need to do additional math if the pesticide you are using is formulated at a rate different than 4 pounds active ingredient (a.i.) per gallon.

Example: Controlling a certain weed requires 3 quarts per acre of a 2,4-D product with 4 pounds a.i. per gallon. Your spray volume calculated above is 40 gallons per acre. According to the chart, you would mix 2.3 fluid ounces of 2,4-D per gallon of water to apply the correct amount of herbicide per acre. If your tank holds 100 gallons of water, then you would add 1 gallon, 3 quarts and 6 fl ounces of 2,4-D to your 100-gallon sprayer tank. (2.3 fl. oz. X 100 = 230 fl. oz. Use the handy conversions below to convert ounces to gallons, quarts, etc.)

Handy Conversions

3 teaspoons = 1 tablespoon	2 tablespoons = 1 fluid ounce
8 fluid ounces = 1 cup	1 cup = 16 tablespoons
2 cups = 1 pint	2 pints = 1 quart
4 quarts = 1 gallon	1 gallon = 128 fluid ounces
32 ounces = 1 quart	1 gallon = 16 cups

1 acre = 43,560 square feet

Table 3: Volume of pesticide at 4 lbs. active ingredient per gallon to mix in one gallon of water*

Spray Water Volume (gallons per acre)	Desired application rate of pesticide per acre			
	1 quart	2 quart	3 quart	4 quart
10	3.3 fluid oz	6.5 fluid oz	9.5 fluid oz	12.3 fluid oz
15	2.0 fluid oz	4.0 fluid oz	6.2 fluid oz	8.5 fluid oz
20	10.0 tsp	3.2 fluid oz	4.8 fluid oz	6.3 fluid oz
30	6.0 tsp	2.0 fluid oz	3.2 fluid oz	4.2 fluid oz
40	4.8 tsp	1.6 fluid oz	2.3 fluid oz	3.2 fluid oz
50	3.8 tsp	1.2 fluid oz	2.0 fluid oz	2.5 fluid oz
60	3.2 tsp	6.3 tsp	1.6 fluid oz	2.0 fluid oz
70	2.8 tsp	5.5 tsp	1.3 fluid oz	1.8 fluid oz
80	2.3 tsp	4.8 tsp	7.2 tsp	9.5 tsp
100	2.0 tsp	3.8 tsp	5.8 tsp	7.6 tsp

*This table only applies to pesticides that contain 4 pounds of active ingredients per gallon. **Read the label**. If the pesticide concentration you are using is different than 4 lb./gal a.i., divide the pesticide mixture number (oz or tsp.) shown on the chart by 4 and multiply that answer by the number of pounds of a.i. per gallon listed on your product label. That quantity would then be mixed per gallon of water in your sprayer.

Refill Method Sprayer Calibration:

Acre-Volume Method:

1. Stake out 1 acre on same ground to be sprayed (210' X 210').
2. Fill tank with water and mark level.
3. Start sprayer power unit.
4. Set desired pressure.
5. Select ground speed.
6. Spray test acre.
7. Add and measure water to fill the tank back to the original level, say ten gallons in this example.
8. Amount added equals application rate per acre.

Calculate acres that can be sprayed with one tank (100 gallons):

$$\frac{\#\text{Gallons in Spray Tank}}{\text{Application Rate/Acre}} = \text{Acres per Full Tank}$$

$$\frac{100 \text{ Gallons in Tank}}{10 \text{ Gallons/Acre}} = 10 \text{ Acres per Tank}$$

Refill Method Sprayer Calibration:

Area-Volume Refill Method:

1. Stake out the test area (1,000 feet for boom broadcast).
2. Put water in tank and mark level.
3. Start sprayer engine.
4. Set pressure.
5. Establish ground speed before entering course.
6. Enter and spray test area. Start and stop the spraying at the beginning and end of the test area while moving at the speed to be used when spraying.
7. Return and measure the amount of water it takes to refill the tank sprayer to the original mark.
8. Record the amount of water used.
9. Calculate the rate of application.

To Find Area Sprayed:

$$\frac{\text{Width of Swath X Length of Run}}{\text{Square Feet per Acre}} = \frac{\text{16-foot Boom X 1000 Feet}}{43{,}560\ \text{ft}^2/\text{acre}} = 0.37\ \text{Acres}$$

To Find Application Rate (assuming 8 gallons used to refill tank):

$$\frac{\text{Gallons Used to Refill Tank}}{\text{Number of Acres Sprayed}} = \frac{\text{8 Gallons}}{0.37\ \text{Acres}} = 22\ \text{Gallons/Acre}$$

To Find Acres Per Full Spray Tank:

$$\frac{\text{Gallons in Spray Tank}}{\text{Application Rate (GPA)}} = \frac{\text{100 Gallons}}{\text{22 Gallons Per Acre}} = 4.5\ \text{Acres per Spray Tank}$$

To Determine the Final Spray Mixture:

Liquid Formulation:

From the Label: 4 Quarts/100 Gallons

Sprayer Tank = 175 Gallons

$$\text{Final Spray Mixture (Liquid Formulation)} = \frac{\text{4 Quarts}}{\text{100 Gallons}} \times 175\ \text{Gallons} = \frac{700}{100} = 7\ \text{Quarts/Tank}$$

Dry Formulation:

From the Label: 2 Pounds per Acre

Sprayer Tank = 100 Gallons

Rate of Application = 22 Gallons/Acre

$$\frac{\text{Gallons per Spray Tank X Lbs. Material/Acre (from label)}}{\text{Gallons per Acre Applied Desired (From Label)}} = \text{Pounds of Material to Add to Sprayer Tank}$$

$$\text{Final Spray Mixture (Dry Formulation)} = \frac{\text{100 Gallon Tank X 2 Lbs./Acre}}{\text{22 Gallons/Acre}} = 9\ \text{Pounds of Material Per Tank}$$

To Vary the Output (may require recalibrating your equipment)

1. Adjust pressure (minor correction)
2. Adjust speed (major correction)
3. Change nozzle or adjust nozzle spacing (major correction)

Calibrating Backpack Sprayer (or similar) Pesticide Application Equipment

This section is designed to be used when calibrating individual backpack sprayers or other hand-carried application equipment used in applying emulsifiable concentrates or other liquid pesticide formulations. Because equipment and walking speed varies by individual, EACH PERSON must calibrate their application equipment before using hand sprayers for pesticide applications. This ensures the correct pesticide application rate can be obtained.

FOLLOW THESE INSTRUCTIONS:

1. Clean your sprayer thoroughly with soap and water, sudsy ammonia or a commercial tank cleaner. Dispose of the rinse material properly. Make sure your application equipment is working properly. Fill sprayer full with clean water.
2. Measure an 18.5-foot X 18.5-foot spot in a typical weedy area. Spray this area uniformly with water and record the number of seconds it takes to evenly cover the area. Remember that consistency is vital to uniform coverage. Develop a smooth, sweeping motion with the spray wand while you walk at a comfortable pace. Keep the pressure constant.
3. Spray water into a large container for the same length of time (number of seconds recorded above) it took you to spray the plot. Maintain the same pressure used in Step 2. Measure the fluid ounces you collect. If the product you are using is formulated at 4 pounds active ingredient (a.i.) per gallon, the ounces of water collected for that specific time converts directly to gallons per acre of pesticide mixture to be applied, i.e. 30 ounces of water sprayed is equal to a rate of 30 gallons per acre.
4. Repeat the first three steps two more times and average the results for increased accuracy.
5. Determine the amount of herbicide you will need to mix in a gallon of water (see Table 4). If the pesticide you are using is formulated at a rate different than 4 pounds a.i. per gallon, do the additional math described at the bottom of the chart.

Example: Controlling a certain weed requires 3 quarts per acre of a 2,4-D product with 4 pounds a.i. per gallon. Your spray volume calculated above is 40 gallons per acre. According to the chart, you would mix 2.3 fluid ounces of 2,4-D per gallon of water to apply the correct amount of herbicide per acre. If your backpack sprayer holds 4 gallons of water, add 9.2 fluid ounces of 2,4-D to your sprayer tank (2.3 fl. oz. X 4 = 9.2 fl. oz.) If needed, convert ounces to another unit of measurement using the conversions below.

Table 4. Volume of pesticide at 4 lbs. active ingredients per gallon to mix in one gallon water*

Spray Water Volume	Desired application rate of pesticide per acre			
	1 quart	2 quart	3 quart	4 quart
10	3.3 fluid oz	6.5 fluid oz	9.5 fluid oz	12.3 fluid oz
15	2.0 fluid oz	4.0 fluid oz	6.2 fluid oz	8.5 fluid oz
20	10.0 tsp	3.2 fluid oz	4.8 fluid oz	6.3 fluid oz
30	6.0 tsp	2.0 fluid oz	3.2 fluid oz	4.2 fluid oz
40	4.8 tsp	1.6 fluid oz	2.3 fluid oz	3.2 fluid oz
50	3.8 tsp	1.2 fluid oz	2.0 fluid oz	2.5 fluid oz
60	3.2 tsp	6.3 tsp	1.6 fluid oz	2.0 fluid oz
70	2.8 tsp	5.5 tsp	1.3 fluid oz	1.8 fluid oz
80	2.3 tsp	4.8 tsp	7.2 tsp	9.5 tsp
100	2.0 tsp	3.8 tsp	5.8 tsp	7.6 tsp

***This table only applies to pesticides that contain 4 pounds of active ingredients per gallon**. **Read the label.** If the pesticide concentration you are using is different than 4 lb./gal a.i., divide the pesticide mixture number (oz or tsp.) in the chart by 4 and multiply the answer by the number of pounds of a.i. per gallon listed on your product label. Mix that quantity per gallon of water in your sprayer.

Handy Conversions

3 teaspoons = 1 tablespoon	2 tablespoons = 1 fluid ounce
8 fluid ounces = 1 cup	1 cup = 16 tablespoons
2 cups = 1 pint	2 pints = 1 quart
4 quarts = 1 gallon	1 gallon = 128 fluid ounces
32 ounces = 1 quart	1 gallon = 16 cups

1 acre = 43,560 square feet

Calibrating Granular Pesticide Application Equipment

For band application:

Where you have only a broadcast rate per acre in pounds, use this formula to calculate rate per acre for band treatment.

$$\frac{\text{Band Width in Inches}}{\text{Distance Between Rows in Inches}} \times \text{Rate/Acre for Broadcast Treatment} = \text{Amount Needed for Band Treatment}$$

Example: The product has a broadcast rate of 40 pounds per acre. Your band width is 7 inches, with 36 inches between rows (the row spacing).

$$\frac{\text{7-inch band width}}{\text{36-inch row spacing}} \times \text{40 pounds per acre broadcast rate} = 0.194 \times 40 = 7.77 \text{ or } 7\frac{3}{4} \text{ Pounds per Acre}$$

For band applications at different row spacings:

Many granular insecticide recommendations are based on an acre of 40-inch rows, or 13,068 feet of row. Row widths less than 40 inches require more granular material per acre, but the calibration in the row stays the same. Narrow rows will take more granular material per acre than wider 40-inch rows. Use Table 5 to calculate the amount used **per acre** for different row spacings.

Table 5. Band rates in pounds per acre for these row spacing

40 inch row spacing	38 inch row spacing	36 inch row spacing	30 inch row spacing	20 inch row spacing
2 lbs/acre	2.1 lbs/acre	2.2 lbs/acre	2.7 lbs/acre	4 lbs/acre
3 lbs/acre	3.2 lbs/acre	3.4 lbs/acre	4.0 lbs/acre	6 lbs/acre
4 lbs/acre	4.3 lbs/acre	4.5 lbs/acre	5.3 lbs/acre	8 lbs/acre
5 lbs/acre	5.3 lbs/acre	5.6 lbs/acre	6.7 lbs/acre	10 lbs/acre
6 lbs/acre	6.4 lbs/acre	6.8 lbs/acre	8.0 lbs/acre	12 lbs/acre
7 lbs/acre	7.5 lbs/acre	7.9 lbs/acre	9.3 lbs/acre	14 lbs/acre
8 lbs/acre	8.5 lbs/acre	9.0 lbs/acre	10.7 lbs/acre	16 lbs/acre
9 lbs/acre	9.6 lbs/acre	10.1 lbs/acre	12.0 lbs/acre	18 lbs/acre
10 lbs/acre	10.7 lbs/acre	11.2 lbs/acre	13.3 lbs/acre	20 lbs/acre
12 lbs/acre	12.7 lbs/acre	13.5 lbs/acre	16.0 lbs/acre	24 lbs/acre
14 lbs/acre	14.9 lbs/acre	15.8 lbs/acre	18.7 lbs/acre	28 lbs/acre
16 lbs/acre	17.0 lbs/acre	18.0 lbs/acre	21.3 lbs/acre	32 lbs/acre

1. Attach a paper or plastic bag or granular calibration tube to the bottom of each row delivery tube.
2. While operating the applicators, drive a distance equal to 1/20 of an acre. Determine the distance by this formula:

   $$\frac{\text{43,560 Square Feet per Acre}}{\text{Row Width in Feet X Number of Rows on Applicator X 20}} = \text{Distance to Drive in Feet}$$

   Example: to calculate the distance to drive (in feet) with a 4-row applicator set to a 36-inch (3-foot) row spacing:

   $$\frac{43{,}560}{3 \times 4 \times 20} = \frac{43{,}560}{240} = 181.5 \text{ feet (the required distance to drive for the calibration)}$$

3. After driving the required distance, remove sacks or tubes and weigh or measure the contents of each. Contents of each should be equal. If not, adjust the output of the row applicator accordingly and repeat the run to check the calibration. Then, combine contents of all sacks and weigh. Total weight should be 1/20 of the recommended amount of pesticide granules per acre.

Example: A granular insecticide is recommended for row application at 1 pound active ingredient per acre for 40-inch row spacing. The formulated product is a 20-percent granule. So, 5 pounds of the product (80 ounces, or 5 x 16) contains 1 pound of active ingredient. Divide by 20, and the combined contents of the tubes should weigh 4 ounces and be close to 1 ounce per applicator tube (there are 4 rows on the applicator).

Recalibrate when changing from one formulation to another, or with decided changes in humidity. When all applicator tubes are delivering equally, you can collect material from 1 tube and divide by 80 to get the 1-ounce reading.

For broadcast applications, use a similar calculation using this formula:

$$\frac{\text{43,560 square feet per acre}}{\text{Applicator Width in Feet X 20}} = \text{Distance to Drive in Feet}$$

For example, with a 10-foot wide application, you should drive:

$$\frac{43{,}560}{10 \text{ X } 20} = \frac{43{,}560}{200} = 217.8 \text{ Feet or } 218 \text{ Feet}$$

Weigh the total contents of the bags from each of the applicator tubes. The weight should be 1/20 of the recommended amount of granules per acre.

For example, a granular herbicide is recommended at 4 pounds active ingredient per acre, or 40 pounds of 10 percent granules. On 1/20 acre, the combined granules collected should weigh 2 pounds or 32 ounces.

Handy Conversions

1 pound = 16 ounces	1 mile = 5,280 feet
1 yard = 3 feet	1 acre = 43,560 square feet

Calibrating Chemigation Pesticide Application Equipment

Chemigation is the process of applying pesticides through an irrigation system. Proper equipment calibration is essential when using this method of pesticide application. Improper calibration can result in too little product being applied, which may result in inadequate pest control. If too much pesticide is applied, the result may be crop or environmental damage. If more chemical is used than is necessary, you will waste money, and if the recommended label rate is exceeded, the applicator may be subject to a fine or other regulatory action, including the destruction of the crop.

Some simple equipment, time and accurate calculations are necessary to calibrate chemigation equipment properly. Conditions at your work site will vary from those at the factory so it is essential that you calibrate on-site and not rely on data provided by the equipment manufacturer. Manufacturer suggestions are a good starting point and will eliminate much trial and error, but you must determine the exact irrigation water and injection pump settings for your equipment.

Measuring Equipment:

- Stopwatch
- Steel measuring tape (at least 100 feet long)
- Pocket calculator
- Flags

You will need a clear calibration tube that indicates units of volume (a graduated cylinder). The calibration tube measures the output of the injection pump and should be large enough to hold a volume sufficient for a minimum of 5 minutes of injection.

The calibration tube is located in the injection line between the injection pump and the supply tank and should be attached by valves so it can be removed when not in use. The steps below describe how to calibrate a center pivot. However, the principles apply to all pumped (sprinkler) chemigation applications.

1. Determine the area in acres to be irrigated.
2. Determine the amount of material desired per acre.
3. Determine the total amount of material required (step 1 x step 2).
4. Determine the time (in hours) that the injection will take.
5. Determine the injection rate in gallons per hour (step 3 divided by step 4).

The calibration process is based on the given measurements of the irrigating system (length, end gun wetting area, etc.), some common mathematical constants and conversions, and the desired rate of chemical injection. The following calculations must be made:

1. Area irrigated
2. Amount of chemical required
3. Travel speed
4. Revolution time
5. Recommended chemical application rate

The following example illustrates the procedure.

1. Area Irrigated:

The area irrigated must be calculated using one of several possible formulas. The degree of difficulty in making this calculation depends on the configuration of the field. The simplest case would be a complete circle without intermittent end guns or corner watering systems. The calculation is:

$$\text{Area of the Circle in Acres} = \frac{\pi \times r^2}{43{,}560 \text{ sq. ft per Acre}}$$

Where:

r = the wetted radius, in feet (the length of the pivot)

π = 3.1416

For this example:

r = 1,300 ft:

$$\text{Area} = \frac{3.1416 \times (1{,}300 \times 1{,}300)}{43{,}560 \text{ square feet per acre}} = 122 \text{ Acres}$$

The area irrigated becomes increasingly more complex with when there are partial circles, circles with intermittent end guns and other configurations. In many cases, it may be wise to leave the end gun off because the water pattern is easily distorted by wind. If an end gun shutoff fails, it may result in an off-target application.

2. Amount of Chemical Required:

Chemical Required = Acres Irrigated X Recommended Chemical Application Rate

In this example, 1 quart of chemical is required per acre:

Chemical required = 122 Acres irrigated X 1 Quart Chemical per Acre
= 122 Quarts (30.5 Gallons) Needed to Treat the Entire Field

3. Travel Speed:

For moving systems, travel speed is one of the most important measurements. When calculating the irrigation system speed, the system should be running "wet" and at the speed and pressure that will be used while chemigating. Always recalibrate when changing speed settings or pressure. Avoid determining pivot speed at one percentage setting and mathematically calculating the pivot speeds for other settings, other than to obtain a "rough" figure.

Two measurements, time and distance, are required to calculate the rotational speed of the pivot. They can be taken in several ways:

- Record the time necessary for the outer pivot tower to travel a pre-measured distance (usually a minimum of 50 ft.).
- Measure the distance traveled by the outer pivot tower in a pre-selected time (usually a minimum of 10 minutes).

The end result of either method is rotational speed in ft/minute. Be aware that a measurement error of only a few feet or a few minutes can create a significant error in the entire calibration process. If the percentage timer is set at less than 100 percent when determining pivot speed, make sure the start and stop measurements are taken at the same points in the move/stop cycle. This is not a concern with some oil hydraulic pivots where the end tower moves continuously. If the terrain is rolling or sloped, check rotational speed at several locations in the field and calculate the average value. It may also be wise to verify rotational speed several times throughout the season to account for differences in wheel track resistances due to cover, soil compaction, track depth, etc.

Assume the measured distance per 10 minutes = 65 ft:

$$\text{Travel Speed} = \frac{65 \text{ Feet}}{10 \text{ Minutes}} = 6.5 \text{ Feet per Minute}$$

4. Revolution Time:

The circumference of the last wheel track and the rotational speed of the pivot are the two measurements needed to calculate revolution time. Circumference is calculated by the formula:

Circumference = $2 \times \pi \times r$

r = the distance in feet from the pivot point to outer wheel track
$\pi = 3.1416$.
For this example, r = 1280 feet

Circumference = $2 \times 3.1416 \times 1280 = 8042$ Feet

Even though the owner's manual accompanying the irrigation system might list the system length, the length required for this calculation is measured from the pivot point to last wheel track. It does not include the overhang. It is a good idea to accurately measure this distance once and permanently record it in the control panel.

Revolution time is calculated by dividing the circumference in feet by the rate of travel in feet per minute.

$$\text{Revolution Time} = \frac{\text{Circumference (Feet)}}{\text{Travel Speed (ft/min)}}$$

Then:

$$\text{Revolution Time} = \frac{8042 \text{ Feet}}{6.5 \text{ ft/min}} = 1237 \text{ Minutes per Revolution}$$

To convert the revolution time to hours, divide the above answer by 60.

Example:

$$\frac{1237 \text{ Minutes}}{60 \text{ min/hr}} = 20.6 \text{ Hours per Revolution}$$

5. Chemical Application Rate:

The application rate is the amount of formulated material needed to treat the field (step 2) divided by the revolution time in hours (step 4).

$$\text{Chemical Application Rate (Gallons per Hour, or gph)} = \frac{\text{Total Material Needed (Gallons)}}{\text{Hours/Revolution}}$$

Example:

$$\text{Chemical Application Rate} = \frac{30.5 \text{ Gallons}}{20.6 \text{ Hours}} = 1.48 \text{ gph}$$

Determining these amounts in gallons per hour (gph) is necessary because most commercially available pumps are rated in gph. Knowing the injection pump capacity in relation to the delivery rate needed can help you establish an initial pump setting. However, be aware that book output values of pumps are normally measured at the factory based on a drive shaft speed of 1725 rpm. Any variance in this shaft speed will alter the pump output. When the injection pump is belt driven from the engine drive shaft, a tachometer is helpful. Pump wear will also alter output. Fine-tuning should be accomplished using a calibration tube placed on the suction side of the injection pump.

Chemicals vary in viscosity and density. Always make the final calibration using the material to be injected and at the operational pressure of the irrigation system. If the volume is small, as with an insecticide, and the calibration tube is measured in milliliters or ounces, gph can be converted to milliliters/minute by multiplying gph X 63.09 or can be converted to ounces/minute by multiplying gph X 2.133.

- If the calibration tube is in milliliters, 1.48 gph X 63.09 = 93 ml/minute.
- If the calibration tube is in ounces, 1.48 gph X 2.133 = 3 oz/minute.

This amount of chemical, in ml/min or oz/min, is the working factor for calibrating the injection pump. Using the calibration tube, make coarse adjustments on one-minute time checks. Make a final check over an extended time period of at least 5 minutes.

For an initial injection pump setting, the desired injection rate is divided by the pump capacity to give a percent setting.

Example:

Required injection rate is 1.48 gph.

Pump is rated at 4 gph max.

$$\text{Injection Rate, \% of Capacity} = \frac{1.48 \text{ gph}}{4.00 \text{ gph}} \times 100 = 37\%$$

Thus, 37 percent is the suggested first setting for the initial calibration attempt.

Calibrating a Stationary Sprinkler System

Solid set, hand lines and wheel lines are examples of stationary irrigation systems that can be used for applying agricultural chemicals.

An advantage of the stationary system is that you can inject the chemical at any time during the irrigation process. An herbicide may be injected midway through the irrigation period to allow additional water to be applied for incorporation. A foliar insecticide, in contrast, will usually be applied near the end of the irrigation cycle to limit the amount of water that is applied following the insecticide application to reduce wash off.

The following is one way to calibrate a stationary sprinkler system.

1. Determine the acres to be irrigated in one set. Multiply the lateral spacing along the main line by the length of the lateral and divide by 43,560 (square feet per acre). If more than one lateral is being operated simultaneously, also multiply by the number of laterals.

   Example: 10 laterals, 800 feet long, spaced 40 feet apart.

   $$\text{Area Irrigated} = \frac{800 \text{ ft} \times 40 \text{ ft} \times 10}{43{,}560 \text{ ft}^2/\text{acre}} = 7.3 \text{ Acres}$$

2. Determine the amount of formulated chemical needed per acre by consulting the product label.
   Example: 4 Pounds of Wettable Powder Herbicide per Acre
3. Determine the total amount of chemical needed (Step 1 X Step 2).
   Example: Total Chemical = 7.3 Acres X 4 Pounds per Acre = 29.2 Pounds
4. Determine the amount of water to be applied during the application. Follow recommendations on the product label.
   Example: The herbicide label recommends that 1.0 acre-inch of water be applied and that the herbicide be injected during the first half of the irrigation period.
5. Determine the rate of water application by the irrigation system. Attach a short piece of hose to the nozzle outlet(s) of one sprinkler, start the irrigation system, and capture and measure the flow for 1 minute in a pail or graduated measuring device. Repeat this procedure at several sprinklers along the lateral and determine the average sprinkler flow rate. Given the sprinkler flow rate in gallons per minute and the sprinkler spacing, the water application rate in inches per hour can be determined from application rate tables or by using the following equation:

Water Application Rate, Inches/Hour = $\frac{96.3 \times gpm}{S_1 \times S_m}$

Where gpm = discharge from sprinkler (sprinkler flow) in gallons per minute
S_1 = spacing of sprinklers on lateral in feet
S_m = spacing of lateral on main in feet.

Example:
Sprinkler Flow = 4 gallons per minute.
Sprinkler Spacing = 40 ft (S_1) X 40 ft (S_m)
Water Application Rate, Inches/Hour $= \frac{96.3 \times 4\ gpm}{40\ ft \times 40\ ft} = 0.24$ in/hr

Another method to determine the water application rate is to determine the sprinkler nozzle size (usually stamped on the nozzle) and discharge pressure, and then consult the sprinkler manufacturer's application rate table. Adjust the length (time) of the irrigation to apply the amount of water necessary for proper chemical application.

6. Determine time to irrigate. Divide the gross amount of water to be applied by the rate of water application (Step 5).

   Gross Irrigation Amount $= \frac{\text{Net Irrigation Amount}}{\text{Irrigation Application Efficiency}}$

   Irrigation Time $= \frac{\text{Gross Irrigation Amount}}{\text{Water Application Rate}}$

   Example:
   Irrigation application efficiency = 80% (assumed) = 0.80
   Net irrigation = 1.0 in.
   Gross Irrigation Amount $= \frac{1.0\ inch}{0.80} = 1.25$ inches

   Irrigation Time $= \frac{1.25\ in}{0.24\ in/hr} = 5.2$ hours

7. Fill the solution tank with the chemical to be applied or chemical-water solution. Start the tank agitator if needed.

   Example: Add 30 gallons of water (approximately 1 gallon of water for each pound of wettable powder) to solution tank, start agitator, and add 29.2 pounds of formulated herbicide. Add more water to bring total volume to 50 gallons.

8. Determine the injection rate by dividing the total gallons in the tank (Step 7) by the time (hours) required to apply the chemical.

   Assume that chemical will be applied for 2 hours at the midpoint of the irrigation time.
   Example: Injection Rate $= \frac{50\ Gallons}{2\ Hours} = 25$ Gallons per Hour

9. Calibrate the delivery rate of the injection pump to make certain the rate is correct.

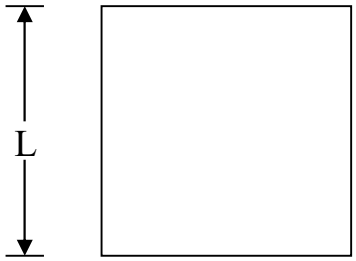
10. If the chemical solution is to be applied throughout or during the last part of the irrigation cycle, allow the irrigation system to operate for sufficient time after the injection to completely flush the chemical from the system. The time required will normally be a minimum of five minutes and may be as long as 15 to 20 minutes.

Determining Irrigated Acreages

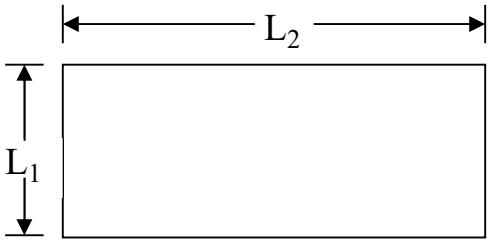
Formulas for calculating acreages in fields and irregular portions of fields are shown below. For irregular fields, sum the areas of the parts of the field using the closest approximations.

1. Area of a square.
   Area of a square = L X L = L^2
   "L" is the length, in feet, of one side of the square
   If L = 2640'
   L^2 = 2640 X 2640 = 6,969,600 ft^2
   Area = 6,969,600 sq. ft
   Acres = $\frac{\text{Area (in } ft^2)}{43{,}560\ ft^2/\text{acre}}$

   Acres = $\frac{6{,}969{,}600\ ft^2}{43{,}560\ ft^2/\text{acre}}$ = 160 Acres

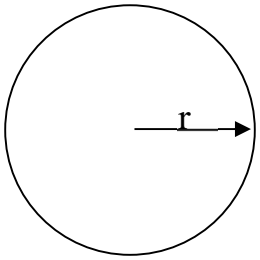


2. Area of a rectangular field.
   Area = L_1 X L_2
   If L_1 = 2640 feet and L_2 = 5280 Feet,
   Area = 2640' X 5280' = 13,939,200 sq. ft
   Acres = $\frac{13{,}939{,}200\ \text{sq. ft}}{43{,}560\ ft^2/\text{acre}}$ = 320 Acres



3. Area of a circle.
   Area = r^2 X π where r = the radius and π = 3.1416
   If r = 1300'
   Area = 1300^2 X 3.14 = 5,309,291 sq. ft

   Acres = $\frac{5{,}309{,}291\ \text{sq. ft}}{43{,}560\ \text{sq. ft}}$ = 121.88 Acres



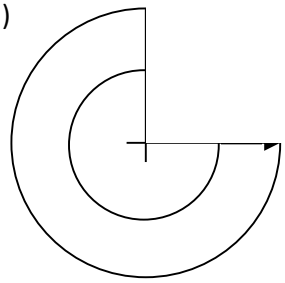
4. Area of part of a circle.

   Area = (r^2 X π) X $\frac{<°}{360°}$ (this is the number of degrees in the partial circle*)
   (this is the total number of degrees in a circle)

   If r = 1300 and <° = 270°

   Area = (1300^2 X 3.1416) X $\frac{270°}{360°}$ = 3,981,978 ft^2

   Acres = $\frac{3{,}981{,}968\ ft^2}{43{,}560\ ft^2}$ = 91.41 Acres



   * <° = Number of degrees, measured with a protractor

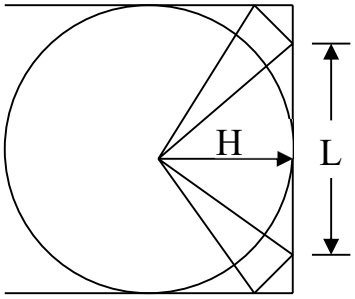
5. Area of a triangle.

   Area = $\frac{H \times L}{2}$

   If H = 1300 ft and L = 1900 ft

   Area = $\frac{(1300)\ (1900)}{2}$ = 1,235,000 ft^2

   Acres = $\frac{1{,}235{,}000}{43{,}560\ ft^2/acre}$ = 28.4 acres



   "H" is the same as system length and is equal to the "radius"

   "L" is length of the base in the triangle

   NOTE: To estimate the acreage included in a very irregularly shaped area irrigated by a corner system, draw a straight line or a circular arc that will most nearly provide an "average" boundary.

Originally published in 1987 as Guidelines for the Safe Use of Pesticides, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.
Updated in 2022 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

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