Pesticide Application & Safety Training for Applicators of Public Health Pesticides

California Department of Public Health

Vector-Borne Disease Section

Instructions

This study guide is meant to replace the manual Pesticide Application & Safety Training for Applicators of Public Health Pesticides.

You can navigate through the guide at your own pace and in any order.

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Click on the button if you want to return to a particular chapter's table of contents.

Click on the button if you want to access the glossary. Important terms are highlighted in yellow and appear in the glossary. The link to the glossary can be found at the beginning of each chapter.

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Introduction: Pesticides

Pesticides are chemical substances used to kill, repel, or control pests of all kinds.

- **Pests: Arthropods and vertebrates of direct public health importance or vegetation, especially weeds, that contributes to arthropod pest production.**

Used to control vectors.

Vector

“Any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including but not limited to: mosquitoes, flies, mites, ticks, other arthropods, and rodents and other vertebrates”. (California Health and Safety Code Section 2002(k)).

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Basic law controlling pesticides, signed into law in 1947.

Established the requirement for registration of pesticides by the US Department of Agriculture.

In 1970 this responsibility was passed to the newly established US Environmental Protection Agency (EPA).

Amendments to FIFRA

1988 – FIFRA-lite: required re-registration of all pesticides.

Currently the EPA has the authority for interpretation and enforcement of pesticide laws, including registrations.

US Food and Drug Administration (USFDA) has the authority to enforce pesticide tolerances on food and raw agricultural commodities.

FIFRA continued…

1972 version of FIFRA established two categories of pesticides:

- **Unclassified: (General Use) available for the public.**
- **Restricted Use: available for use by certified applicators only.**

FIFRA continued…

FIFRA delegates responsibility for certification of restricted use pesticide applicators to the individual states.

- **In California, the California Department of Public Health certifies government employees who apply restricted pesticides (HSC 106925).**

FIFRA Requirements

All pesticides must undergo thorough testing for efficacy, safety, and toxicity as a basis for registration

All pesticide formulations must be clearly and completely labeled as a condition of their sale.

FIFRA Administration in CA

California Environmental Protection Agency: Department of Pesticide Regulation (DPR)

- **DPR maintains direct oversight of pesticide registration and use-reporting, usually working through local County Agricultural Commissioners.**
- **California and all other states can and do further regulate the sale, use, and possession of pesticides via a state process that mirrors the federal process**

CHAPTER 1: Public Health Pests and Disease Vectors

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Introduction

How to identify a pest

Invertebrates

Vertebrates

Weeds

INTRODUCTION: Public Health Pests

Public health pests are organisms which attack or annoy us in some manner.

Some animal species carry pathogenic microbial organisms such as bacteria or viruses.

If an animal such as an insect which bites or stings a person and the person becomes ill, then the animal has served as a disease vector.

Public Nuisances

California Health and Safety Code 2002(j)) defines a public nuisance as:

“Any property, excluding water, that has been artificially altered from its natural condition so that it now supports the development, attraction, or harborage of vectors”.

Any water that is a breeding place for vectors.

Any activity that supports the development, attraction, spread or harborage of vectors.

First Step to Solving a Pest Problem

<u>Properly identify the species</u>: Often a difficult task best left up to highly specialized biologists (taxonomists).

Identification of species is important to understand the habits, developmental sites, and susceptibility of the pests to control measures.

Pests can be invertebrates, vertebrates or plants.

First Step to Solving a Pest Problem

Only after gaining experience can pesticide applicators know which pests can be identified by sight and which pests will need to be sent to specialists for identification.

Failure to properly identify a pest causing a problem can result in wasted time, money, chemicals and effort.

HOW TO IDENTIFY PESTS

Compare collected specimens with identified specimens in museums or with photographs.

Use an illustrated key.

Contact an authority (farm advisor, agricultural commissioner, or a biologist in the USDA, Cooperative Extension, public health department, or at a college/university).

INVERTEBRATES

Invertebrates are organisms that lack a spine. Examples are insects, spiders sponges, starfish, earthworms.

Nearly all of public health invertebrate pests are in the Phylum Arthropoda and are called arthropods.

- **Insects and arachnids (ticks, mites, and spiders)**

Insects and related arthropods

Public health pests include cockroaches, mosquitoes, gnats and other flies, wasps and bees.

Pest insects may vector disease or annoy by causing allergic reactions, stinging or invading body tissues.

VERTEBRATES

Vertebrates are organisms with a spine. Examples are dogs, cats and humans.

Pest vertebrates include rats, mice, venomous snakes and birds.

It is important to remember that a pest in one setting may be beneficial in another.

- **Rattlesnakes are unwelcome in residential yards but are prized by farmers for eating field rodents.**

WEEDS

A **weed** is a plant growing where it is not wanted.

Weeds can affect public health by promoting mosquitoes or other arthropod pests and providing protection to injurious species.

Weeds can be controlled with herbicides.

CHAPTER 2: Pesticide Classifications and Formulations

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Classification of pesticides

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Rodenticides

Pesticide formulation

Pesticide formulations with a combination of pesticides

INTRODUCTION TO PESTICIDES

Pesticides are defined as substances or mixtures of intended for controlling, preventing, destroying, repelling or attracting any biological organism deemed to be a pest.

Examples include insecticides, herbicides, avicides, and nematicides.

CLASSIFICATION OF PESTICIDES

Pesticides may be classified in a number of ways. These classifications can provide useful information about the pesticide chemistry, how they work, what they target, etc.

Slides 27 through 47 are brief descriptions of some commonly used classification systems.

Classification: Chemical Nature

Organic or inorganic.

Organic pesticides can be further divided into natural synthetics and synthetic organics

- **Natural organics are derived from plants. Examples are pyrethrum and rotenone.**
- **Synthetic organics are produced through chemical synthesis and comprise most "modern" pesticides. Examples are permethrin and malathion.**

Classification: Target Pest Species and Pesticide Function

PESTICIDE	TARGET PEST/FUNCTION
Acaricide	Mites, ticks
Anticoagulant	Rodents
Attractant	Attracts insects/birds
Avicide	Birds
Bactericide	Bacteria
Defoliant	Plant Leaves
Desiccant	Disrupts water balance in arthropods
Fungicide	Fungi
Growth regulator	Regulates insect and plant growth
Herbicide	Weeds
Insecticide	Insects
Molluscicide	Snails, slugs
Nematicide	Nematodes
Piscicide	Fish
Predacide	Vertebrate predators
Repellent	Repels vertebrates, invertebrates
Rodenticide	Rodents

Classification: Chemistry

Insecticides are designed to control insects, and acaracides control ticks and mites.

In public health applications, they are most commonly used to control mosquitoes, flies, ticks, mites, lice, and fleas. Since insecticides and acaracides are often the same pesticides, they are not discussed separately.

Organochlorines

Chlorinated hydrocarbons: Includes the well known insecticide DDT (still legally used in some areas of the world).

In the United States: DDT's registration has been suspended by EPA for nearly all uses.

Most other organochlorines (chlordane, dieldrin, and lindane) have met similar fates.

Organophosphates (OPs)

Contain phosphorous in their molecules (naled, malathion, and some formulations of dursban).

Are considered by most to pose a greater human health risk for pesticide applicators that other families of pesticides.

Use has dramatically decreased because of resistance, the potential for non-target effects, and the development of alternative products.

Carbamates

Chemically similar in structure to organophosphates, but are derivatives of carbamic acid.

Carbaryl (Sevin) for dusting rodent burrows to control fleas, Propoxur (Baygon) for use against insect pests, as well as bee and wasp control sprays and some herbicides.

Pose a relatively high risk for human poisoning.

Pyrethrum

Natural organic insecticide that is derived from plants in the genus *Chrysanthemum*.

Considered amongst the safest for use around food because they are non-persistent (breaking down easily on exposure to sunlight).

Insecticides containing pyrethrins are neurotoxic to nearly all insects. They are harmful to fish (direct application to water is restricted) but far less toxic to mammals and birds (in comparison to other synthetics).

Synergists

Materials that are not necessarily pesticidal by themselves, but have the effect of increasing the toxicity of insecticides with which they are mixed.

Pyrethrins are usually mixed with PBO (piperonyl butoxide) which acts as a synergist. Without PBO, insects treated with the same dose of pyrethrins would be knocked down, but would eventually recover.

PBO may have a long residual life in aquatic systems.

Pyrethroids

Non-persistent synthetically produced molecules that are chemically similar to pyrethrins.

At rates applied for vector control, they break down quickly in sunlight and are rarely present after just a few days.

Mode of action is the same of pyrethrins and are also synergized with PBO.

They may not break down as readily in sunlight as do pyrethrins.

Pyrethrins & Pyrethroids

Are now among the most common public health pesticides used in California, especially for the control of adult mosquitoes.

Biorational Pesticides

The EPA defines biorationals as "certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals". Also called biopesticides.

Relatively non-toxic to humans and environmentally safe.

There is presently no strict legal definition for the term biorational: some products (such as Bti) will satisfy definitions for both biorational and biological control agent.

Two Groups of Biorational Pesticides

1. **Biochemical: hormones, enzymes, pheromones, and natural insect and plant regulators. Example: methoprene (Altosid).**

2. **Microbial: viruses, bacteria, fungi, protozoa, and nematodes. Example: *Bacillus thuringiensis israelensis* (Bti).**

Biorational Pesticides

The EPA defines biorationals as "certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals." Can be either biochemical (hormones, enzymes, pheromones) or microbial (bacteria, viruses, fungi, or protozoa).

Not particularly selective among arthropod species, but generally have extremely low toxicity for vertebrates, including people.

Insect growth regulators (IGRs) are a biochemical, biorational pesticide. IGRs disrupt the molting process of insects, keeping pupae from molting into adults.

Example: Methoprene is an IGR used in mosquito control.

Microbial Pesticides

Kill arthropods either by toxins released by microbial organisms, or by infection by the organisms (most are more selective than biochemical pesticides).

Example: bacterial toxin produced by Bti, and the live bacteria: *Bacillus sphaericus* (Bs).

These bacteria are used against mosquito larvae (with Bti being effective in killing black fly larvae as well).

Classification: Materials Applied to Water Surfaces

Alcohols: act by reducing surface tension of the water, eventually leading to the drowning of mosquito larvae or pupae (i.e. Agnique).

Petroleum Oils: refined from crude oil and used as both a carrier for insecticides and more directly as active ingredients when mixed with a surfactant and applied to the surface as a suffocating agent against mosquito larvae an pupae (i.e. Cocobear).

Other Classifications: Stomach Toxicants

Stomach toxicants enter an insect's body through mouth and digestive tract.

Bacteria or their toxins applied to water where filter-feeding mosquito or black fly larvae consume the poison.

Kill by destroying the midgut (stomach) of the larvae.

Ingested Anticoagulants

Used to control rodents – who die from internal bleeding, the result of loss of the blood's clotting ability and damage to the capillaries.

Delayed action: effects follow several days after ingestion of the lethal dose. As a result, bait shyness usually does not occur.

This is also a safety advantage because this delayed action gives time to administer the antidote (vitamin K1) to save pets, livestock, or people who have accidentally ingested the bait.

Contact Toxicants

Generally enter the pest or plant by exposure to water, some treated surface (leaves) or an aerosol (insecticidal fog).

Act upon the nerve and respiratory centers of arthropods.

Most adult mosquito control products are contact toxicants.

Fumigants

Volatile compounds that enter the bodies of insects in a gaseous phase.

No longer any registered for use against insects in California, but are sometimes used in rodent control.

Systemic Toxicants

Absorbed by plants, pets, or livestock and are disseminated throughout the organism via the vascular system.

Some are quickly lethal, others work to prevent the pest from maturing.

Typically used for tick and flea control on pets, as well as dog heartworm prevention.

Chemical Repellents

Prevent bloodsucking insects from biting humans, livestock, or pets.

Most common used to protect people is dimethyl toluamide (DEET).

Mechanical repellents (such as high frequency emitters) are generally unproven and ineffective.

HERBICIDES

Vector control agencies frequently use herbicides to kill plants, or inhibit their growth when the plants either contribute to vector ion or prevent technicians from being able to control vectors efficiently.

Herbicides can be separated into organic or inorganic materials.

Organic Herbicides

Two major groups: petroleum oils and synthetic organic herbicides.

Petroleum oils are refined rom crude oil, and are usually applied without dilution.

Synthetic organic herbicides are artificially created in laboratories. Common synthetic organics are 2,4-D and glyphosate.

Inorganic Herbicides

Chemical compounds which do not have a carbon structure, such as salt, copper, sulfate, sulfuric acid, and sodium chlorate.

The salt or metal is toxic to plants, often preventing proper uptake of water or inhibiting movement of material across cell walls.

Many are restricted materials because these herbicides are extremely persistent and have caused serious soil pollution problems.

Phenoxies

Used in both crop and non-crop areas for control of most annual and perennial broadleaf weeds.

2,4-D, MCPA, dichlorprop (2,4-DP), and 2,4-DB (Butoxone or Butyrac).

Primarily plant growth regulators and affect the actively growing tissue of the plant.

Ester formulations of the phenoxies are relatively volatile and turn into a gas during hot summer days. Care should be taken to not use them around susceptible broadleaf plants and ornamentals.

Triazines

Used to control annual grasses and broadleaf weeds. Triazines affect plants by inhibiting their ability to photosynthesize.

Have been found as contaminants in groundwater.

Atrazine (Aatrex), simazine (Princep), and metribuzin (Sencor or Lexone).

Primarily used as non-selective pre-emergent herbicides.

Prometon (Pramitol) can be used as a pre-emergent or post-emergent herbicide on non-crop land.

Thiocarbamates

Used for control of annual grass seedlings and broadleaf weed seedlings.

EPTC (Eptam).

Inhibit the meristematic growth of plants, such as root and shoot tips and are applied as a pre-plant, soil incorporated treatment.

Ureas & Uracils

Ureas: Diuron (Karmex), tebuthiuron (Spike) and uracil: bromacil (Hyva).

Primarily applied to soil as pre-emergence herbicides, but also provide post-emergence control for certain plants.

Affect plants by inhibiting their ability to photosynthesize.

Benzoics

Used in both crop and non-crop areas for control of numerous broadleaf weeds and annual grasses.

Banvel is a commonly used benzoic acid.

Effective when applied either to the plant foliage or to the soil and work as plant growth regulators that affect the actively growing tissues of plants.

Acetanilides

Used for control of many annual grasses and broadleaf weeds.

Alachlor (Lasso), acetochlor (Harness or Surpass), metolachlor (Dual) and pronamide (Kerb).

Can be applied either pre-emergence or pre-planting in crop areas.

Sulfonylureas

Used to control many broadleaf plants in small grain crops, pastures, and non-crop areas.

Highly active compounds used at extremely low rates.

Chlorsulfuron (Glean and Telar), triasulfuron (Amber), sulfometuron (Oust) and metsulfuron (Ally and Escort).

Applied as foliar treatments and also to control newly emerging broadleaf seedlings.

Chlorsulfuron and sulfometuron are more persistent in nature and will carry over into a second year when applied to high-PH soils. Low residues from wind drift or in wind blown soil can cause losses in crops like corn, potatoes, and sugar beets.

Imidazolinones

Act as biosynthesis inhibitors within the actively growing plant.

Broad spectrum herbicides and may be used against grass, broadleaf annuals, biennials, and perennials, vines, brush and trees.

Root uptake from soil may result in tree death.

Imidazethapyr (Pursuit), imazamethabenz (Assert), and imazapyr (Arsenal).

Herbicides Pattern of Use

Herbicides can be selective or non-selective.

Applied to soil or plant foliage.

How the herbicide moves within the plant (systemic versus non-systemic).

Where it may be used (terrestrial, aquatic, ditch bank, etc.).

Classification differs because the effects of many herbicides depends on dosages.

Selective Herbicides

Used to control certain plant species without injuring others.

Some affect plant foliage while leaving roots unaffected.

Can be applied to water before (pre-emergence) or soil (post emergence) after the growing season of plants).

The most common selective herbicides are those that affect broad-leaf plants but not grasses. Some herbicide formulations will wet broad-leaved plants but run off grasses.

Complete Weed Kill

Requires well-directed and properly applied sprays when using contact herbicides.

Complete coverage of the weed is a must.

Otherwise application of selective herbicides may kill only the parts of the plant actually sprayed.

Selective Herbicides: 2,4-D, dicamba, and picloram.

Pre-emergent herbicides with selective properties: atrazine, trifluralin, and oryzalin.

Non-selective Herbicides

Must be used with extreme caution. Do not apply in sloping areas or where soil may be taken for use in a different location.

Accurate dilution and calibration of equipment is critical along with designing sound weed control strategies.

Used primarily in situations where complete removal of vegetation is desired, such as transportation right-of-ways.

Glyphosate, imazapyr, bromacil, and paraquat.

Contact Herbicides

Applied directly to the plant, and may affect only the part of the plant contacted.

Can be used for preventing growth of bush and tree limbs into pathways.

Bromoxynil, paraquat, and diquat.

Systemic Herbicides

Pesticides that move from one part of the plant to another via the plant's vascular system.

Particularly useful for control of deep rooted perennial vegetation.

Plant foliage systemic pesticides: MSMA, glyphosate, dichloprop, 2,4-D, dicamba, picloram, and chlorosulfuron.

Soil applied systemic pesticides: Simazine, diuron, pronamide, and EPTC.

Triazines and thiocarbamates will translocate through both processes (but root uptake is recommended).

Plant Growth Regulators

Used for regulating or suppressing the growth of a plant and/or seeds.

May be very selective, preventing growth or seed production of certain grasses, brush, or annual broadleaf plants without affecting non-target grasses.

Usually applied directly to the foliage of the target plant.

Factors Affecting Foliar Applied Herbicides

Age and degree of maturity of plants treated.

Time and weather conditions of day of the application (as well as season of the year).

The life cycle stage of the plants (budding, flowering, overwintering etc.).

Type of life cycle of the plant (annual, biannual, or perennial.

Life form of the plant treated (woody, succulent, broad leaved, grassy etc.).

Morphology of the plant treated (cuticle thickness, presence of leaf hairs etc.).

Factors Affecting Soil Applied Herbicides

Physical and chemical characteristics of the soil as well as the climatic conditions will determine effectiveness of a soil applied herbicide, the persistence of it in the soil, and the potential movement of the herbicide through the soil (leachability).

Polarity of their constituent particles (positive, negative, or neutral).

Soil texture: light soil (sands, loams), or heavy soils (clays) and the presence of an underlying hard-pan.

The amount of organic material in the soil.

Moisture content of the soil.

Soil Testing

Local county extension office or a Natural Resources Conservation Service (NRCS) Office can give information on collection of soil samples for testing.

Herbicide labels have recommended rates of application based on the soil texture.

The texture is determined by the percentage of sand, silt, clay and organic material in it.

Generally: heavier soils require higher amounts of herbicide for plant control than lighter soils.

Herbicide Persistence

Factors include:

Rate of application, soil temperature, exposure to sunlight, microbial and chemical decomposition, solubility of a herbicide, and precipitation.

These also affect how fast an herbicide will be degraded, and how deep it will leach through the soil.

Planning Herbicide Applications

Consider the vegetation that is close to the application site.

Take precautions to avoid movement of herbicides into surrounding areas.

Should be avoided when it is raining, windy, or in areas where overland water flow is likely to occur.

Volatile herbicides such as the 2,4-D ester formulation and dicamba will vaporize during hot summer days.

General Recommendations

Mix and apply herbicide formulations having a low volatility.

Apply herbicides using the lowest practical spray pressures.

Apply herbicides using the largest practical spray droplet size.

Apply herbicides when wind speed is low.

Do not apply herbicides during a temperature inversion (when air is coolest at ground level, gets warmer up to a certain height and cooler from that point up.

Aquatic Plant Systems

Management of vegetation in and around lakes and ponds, other than limited applications of algaecides and control of emergent vegetation, is beyond the scope of activities covered by a vector control technician license.

Active management of aquatic systems is very complicated and takes specialized knowledge – needs additional training and certification.

RODENTICIDES

Primary targets: rodents such as rats and mice in urban and suburban environments, but can be used in rural settings to control diseases such as plague and hantavirus.

Other vertebrates may targeted because they are disease reservoirs or because of damaging activities. Example: squirrels, gophers, hares, and rabbits damaging infrastructure.

Classification of Rodenticides

First Generation: higher concentration, usually between 0.005 and 0.1%. Consecutive intake over multiple days so a lethal dose may bio-accumulate. Considered less toxic.

Second Generation: ("superwarfarins") applied in lower concentrations in baits (usually in order 0.001-0.005%) and are usually lethal after a single ingestion. Effective against rodents that are resistant to first generation anticoagulant.

Coumarins

Most widely used group of rodenticides.

Affect all mammals, including humans, by serving as blood anticoagulants.

Kill rodents over time by two related effects: inhibiting prothrombin formation, thus disrupting clotting, and they also damage capillaries, resulting in internal bleeding.

Best known member of this group is Warfarin.

Coumarins

Warfarin very successful as a rodenticide when it was first introduced because rodents did not exhibit bait shyness due to the extended period of action of the coumarins.

Physiological resistance to coumarins have been reported in rats in some areas.

Some newer coumarins developed (brodifacoum, bromadiolone) will kill rodents in 4-7 days after a single feeding (can be used where rodents are encountered that are resistant to conventional anticoagulants).

Indandiones

Anticoagulants such as Pindone, Diphacinone, and chlorophacione.

- **Pindone was the first anticoagulant developed, and requires daily feeding to cause rodent death.**
- **Diphacinone will cause death after a single feeding, but over time may induce bait shyness.**
- **Chlorophacione will result in rodent death after a single feeding, and unlike other anticoagulants: does not cause bait shyness.**

Benzenamines

Not an anticoagulant, but are particularly effective against Norway rats, roof rats, and house mice.

Bromethalin: (Vengeance, Fastrac, Gladiator).

When used with baits, rodents stop all feeding after a single dose and death occurs shortly after ingestion.

Cholecalciferol (Vitamin D3)

Active ingredient in the rodenticides Quintox, Rampage, and Muritan.

Cause calcification of soft tissues, which can be fatal to rats after extended feeding.

Used in baits and is tasteless.

Less toxic to humans than most rodenticides, but may poison small pets.

Compound 1080

Sodium Fluoroacetate: one of the most poisonous pesticides known.

This material has gained considerable notoriety in connection with coyote control programs.

Governor predator control programs are now the only permitted use of Compound 1080.

Strychnine

Botanical rodenticide – highly toxic to all warm-blooded animals.

Somewhat commonly used for gopher and other underground pest control when pets and people are not present.

Elsewhere is rarely used because of it's high toxicity and its relative poor performance as a rodenticide in comparison with anticoagulants.

By Pesticide Formulation

Definition: The resulting mixture of pesticide active ingredients, diluents, synergists, additives, and carriers. This is the form that pesticides are sold by distributors or retailers.

It is also the form of pesticides that EPA registers.

Formulations are another way to classify pesticides.

Technical Grade

Unformulated pesticides used only by toxicologists and other pesticide chemists or biologists conducting tests on pesticide resistance.

Either formulated by manufacturers or by commercial pesticide distributors.

All formulations sold in the USA must be labeled with complete instructions and restrictions for use.

PESTICIDE FORMULATION

Done to improve safety, ease of handling, storage, ease of use, and effectiveness of pesticides.

Almost always the form in which pesticides are obtained by vector control specialists (must be registered, have an EPA registration number, a label, and a Material Safety Data Sheet.

May undergo a final dilution with water or other diluent after being added to a spray tank or similar device (not formulation – tank mix).

Emulsifiable Concentrates

Concentrated oil solutions of technical grade pesticides combined with an emulsifier added to permit further mixing with water.

Emulsifiers are detergent like materials that allow the suspension of very small oil droplets in water to form an emulsion.

Used widely in vector control operations with the final water dilutions being made in spray tanks (mixes are milky in appearance).

Losing popularity somewhat with the rise in costs of petroleum products.

Wettable Powders

Finely ground, dry powders consisting of active pesticide ingredients mixed with other ingredients to aid in mixing and dispersion.

Intended for mixture with a liquid (usually water) for application by spray equipment.

Generally mixed with water to form a slurry before being added to the spray tank.

Require constant agitation.

Wettable powders are harder on equipment than other formulations and can cause wear on pumps, gaskets, and spray nozzles.

Soluble Powder

Similar to wettable powders except the active ingredient as well as the diluent and all formulating ingredients are completely soluble in water.

Uses are similar to those of wettable powders.

Dusts

Finely ground mixtures of active ingredient and a carrier material.

Intended for direct application without further mixing.

Never used where drift is a potential problem.

For this reason herbicides are not formulated as dusts.

In vector control, dusts are frequently used to control fleas and other ectoparasites on pets.

Also applied to rodent burrows and bait stations to control fleas in plague control operations.

Granules

In a granular formulation, the active ingredient is mixed with various inert clays to form particles of various sizes.

These require specialized dispersal equipment, and may be applied from the air or on the ground.

May be used with small hand-cranked units or scattered by hand (with personal protection).

Useful in treating mosquito larvae where heavy vegetation would prevent insecticide from reaching the water, or where drift could be a problem.

Fumigants

Volatile chemicals stored as liquids under pressure, or incorporated into a solid form with clay which releases toxic gas when combined with water vapor.

Used for vector control of rodents and their associated ectoparasites underground.

Fumigants are used for structural pest control to kill cockroaches.

Baits

Contain active ingredients that are mixed with a pest food or attractant.

Principal uses include control of household pests such as ants, mice, rats, roaches and flies.

Used outdoors to control birds, ants, slugs, snails and agricultural pests such as crickets and grasshoppers.

Aerosols

Pressurized cans which contain a small amount of pesticide that is driven through a small nozzle under pressure from an inert gas (called a propellant).

Often used in households: to kill flies, weeds, and in structural pest control.

Use peaked during the 1990s before concern for propellants consisting of chlorofluorocarbons were linked to damage to the ozone layer.

Since then – uses have dropped significantly.

Flowables

A **flowable** liquid usually mixed with water for use in a sprayer.

Forms a suspension in water which requires continual agitation.

Principal uses are similar to those of emulsifiable concentrates.

Water-Soluble Concentrate

Liquid formulations that form true solutions in water and require no agitation once mixed. They are used in the same way as emulsifiable concentrates.

Ultra Low Volume Concentrates (ULV)

ULV concentrates are sold as technical product in its original liquid form, or solid product dissolved in a small amount of solvent.

Applied using a special aerial or ground equipment that produces small droplets (~10 – 30 microns) at very low application rates.

Main use is as mosquito adulticides.

Fogging Concentrates

Combines a pesticide with a solvent.

Truck-mounted machines called foggers are used for public health to control flying insects like flies and mosquitoes.

Foggers come in two types:

- **Thermal Foggers: use flash heating of an oil solvent to produce a visible plume of vapor or smoke.**
- **Cold (Ambient) Foggers: Atomize a jet of liquid in a venturi tube under pressure from a high velocity air stream. Can use insecticides combined with oil, water, or emulsifying agents.**

Slow or Controlled Release Formulations

Can be encased (encapsulated) in an inert material for a controlled release, resulting in decreased hazard and increased likelihood of the active ingredient reaching the target organism.

Sustained-release mosquito larvicides are based on this principle.

Methoprene briquettes slowly release a juvenile hormone analogue to disrupt metamorphosis.

FORMULATIONS WITH COMBINATIONS OF PESTICIDES

When two or more chemicals can be mixed safely they are called compatible.

The reasons to combine pesticides are:

1. **To increase the effectiveness of one of the chemicals.**

2. **To provide better control than that obtained from one pesticide.**

3. **To control different types of pests with a single application (more economical to do at the same time).**

Synergism

The material added to increase the effectiveness of the primary chemical is called a synergist.

Best known example: the addition of piperonyl butoxide (PBO) to pyrethrum, pyrethrins, or some synthetic pyrethroids.

The opposite of synergism is antagonism.

Caution in Mixing Pesticides

Always check the label of a pesticide prior to mixing pesticides.

Some pesticides will not mix, or produce a negative effect called an antagonism (opposite of synergism) such as chemical reactions which may form new compounds.

When two or more pesticides cannot be used in combination, they are called incompatible.

Incompatibility May Result in:

Separation of the pesticide from the water or other carrying agent.

Effectiveness of one or both compounds may be reduced.

Precipitation may occur and clog the screen or nozzles of application equipment.

Various types of phytotoxicity may occur.

Excessive residues may result.

Excessive runoff may occur.

CHAPTER 3: PESTICIDE LABELS AND LABELING

Chapter 3 Table of Contents

Introduction

Labels and labeling

Format for pesticide labeling

INTRODUCTION: PESTICIDE LABELS AND LABELING

1972 amendment to FIFRA required registration and labeling to all pesticide products transported or sold in interstate and intrastate commerce.

Pesticide labeling is administered by the EPA.

Information on a label is designed to provide safety to applicators, the public, and the environment, and to encourage the appropriate and effective use of the labeled pesticide.

LABELS & LABELING

Label: the printed material attached to a pesticide container or a wrapper of a retail pesticide package.

Labeling: all of the printed instructions that come with a pesticide (label on product, brochures and flyers provided by manufacturer, and other information such as handouts from the dealer).

Pesticide Label: a Legal Document

Contains information on how, when and where the pesticide can be used.

Lists hazards to humans and domestic animals (as well as any environmental hazards).

Contains a signal word: DANGER, WARNING, OR CAUTION depending on its toxicological classification.

ALL pesticide labels contain the warning KEEP OUT OF REACH OF CHILDREN.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS) is a document that contains information on the hazard from fire and explosion, health hazard data, reactivity data, and procedures required for environmental protection.

The operator must always have in his possession sample labels and a MSDS for the pesticide being applied.

Signal Word

Signal word: Danger, warning or caution. Assigned based on the most severe toxicity category assigned to the five acute toxicity studies (presented next slide).

If Methanol is present in a formulation in a concentration of 4% or more, it is automatically to be assigned to signal word "Danger".

Required to appear on the front panel of all pesticide labels, along with the statement "KEEP OUT OF REACH OF CHILDREN" (KOOROC).

Toxicity Categories for Pesticides

Study	Category I	Category II	Category III	Category IV
Signal Word	DANGER/POISON	WARNING	CAUTION	CAUTION
Acute Oral	Up to & including 50mg/kg	>50 thru 500 mg/kg	>500 thru 5,000 mg/kg	>5,000 mg/kg
Acute Dermal	Up to & including 200mg/kg	>200 thru 2,000 mg/kg	>2,000 thru 5,000 mg/kg	>5,000 mg/kg
Acute Inhalation	Up to & including 0.05 mg/liter	>0.05 thru 0.5 mg/kg	>0.5 thru 2 mg/liter	>2 mg/liter
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue)	Corneal involvement or other eye irritation clearing in 8-21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or slight irritation at 72 hours (no irritation or slight erythema)

When Should You Read a Pesticide Label & the Material Safety Data Sheet?

1. Before you buy the pesticide.
2. Before you transport, mix, or load the pesticide.
3. Before you apply the pesticide.
4. Before you store the pesticide.
5. Before you dispose of unwanted pesticide or the empty container.

1. Before you buy the pesticide:

Is it the proper chemical for the job?

Does it require special equipment or application technique?

Do you have the qualifications to use it?

2. Before you transport, mix, or load the pesticide:

Does it require special precautions for transportation?

How to mix and how much to mix?

What protective clothing and equipment are required?

What first aid procedures may be required in case of accidental exposure?

3. Before you apply the pesticide:

When do you apply the material? How? At what rate of application?

What protective clothing and equipment are required?

What are the residue or re-entry restrictions that apply to its use?

4. Before you store the pesticide:

Are there heat, cold, or UV light recommendations?

****** Never store pesticides near food or feed or in many cases where they may become contaminated by other pesticides******

5. Before you dispose of unwanted pesticide or the empty container:

Does the pesticide meet any criteria established by the EPA for hazardous waste?

What is the proper procedure for disposal to avoid health risks or environmental contamination?

What is the proper procedure for disposal of the empty pesticide container?

FORMATS FOR PESTICIDE LABELING

The EPA has suggested formats for pesticide labels. With minor differences, the formats are the same for both unclassified and restricted use pesticides.

The following information is required:

Front Panel

1. Restricted Use Pesticide Statement (if applicable).
2. Product Name, Brand, or Trademark.
3. Ingredient Statement.
4. KEEP OUT OF REACH OF CHILDREN.
5. Signal Word (Danger, Warning, Caution).
6. First Aid.
7. Skull & Crossbones Symbol (if applicable – see next slide).
8. Net Contents/Net Weight.

Skull & Crossbones Symbol

Applies to pesticides in Toxicity Category I where the toxicity determination is based on oral, inhalation, or dermal toxicity as opposed to skin or eye irritation.

Must be prominently in red and on a background of distinctly contrasting color.

Back Panel

1. Precautionary Statements:
   - Hazards to humans & domestic animals.
   - First aid.
   - Environmental hazards.
   - Physical or chemical hazards.
2. Directions for Use.
3. Storage and Disposal.
4. Worker Protection Labeling.

Front or Back Panel

1. EPA Registration Number and Establishment Number

(The EPA Registration # is the most important piece of information for tracking pesticide products and its appearance on each pesticide label is an absolute requirement)

2. Company Name & Address

The Changing Nature of Pesticide Labels

If you are in doubt as to which pesticides are on either the federal or California list of restricted pesticides, this information can be found at:

The EPA website:

http://www.epa.gov

Or the DPR:

http://www.cdpr.ca.gov

CHAPTER 4: TOXICITY OF PESTICIDES TO HUMANS

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Introduction

Pesticide toxicity and hazards

Types of toxicity

Toxicity testing and measurement

Toxicity testing in experimental animals

Toxicity testing required for registration

How pesticides affect humans

INTRODUCTION: PESTICIDE TOXICITY AND HAZARDS

Toxicology is the science of poisons.

Modern vector control operations emphasize the use of pesticides that are the least hazardous to non-target organisms.

Regulatory agencies place great stress on means of reducing human hazards to pesticides.

There is a difference between the terms "toxicity" and "hazard".

PESTICIDE TOXICITY AND HAZARDS

Toxicity defined as the inherent poisonous potency of a material.

- **The capacity of a substance to produce illness or death.**

Evaluated in toxicology laboratories and is always expressed in quantitative terms such as LC_{50} (the concentration at which a material is lethal to 50% of some reference organism).

Hazard

Defined as the danger or risk of injury or other harm faced in connection with exposure to a pesticide. The degree of hazard is a result of a combination of toxicity of the pesticide and the risk of exposure.

Together, toxicity and hazard information can be used to determine risk.

Important Factors in Evaluating the Potential for Poisoning:

The concentration of the pesticide in a formulation.

The length of human exposure to a pesticide.

The route of entry into the human body.

TYPES OF TOXICITY

Can be classified by: nature of exposure, by the route by which exposure occurs, or by the body function or system affected.

Generally, any poison is more toxic if ingested by mouth than if inhaled, and more toxic inhaled than if by dermal (skin exposure).

Classification by Type of Exposure:

Divided into four types, based on the number of exposures to a poison and they time it takes for toxic symptoms to develop:

- **Acute Toxicity**
- **Chronic Exposure**
- **Sub-chronic Exposure**
- **Delayed Toxicity**

1. ***Acute Toxicity:*** **When a person is exposed to a single dose of a pesticide. Can be acute dermal, acute oral, acute inhalation.**

2. ***Chronic Exposure:*** **When there is repeated or continuous exposure to a pesticide by a person (chronic dermal, chronic oral, or chronic inhalation toxicity).**

3. ***Sub-chronic Exposure:*** **When there has been repeated or continuous exposure to a pesticide, but no measurable toxic affects have resulted.**

4. Delayed Toxicity

May occur many years after exposure to a chemical and is most often only discovered in retrospective epidemiological studies (studies that are done after the fact).

Example of a chemical that produces delayed toxicity is fipronil.

Classification By Body System Affected

Cutaneous Toxicity: Most often associated with petroleum based products, pyrethroids, and some herbicides.

- **Account for approximately one-third of all pesticide-related occupational illnesses.**

Dermatitis - any skin rash associated with inflammation and redness.

Primary Irritant Dermatitis (PID)

Caused by chemical substances that directly irritate the skin (such as acids and bases).

May be very minor or very severe, causing blisters or ulcerations.

Most frequently caused by herbicides (refined petroleum produces or formulations that use refined petroleum as a carrier).

Exposure to pyrethroids can cause a crawling or tingling sensation in the skin, and may irritate mucous membranes.

Allergic Contact Dermatitis (ACD)

Caused by chemical substances that stimulate development of an allergic reaction.

Workers may handle an allergenic substance for years before ACD develops or it may develop after a single exposure.

Symptoms vary from redness and itching to large painful blisters (Naled and malathion may result in ACD).

Classification By Route Of Entry

Pesticides can enter the body through the skin (dermal exposure), the lungs (respiratory exposure), the mouth (oral exposure), or they eyes (orbital exposure).

Liquids or gasses can penetrate the body via any of these four routes. Solids tend to have a lower chance of entry through the lungs or eyes.

Dermal Exposure

Absorption through skin is the most common route of which pesticide applicators are poisoned by pesticides.

May occur as a result of a splash, spill, or drift when mixing, loading or disposing of pesticides.

May also occur from exposure to large amounts of residue.

Dermal Exposure

Wettable powders, dusts, and granular pesticides are not as readily absorbed into body tissues, as are the emulsifiable concentrate liquid formulations which contain a high percentage of the toxicant in a relatively small amount of solvent.

Degree of dermal absorption hazard depends on the dermal toxicity of the pesticide, the extent of exposure, the pesticide formulation and the part of the body contaminated.

Wash immediately if you become contaminated!

Oral Exposure

Pesticides may be consumed through carelessness or by individuals who are intent on personal harm.

The most frequent cases of accidental oral exposure are those in which the pesticides have been transferred from their original containers to an unlabeled bottle or food container.

Children are especially at risk for oral exposure particularly if pesticides are stored in an unauthorized container.

Respiratory Exposure

Sometimes inhaled in sufficient amounts to cause damage to the nose, throat, and lung tissues.

Hazardous because of the potentially rapid absorption of vapors and fine particles.

High risk activities: using concentrating material or low volume equipment and application in confined spaces.

Respirators and gas masks can provide respiratory protection.

Eye Exposure

Eyes are particularly absorbent. Getting any pesticide in the eye presents an immediate threat of blindness, illness, or even death.

Dilute spray or dust may drift into the eyes.

Granular pesticides (pellets) when applied with power equipment can bounce of vegetation and other surfaces at high velocity and cause damage if an applicator is struck in the eye.

Eye protection (shields or goggles) is always needed when measuring of mixing concentrated and highly toxic pesticide.

TOXICITY TESTING & MEASUREMENT: Visualizing Concentrations

One part per million (Ppm) = about one drop of liquid pollutant in about 13 gallons of water.

One part per billion (Ppb) = about one drop of liquid pollutant in about 250 55 gallon drums.

One part per trillion (Ppt) = one drop of a liquid pollutant in 20 Olympic-sized 6-foot-deep swimming pools.

TOXICITY TESTING IN EXPERIMENTAL ANIMALS

Used to establish the toxicity category for pesticide formulations and for the preparation of material safety data sheets to provide information on recommendations of things such as first aid, necessary protective devices, antidotes, and handling procedures for pesticides.

The results are submitted to the EPA and other agencies as a requirement for registration of a pesticide formulation.

Dose-Effect Relationships

A concentration can be calculated at which some pre-defined effect occurs in half of each group of test subjects.

This is called the effective dose 50 and is written: "ED_{50}".

If death is the effect being measured the expression lethal dose 50 or "LD_{50}" is used.

With higher percentages like 80% or 90% of the test subjects are affected, the expressions "ED_{80}" and "ED_{90}" are used.

Terms Related to Dose-Effect Relationships

No Observable Effect Level (NOEL): the highest dose that results in no observable change in 50% of a test population.

Toxic Dose (TD): the dose that will produce signs of toxicity in a certain percentage of species of animals.

Lethal Concentration 50 (LC_{50}): usually used for toxicity testing for exposures of pesticides in the vapor state, such as fumigants.

Things to Remember: (regarding dose-effect relationships)

The standard units used to describe dosage in pesticide tests is mg/kg of body weight.

The smaller the number, the more toxic the chemical tested. **For example chemical with a small LD_{50} such as 5mg/kg much more dangerous than one at 1,000 to 5,000 mg/kg.**

The expressions TD_{50}, ED_{50}, LD_{50} etc. are calculated the same way but do not always bear the same relationship to one another.

TOXICITY TESTING REQUIRED FOR REGISTRATION: Risk Assessments

Before a pesticide can be released for sale it must go through a process known as risk assessment. This is the process by which the various toxicity categories are assigned to pesticide formulations. The basic risk assessment consists of four steps:

1. **Hazard identification. The toxicity of a given product based on acute and chronic toxicity tests performed with experimental animals.**

Risk Assessment

2. **Dose-response assessment: These are the tests performed at different dose levels on groups of experimental animals to obtain ED50 and LD50 numbers.**

3. **Exposure assessment: The exposure assessment is based on the proposed use of a pesticide formulation and the probability of exposure to applicators, other workers, children, and the general public.**

4. **Risk characterization: Based on combining the hazard identification and exposure results. This is a simple explanation of a very complex and drawn-out process.**

Groups of Vertebrate Toxicity Tests

Candidate pesticides may go through as many as six groups of tests in order to establish toxicity levels.

These groups are Acute Toxicity (oral, dermal, inhalation, eye, and others), Subchronic toxicity, Chronic toxicity, Genetic toxicity, Neurotoxicity, and Special studies (companion animal toxicity, metabolism, dermal penetration, and immunotoxicity).

HOW PESTICIDES AFFECT HUMANS

Symptoms: what a person feels and can express to others. Example: pain or nausea.

Signs: things one person can observe in another person, even if that person is unconscious. Example: redness of skin, swelling, or hot dry skin.

You should learn and be alert to the early stages of poisoning: if any sign or symptom develops, you should immediately and completely remove the source of exposure.

How Pesticides Affect Humans

Early recognition of the signs and symptoms of pesticide poisoning and immediate and complete removal of the source of exposure may save a person's life.

This is especially critical if the person is unconscious, or otherwise unable to communicate clearly.

Organophosphate Pesticides

These poisons attach themselves to an enzyme in the blood called *cholinesterase*.

Cholinesterase is necessary for proper nerve functioning. When it is unable to perform its normal functions, the body's nerves fail to send messages to the muscles properly, resulting in twitching, tremors, or constant contraction (*tetany*). In severe cases the victim may suffer convulsions.

Quick and proper medical treatment may reverse the effects of the poisoning and save the life of the person even in a severe poisoning event.

Carbamate Pesticides

The mode of action of carbamates is similar to that of organophosphates, and they also inhibit the enzyme cholinesterase.

Carbamates break down rapidly in the human body. Accordingly, the effect of carbamates on cholinesterase inhibition may be relatively brief. Blood tests may not give an accurate indication of carbamate poisoning.

Signs and Symptoms of Organophosphate/Carbamate Poisoning

MILD POISONING	MODERATE POISONING	SEVERE POISONING
Fatigue	Unable to walk	Unconsciousness
Headache	Weakness	Severe restriction of the eye pupil
Dizziness	Chest Discomfort	Muscle twitching
Blurred Vision	Constriction of the eye pupil	Secretions from the nose and mouth
Excessive sweating and/or salivation	Greater severity of signs of mild poisoning	Difficulty breathing
Nausea & vomiting	(With continued exposure) Coma & Death	Coma & Death

Blood Tests for Operators

California regulations require medical supervision of workers whose duties expose them to pesticides known to have the potential to inhibit blood cholinesterase levels (organophosphates and carbamates).

The enforcement of this program is the responsibility of the CA Department of Pesticide Regulation.

For more information see Section 6728 of the California Code of Regulations.

Botanical Pesticides

Pesticides derived from plants vary greatly in their chemical structure and their toxicity to humans.

The toxicity of these pesticides range from pyrethrum (one of the least toxic of all insecticides to mammals) to strychnine, which is one of the most toxic.

Pyrethrum

A natural botanical pesticide containing the active ingredient of pyrethrin.

Among the least toxic pesticides to mammals (LD_{50} in rats at about 1,500 mg/kg).

Pyrethroids

Synthetic pesticides with chemical structures similar to pyrethrins.

Include permethrin, resmethrin, sumithrin, deltamethrin, and others.

Exhibit a wide range of toxicity, from very low (permethrin, LD50 in rats >4,000 mg/kg) to very high (tau-fluvalenate, LD50 in rats 261 mg/kg).

In aquatic environments these materials can be very toxic to fish and other organisms.

Fumigation Materials

The only material considered a fumigant used in vector control is zinc phosphide, a rodenticide.

Zinc phosphide is considered extremely toxic if inhaled, but because it has no dermal toxicity, it is very easy to work with when wearing a cartridge respirator and eye protection.

CHAPTER 5: FIRST AID FOR PESTICIDE POISONING

Chapter 5 Table of Contents

Introduction

General first aid for pesticide poisoning

Specific instructions

Emergency information

INTRODUCTION TO FIRST AID

In vector control, we are fortunate that few restricted use and highly toxic pesticides are still in use. Most modern pesticides are easy to mix, load, and apply safely and have extremely low mammalian toxicity.

The most dangerous pesticides used for vector control are organophosphates used for mosquito control, fumigants used for rodent control, and some aquatic herbicides.

GENERAL FIRST AID FOR PESTICIDE POISONING

1. **Stop the exposure *immediately*.**

2. **Give artificial respiration if the victim is unconscious. If highly toxic material is in the victims mouth or respiratory path, use chest compression, not mouth to mouth.**

3. **Decontaminate the victim by washing off any skin residues of pesticide, and remove any contaminated clothing. Speed is absolutely essential in this step.**

GENERAL FIRST AID FOR PESTICIDE POISONING

4. Obtain Professional Help

- Call 911.
- Call the nearest physician.
- Call your local or regional poison control center. If you don’t know the number or location, call toll-free to 800-222-1222.
- Call the Chemical Transportation Emergency Center (CHEMTREC) 800-262 8200.

GENERAL FIRST AID FOR PESTICIDE POISONING

The label and MSDS should be consulted for specific first aid instructions.

If you are exposed to a pesticide while working alone, remain calm. Symptoms of pesticide poisoning from vector control products are usually mild and take time to develop.

GENERAL FIRST AID FOR PESTICIDE POISONING

If you are alone with the victim, you must give first attention to the victim, especially in starting breathing and separating the victim from the pesticide source and decontaminating the victims skin.

If another person is with you and the victim one should perform first aid, the other seek professional help.

Due consideration must be given to the protection of yourself and other personnel in the vicinity of the incident (especially in a large pesticide spill).

Steps to be taken after First Aid

First aid should never be considered a substitute for professional medical treatment.

1. **After professional medical treatment has been sought for the poisoning victim, bring the label and MSDS to the doctor or poison control center. Save the container and remaining pesticide should an official request to see it.**

Steps to be taken after First Aid

2. Eliminate the source of the contamination to prevent or reduce the risk that others may be exposed. In the case of a significant pesticide spill, this will have to be done by professionals trained to respond to these type of emergencies.

3. Decontaminate any clothing or equipment as needed. Wash contaminated clothing by itself with detergent and water.

SPECIFIC INSTRUCTIONS: Poison in the Eyes

Hold eyelids open; wash eyes immediately with a gentle stream of clean running water (use large amounts of water).

Delay of only a few seconds can greatly increase the extent of injury.

Continue washing for 15 minutes or more. Do not use chemicals or drugs in the wash water (they may increase the extent of injury).

Call or send for help while rinsing the eyes.

Inhaled Poisons

If the victim is in an enclosed space, do not attempt a rescue without proper respiratory equipment. Get the victim to fresh air immediately.

Loosen all tight clothing. Apply artificial respiration if breathing has stopped or is irregular. Call for emergency help and keep the victim calm.

Prevent chilling (wrap victim in a blanket but don't overheat). If victim is convulsing, watch his or her breathing and protect the patient from falling or striking his or her head on the wall or floor. Keep the victims chin up so the air passage will remain free for breathing.

Swallowed Poisons

Call for emergency help immediately. If a non-corrosive substance has been swallowed, label directions, MSDS or medical personnel from a Poison Control Center may direct you to induce vomiting.

To induce vomiting: place the blunt end of a spoon (not the handle) or your finger at the back of a patients throat or use an emetic of two tablespoons of salt in a glass of warm water.

Swallowed Poisons

When retching and vomiting begin, place patient face down with head lowered, thus preventing vomitus from entering the lungs and causing further damage. Do not let patient lie on back.

Never induce vomiting unless directed by the pesticide label, MSDS, or a medical professional to do so.

Do not induce vomiting if: patient is unconscious or experiencing convulsions, has swallowed petroleum products (kerosene, gasoline) or a corrosive poison.

Chemical Burns of Skin

Remove contaminated clothing.

Wash with large quantities of running water.

Immediately cover with loosely applied clean cloth (any kind will do).

Avoid use of ointments, greases, powders and other drugs.

Treat shock by keeping patient flat, warm, and reassured until the arrival of a doctor.

EMERGENCY INFORMATION

If you have employees working with pesticides you are required to post the name, address, and current telephone number of the physician, clinic, or hospital emergency room that will provide care in the event a person should be poisoned.

This information must be clearly posted at all work sites (vehicles, storage facilities, mixing areas, loading areas).

EMERGENCY INFORMATION

Vector Control agencies should designate an emergency coordinator. This person must know what to do in case of a poisoning, fire, spill or other emergency and should be available 24 hours a day, 7 days a week.

It is important to have a well-designed emergency poison incident plan in place before an emergency arises.

The universal emergency number for all pesticide control centers in California is 800-222-1222.

Nationwide Emergency Contact Information

The following should be clearly posted in a prominent place, such as near a telephone in the main district office:

- **American Association of Poison Control Centers: 703-894-1858.**
- **National Pesticide Information Center Hotline: 800-222-1222.**
- **Chemical Transportation Emergency Center (CHEMTREC): 800-262-8200.**
- **Regional Poison Control Centers in CA are in Sacramento, Madera, San Diego, and San Francisco (all use emergency telephone number and website address).**
- **http://www.calpoison.org**

CHAPTER 6: PROPER HANDLING OF PESTICIDES

Chapter 6 Table of Contents

Introduction
Transporting pesticides
Storing pesticides
Mixing and loading pesticides
Applying pesticides
Equipment cleanup
Disposal methods for pesticide wastes
Disposal of unused/excess pesticides
Personal clean-up
Pesticide spills
Pesticide fires
Adverse pesticide related events

INTRODUCTION TO THE PROPER HANDLING OF PESTICIDES

It is necessary to maintain careful and continuous control over the use and handling of pesticides during the transport, storage, mixing, loading, application and disposal.

If improperly used, these chemicals can poison people, pets, and livestock. They can also damage beneficial insects, birds, fish and other wildlife, harm desirable plants, and contaminate soil and groundwater.

TRANSPORTING PESTICIDES

When you transport pesticides, you are legally responsible for them. To reduce the likelihood of pesticide spills or exposure of workers riding in vehicles transporting pesticides, the following guidelines should be followed:

1. **Pesticides are most safely transported in the beds of trucks. They should never be in the passenger compartment of any vehicle.**

TRANSPORTING PESTICIDES

2. People should never be allowed to ride in the beds of pick-up trucks carrying pesticides. This applies especially to children as passengers.

3. Pesticides should never be transported in the same compartment with food, feed, or clothing.

4. All pesticide containers should be secured tightly (especially glass containers).

TRANSPORTING PESTICIDES

5. Pesticide containers made of paper, cardboard, or similar containers should be protected from moisture during transport.

6. Pesticides in parked service vehicles must be made secure from theft, tampering, and contamination.

STORING PESTICIDES

It is necessary and legally required that pesticides be stored in a safe, secure and well-identified place.

1. **Always store pesticides in their original, labeled container with the label clearly visible.**

2. **Always store pesticides in tightly sealed containers and check containers periodically for leakage, corrosion breaks, tears, etc.**

STORING PESTICIDES

3. Always store pesticides where they are protected from freezing or excessive heat.

4. Always be certain that pesticide storage areas are well-ventilated to prevent the accumulation of toxic fumes.

5. Always store different types of pesticides in different areas, to prevent cross contamination and the possibility of applying a product inadvertently.

STORING PESTICIDES

6. **Never store pesticides in old bottles or food containers where they could be mistaken for food or drink for humans or animals.**

7. **Never store pesticides near food, feed, or seed.**

8. **Agencies or programs that store significant amounts of pesticide should have a designated pesticide storage facility.**

Requirements for Pesticide Storage

1. Locking doors.
2. Adequate lighting.
3. Adequate ventilation.
4. Fire extinguishers readily available.
5. Spill containment design or equipment.

Requirements for Pesticide Storage

6. Warning placards if Category I or II pesticides are stored – including emergency contact information.

7. Personal protective equipment readily available.

8. Wash water and eye wash stations available.

9. Presence of label and MSDS book for stored materials.

Not Required but Recommended for Pesticide Storage

1. Fire resistant construction.

2. Emergency shower station.

3. Spill containment floor design or drum pallets.

MIXING AND LOADING PESTICIDES

One of the most dangerous jobs related to pesticide-related illness, is the mixing and loading of concentrated chemicals, specifically low-volume and ultra-low volume formulations. A few common-sense rules can make it much safer:

1. **Before handling a pesticide, *READ THE LABEL*.**

2. **Based on label recommendations, *put on protective clothing* and use other necessary protective equipment.**

MIXING AND LOADING PESTICIDES

3. Mix the pesticides outdoors, in a place where there is good light and ventilation.

4. Stand upwind of the pesticide to avoid contaminating yourself.

5. Use a sharp knife to open paper bags, do not tear them or the label.

6. Measure accurately, use only the amount you need to apply at the rate specified on the label.

MIXING AND LOADING PESTICIDES

7. When removing concentrated material from the container, keep it below your waist if possible to avoid the possibility of splashing or spilling any pesticide in your face and eyes.

8. If you splash or spill a pesticide while mixing or loading, stop immediately, remove contaminated clothing and wash thoroughly with detergent and water. Speed is essential in cleaning up the spill.

APPLYING PESTICIDES

Careful attention to the following guidelines during pesticide applications will not only protect you, other people, animals, and the surrounding environment, it will also greatly increase your chances of effectively controlling the pest.

1. **Before you begin the application, *READ THE LABEL*. Don't trust your memory for details concerning the use of any pesticide.**

2. **Check the application equipment. Look for leaking hoses or connections, plugged or worn nozzles, and examine the seals on filter openings to make sure they will prevent spillage of the chemicals.**

APPLYING PESTICIDES

3. Calibrate your equipment before use. Make certain your equipment is adjusted according to the manufacturer's specifications and meets label requirements for the product being applied. This will assure the proper dosage is being applied to the target site.

4. Before all pesticide application starts, clear all livestock, pets, and people from the area to be treated. Although it would be the ideal situation, most ULV labels do not require this.

5. Apply the pesticide at the recommended rate. Do not exceed the maximum application rate specified on the label or the written recommendation.

APPLYING PESTICIDES

6. Apply pesticides only at the correct time and under acceptable weather conditions. Be especially careful when temperatures exceed 85 degrees F or are below 50 degrees F.

7. When handling Category I and II toxic pesticides, one should try to not work alone.

8. Use extreme care to prevent the pesticide from contaminating unintended target sites, especially bodies of water.

9. Avoid situations where the pesticide may drift from the application area and contaminate non-targets.

10. Do not contaminate food or feed through careless application methods.

EQUIPMENT CLEAN-UP

After completing the application of any pesticide, immediately clean the mixing, loading, and application equipment with the following precautions:

1. **Know the correct procedures for cleaning and decontamination.**

2. **Wear the appropriate personal protective equipment.**

3. **Know and use the specific area set aside for cleaning. This will usually be on a wash rack or concrete apron that has a well-designed sump to contain all contaminated wash water and pesticides for later disposal or in the field where rinse water is considered part of the application.**

DISPOSAL METHODS FOR PESTICIDE WASTES

Waste materials should be considered hazardous to the public, the people handling them and the environment.

Deciding how to dispose of pesticide wastes should be done on a case-by-case basis. Materials that meet the legal requirements as hazardous wastes in California must be disposed of according to special rules controlled by the California Department of Toxic Substances Control (DTSC).

Pesticide Container Disposal

Always dispose of pesticide containers in a manner specified on the label.

Many pesticide containers can be recycled, either as part of a regular recycling program, if approved on the label or by returning to the chemical supplier.

Correct Triple Rinse Procedure

1. Empty the container into the mixing tank and allow the pesticide to drain for an extra 30 seconds.
2. Add the correct amount of water for thorough rinsing as follows:

Size of Container	Amount of Rinse Water
Less than 5 gallons	One-fourth container volume
5 gallons or more	One-fifth container volume

3. Replace the container closure; then rotate and shake the container, so that the rinse reaches all interior surfaces.

Correct Triple Rinse Procedure

4. Drain the rinse solution from the container into the mixing tank. Allow the container to drain for an extra 30 seconds after emptying.
5. Repeat this rinsing procedure at least two more times for a total of three rinses. Empty each rinse into the mixing tank so the pesticide goes on the target for which it is intended (this procedure also saves money). Never pour pesticides down an ordinary drain or flush them down a toilet!
6. When the triple rinse procedure is complete, let the container dry and replace the cover.

DISPOSAL OF UNUSED/EXCESS PESTICIDES

How to dispose of *unused* (still in the original container) and *excess* (already mixed, but not needed) products:

1. **Easiest solution: only mix as much product as will be needed.**
2. **Apply it according to the label.**
3. **Find another person or area with the same pest problem, so that the pesticide gets used up legally and effectively.**
4. **Dispose of the pesticide in an approved location. Contact the California Department of Pesticide Regulation, or the County Agricultural Commissioner for specific information on regulations and pesticide dump sites.**

PERSONAL CLEAN-UP

After completing the pesticide application, dispose of excess material, clean the application equipment, and thoroughly wash all of your protective equipment.

Remove work clothes and wash them in an area separate from other laundry items or dispose of them if they are disposable coverall (e.g., Tyvek®).

Do not allow children to play in or with the contaminated clothing, and warn whoever will be washing the clothes of the possible danger.

Take a shower and wash yourself completely with soap and water, including hair and fingernails.

Do not put on any article of work clothing until after it has been laundered.

PESTICIDE SPILLS

Reporting of pesticide spills is required under Section 105215 of the Health and Safety Code (Appendix 2).

Since some pesticides qualify as hazardous materials, a variety of local, county and state agencies will become involved in reporting and cleanup, especially if the spill occurs in transit.

In this case, peace officers are often the first responders and are required to report pesticide spills under the California Vehicle Code.

PESTICIDE SPILLS

Pesticide spills that cannot easily be cleaned up and decontaminated by vector control program personnel can be reported directly to the local health officer who will in turn contact the County Agricultural Commissioner or the County Health or Environmental Health Department.

Use common sense to determine the danger of a spill: e.g. a spill that occurs in a confined and enclosed area versus an open area.

PESTICIDE SPILLS

In spite of the most careful use and handling of pesticides, accidental spills and fires occasionally occur.

These range in size from small spills of a household pesticide container to huge fires involving entire manufacturing warehouses filled with the most toxic pesticides.

Intelligent planning, knowledge of the chemicals involved, and calm consideration of the actual hazards to be dealt with during an emergency will reduce the risk and damage resulting from the accident.

PESTICIDE SPILLS

When a spill occurs, it should be cleaned up as quickly and safely as possible.

The highest priorities are to prevent human exposure to the pesticide and to prevent the spread of the spill

In the event of a large spill that cannot be easily contained, contact emergency services personnel, tell them the nature of the chemical and explain what you know about the chemical involved. If it is a Toxicity Category I or II pesticide, their lives may depend on your warning!

General Rules for Pesticide Spill Clean-ups

1. **Avoid exposure of people and animals to the pesticide. If you spill a pesticide, immediately see to it that no one is exposed or contaminated by accidentally walking into the spill or breathing the fumes.**

2. **Start by putting on protective clothing to prevent contaminating yourself.**

3. **Provide some sort of a barrier to the spread of liquid pesticide. A barrier can be dirt, sawdust, old newspapers, or anything that will soak up the pesticide.**

General Rules for Pesticide Spill Clean-Ups

4. Remove the contaminated materials to a safe place. If the spill is inside the home or another building, soak up liquid pesticides or sweep up powders and remove them to the outside. Ventilate the area to prevent the buildup of toxic fumes.

5. Thoroughly clean the affected surface. Consult the label for specific disposal and decontamination instructions. Take care to prevent the wash from spreading and possibly contaminating a larger area. Make sure any wash does not go into storm drains or sewer systems.

General Rules for Pesticide Spill Clean-ups

6. **If the spill cannot be easily cleaned and involves a public area, such as a highway, notify the police, sheriff's office, fire department, the highway patrol, or other local emergency services agencies.**

7. **While waiting for emergency personnel to arrive, do what you can to prevent others from being exposed to the pesticide.**

PESTICIDE FIRES

If a fire occurs in an area where pesticides are used or stored, and the fire is very small and easily extinguished, you may elect to attack it yourself if you follow certain precautions:

1. **Use foam or carbon dioxide from a fire extinguisher in lieu of water if at all possible.**

2. **Wear protective safety equipment.**

3. **Avoid exposure of smoke, mist, spray, runoff, and concentrated pesticide chemicals.**

General Rules for Pesticide Fires

In the event of any large fire, contact emergency fire services immediately!

When large fires involving the presence of pesticides occurs, the fire department responding to the emergency call will seek the aid of specialized agencies which deal with such chemical emergencies.

Care should be taken to make sure people are not exposed to toxic fumes, poisonous runoff, and concentrated pesticides from leaking or exploding storage containers.

General Rules for Pesticide Fires

Maintaining communications with the responding fire department is essential.

Keep them updated on what chemicals you are storing, where it is stored, how much is being stored, and supply them with any information such as material safety data sheets they may request concerning the nature of the chemicals.

General Rules for Pesticide Fires

Before the fire department arrives:

1. **Do not risk your life to fight a large fire, unless you have been trained to do so. It is the job of highly trained professionals. You may inadvertently risk the health and safety of the professionals or others, particularly if you are injured in your attempts.**
2. **Avoid poisoning. Keep yourself and others out of smoke, mist, spray, and pesticide runoff.**
3. **Notify all those in close proximity of the fire and downwind and tell them to evacuate the area.**
4. **Wear personal protective equipment if it can be safely retrieved.**

General Rules for Pesticide Fires

After the arrival of the fire department:

1. **Without risking your health or safety, take steps to minimize contamination of areas outside the fire zone by runoff from fire fighting. This can help contain spilled pesticide and thus avoid affecting people, domestic animals, and the environment. It is especially important to avoid runoff of contaminated water into nearby streams or lakes.**

2. **Cool nearby pesticide containers, move vehicles and any threatened mobile equipment if it is safe to do so.**

ADVERSE PESTICIDE RELATED EVENTS

For vector control agencies, adverse pesticide related events must be reported to the California Department of Public Health and the County Agricultural Commissioner.

Adverse events (conspicuous or suspected) that must be reported include:

- **Any human illness associated with a vector control pesticide application.**
- **Any report of harmful non-target effects of an application to plants, domestic animals, or wildlife.**
- **Any pesticide spill requiring an emergency services response.**

Chapter 7: Protective Clothing and other Safety Devices

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Introduction

Minimum protective clothing

Types of protective clothing

Care of clothing

Types of eye, mouth, and face protection

Protection from inhalation hazards

Checklist for avoiding pesticide exposure

INTRODUCTION TO PROTECTIVE CLOTHING & SAFETY DEVICES

The hazards associated with contamination by any pesticide vary with the type of pesticide and the route of exposure.

By wearing protective clothing and using available safety devices such as face masks, goggles, and gloves, the danger from contamination by pesticides can be minimized.

INTRODUCTION TO PROTECTIVE CLOTHING & SAFETY DEVICES

Information about required safety devices and clothing is available on pesticide labels and on material safety data sheets. Personal and environmental safety devices should be available at all work sites where pesticides are handled, mixed or used.

The use of pesticide safety clothing and other safety devices should never be a substitute for taking common sense precautions when using pesticides.

MINIMUM PROTECTIVE CLOTHING

You should always wear a clean cap or hat, clean coveralls, or a long sleeved shirt and trousers. The wearing of shorts, sandals, tank tops, and other articles of clothing that result in large areas of exposed skin should never be permitted in a pesticide work place.

Some general guidelines for interpreting pesticide label statements which require protective clothing and equipment are available from the California Department of Food & Agriculture (FAC Section 12980-12988) at *http://www.legingo.ca.gov/cgibin/calawquery?codesection=fac&codebody*

TYPES OF PROTECTIVE CLOTHING

Skin contamination is the leading cause of occupational pesticide-related illness. Therefore, protecting the skin should be given first priority.

Coveralls, aprons, spray suits, gloves, hats, boots, goggles, and face shields are designed to protect pesticide users from getting the pesticide on the skin or into the eyes.

Lightweight Disposable Coveralls

Made of chemical-proof material.

Lightweight and reasonably comfortable in hot weather.

Offer excellent protection if not damaged.

Some come with direction for re-use after laundering.

All coveralls that become severely contaminated should be discarded.

Washable Cloth Coveralls

Washable fabric may be reused many times.

Critical that if washable cloth coveralls are worn, they must be laundered before each day's work.

Adequate for working with dry pesticides (granular formulations or bait blocks) and some liquid pesticides used in vector control.

If coveralls become wet or even damp with pesticide, they will act as a continuous source of contamination.

Remove the cloth coveralls if liquid pesticide is spilled onto it, and shower if the pesticide has significant dermal toxicity.

Aprons

When pouring or otherwise handling Category I or II liquid pesticides, you should wear additional protection in the form of a rubber apron or chemical-proof disposable (Tyvek) coveralls that cover your body from chest to your boots.

Be certain the apron will resist the solvents used in formulating the pesticide.

Check the label for any specific requirements.

Spray Suits

May be required for the handling, mixing and application of Category I or II pesticides.

Made of liquid-proof and tear-resistant materials.

Tend to be uncomfortable in hot weather, and overheating can be an occupational hazard. Thus worker should avoid doing work with such pesticides except when the weather is cool.

Gloves

When working with liquid pesticides, protect your hands by wearing liquid-proof gloves with no rips or tears. Cloth, leather, or other materials can lead to chronic exposure.

Gloves of natural rubber will provide protection from organophosphates and carbamates. Unlined flexible plastic gloves are considered best for all other pesticides so long as they are designed for use with solvents and pesticides.

Leather gloves may provide satisfactory protection when working with dry pesticides that have no dermal toxicity. But almost all other situations should be avoided.

When using your gloves, wear your sleeves so that they prevent spills and splashes from running into your glove and onto your hand.

Hats

Pesticide workers applying liquid products that may have dermal toxicity should use a liquid-proof hat preferably made of washable plastic.

May be hard or flexible plastic but should have a plastic sweatband and be washed thoroughly after each use.

Cloth, straw, or felt hats are not recommended.

Boots

When mixing or loading Category I or II pesticides wear knee-length pull-on rubber boots without buckles or laces (this makes them easier to clean).

Trouser legs should be worn outside of your boots to avoid spills and splashes running into the boot and onto your leg. Wash the boots thoroughly inside and out after each use.

CARE OF CLOTHING

Wear clean clothing daily.

If your clothes become contaminated with pesticide, shower and change them immediately – if they are highly contaminated dispose of them in a safe manner.

Do not store contaminated clothing and wash them separately from family laundry.

If you are manager of a program, make sure personnel are provided appropriate protective clothing as required by state and federal regulations.

TYPES OF EYE, MOUTH, AND FACE PROTECTION: Goggles

Especially important to protect the eyes with chemical goggles when handling dusts, wettable powders, or granules.

Manufactured so they fit over ordinary eyeglasses (prescription eyes pieces also available for those who use goggles frequently).

Must be washed with soap and water after each use.

Check the label for specific eye protection requirements or recommendations.

Face Shields

May be advisable or required by the label for some herbicides used for vector control – particularly when loading or mixing liquid concentrates.

Made of clear plastic, attached to a hard hat, and can be raised or lowered as needed.

Must be washed with soap and water after each use.

PROTECTION FROM INHALATION HAZARDS

"You must wear a respirator if the pesticide label requires one. You may need to wear a respirator if the pesticide label says "Avoid breathing vapor or mist". Your supervisor must give you a respirator when it is needed. You <u>must</u> wear it."

- Pesticide Safety Information, HS-1746, California Department of Pesticide Regulation

Protection from Inhalation Hazards

Devices designed to protect the respiratory system from hazardous materials are called respirators. Any device used must have federal approval for use with pesticides.

Must be worn when working with pesticides that may be harmful when inhaled.

Full-face respirators: protect from pesticides that can irritate eyes and lungs.

Positive / Negative Pressure Respirators

Positive pressure respirators: devices that have a pump system to force purified air into the mask.

Negative pressure respirators: filter air as it is sucked through a filtering media contained in a cartridge or canister (designed to protect against vapors of specific chemicals). These require a tight seal of the mask around the nose and mouth.

Positive Pressure Respirators

Designed to supply full-face protection: cover the eyes, nose and mouth.

Proper fit is absolutely essential with this type of respirator.

Incorporate a battery powered air pump worn on the belt, feeding filtered air into the head piece in a constant flow.

Often used by individuals involved in vector-borne disease surveillance operations, such as plague or hantavirus investigations.

Respirator Proper Fit

Respirators come in different sizes, and it is essential that workers know how to test for a proper fit.

This testing should take place in an area where there is no chance of pesticide exposure.

Any respiratory to be used to protect workers from pesticide vapors must be labeled as approved by the National Institute for Occupational Safety and Health (NIOSH).

Clearance to Using Respirators

High blood pressure, heart disease, lung disease, or a perforated eardrum may interfere with effective use of a respirator.

A physician can certify if certain workers should not use a respirator and thus should not work around pesticide vapors.

Medical clearance is required prior to using most if not all respirators.

Beards, bushy mustaches, or long sideburns may interfere with proper fitting of respirators. In these cases there are special respirators that can still provide a tight seal.

SCBA Protection

Some fumigant labels require you to wear a self-contained breathing apparatus (SCBA).

With this type of device all air for breathing is contained in a tank of some kind, and no outside air enters the respiratory system.

This type of protection will rarely, if ever, be required with public health pesticides.

Chemical Cartridge Respirators

Most are half-face masks with respirators that cover the nose and mouth, but do not protect the eyes. Should be fit tested prior to use.

They have one or two cartridges that screw into the face piece and can be easily removed for replacement. These types are usually equipped with one-way valves that allow the inhaled air to pass through the cartridges and out via a separate exhalation valve.

Designed for use where high concentrations of pesticides are unlikely (used when mixing or loading pesticides outdoors with adequate ventilation).

Respirator Cartridges

Usually contain an absorbing material such as activated charcoal.

Have filter pads to remove dust and spray particles, thus prolonging the life of the absorbent material.

The effective life of chemical absorbing cartridges or canisters varies according to the concentrations of pesticides encountered, the humidity, temperature, and volume of breathing.

The devices gradually lose effectiveness during storage because of the exchange of air within the unit due to changes in temperature and atmospheric pressure.

Filter Cartridges Should be Replaced When:

Directions on the pesticide label say so.

The respirator maker says so.

You first smell or taste a pesticide, or experience irritation.

At the end of each day's use.

Follow the rule that replaces the filter cartridge according to the manufacturer.

Use & Cleaning of Personal Respiratory Devices

All negative pressure respirators must be fit-tested to ensure the mask is properly sealed. A proper fit can be obtained by adjusting headbands, or switching to another size or respirator type.

Change respirator filter cartridges as previously mentioned.

Clean respirators after each use. Remove and discard used filter pads, and cartridges as needed and wash face pieces with soap and warm water. Dry with clean cloth and leave in a well-ventilated shady area. Replace the used cartridges and filter pads with new ones.

Use & Cleaning of Personal Respiratory Devices

Store the respirator and its replaced parts in a dark, clean, and dry place (preferably in a tightly closed paper or plastic bag).

When respirators are broken or otherwise inoperable, they must be fixed prior to use or your supervisor must supply new ones.

Remember: respirators only protect pesticide workers from breathing chemicals. When pesticides are used, protection of the skin is also important.

CHECKLIST FOR AVOIDING PESTICIDE EXPOSURE

For avoiding DERMAL exposure:

1. **Check the label for special instructions or warnings regarding dermal exposure.**

2. **Use recommended protective clothing and other equipment as listed on the label.**

CHECKLIST FOR AVOIDING PESTICIDE EXPOSURE

For avoiding ORAL exposure:

1. **Check the label for special instructions or warnings regarding oral exposure.**
2. **Never eat, drink, or smoke while working with any pesticide.**
3. **Wash thoroughly with soap and water before eating, drinking or smoking.**
4. **Do not touch your lips to contaminated objects (such as nozzles).**
5. **Do not wipe your mouth with contaminated hands or clothing.**
6. **Do not expose food, beverages, drinking vessels, or cigarettes to pesticides.**
7. **Wear a face shield when handling concentrated pesticides.**

CHECKLIST FOR AVOIDING PESTICIDE EXPOSURE

For avoiding RESPIRATORY exposure:

1. **Read the label to find out if respiratory protection is required.**
2. **If respiratory protection is required, use only an approved respiratory device.**
3. **Avoid working for extended periods in areas where volatile pesticides are used or stored.**

CHECKLIST FOR AVOIDING PESTICIDE EXPOSURE

For avoiding EYE exposure:

1. **Read the label to find out if eye protection is required.**

2. **If eye protection is required, use goggles to protect your eyes or a face shield to protect your eyes.**

3. **Pour or mix pesticides below eye level.**

Chapter 8: Equipment and Calibration

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Introduction

Pesticide application equipment

Sprayer components

Sprayer maintenance

Calibration of pesticide equipment

INTRODUCTION TO EQUIPMENT & CALIBRATION

Some pesticides used in vector control are available in granular forms and can be applied by simple equipment such as fertilizer spreaders. Others require require specialized equipment for application.

Some pesticides come in concentrated forms and must be diluted to produce a tank mix.

Mosquito adulticides are applied as fogs and require ULV equipment.

INTRODUCTION TO EQUIPMENT & CALIBRATION

The labels of pesticides used in applications carry specific restrictions on application rates and/or droplet size.

It is critical that equipment be maintained in good working order and that the equipment be calibrated frequently to make sure applications conform to label requirements.

INTRODUCTION TO EQUIPMENT & CALIBRATION

The first question that needs to be asked when choosing the type of pesticide application equipment is whether a liquid or a solid (dust or pellets) pesticide formulation will be used.

For liquid formulations, the basic choice will hinge upon the spray techniques used. Spray techniques, in turn, are classified on the basis of the spray volume used.

Three basic types of liquid spray techniques are:

1. **High Volume (40 gallons per acre or more).**
2. **Low Volume (0.5-40 gallons per acre).**
3. **Ultra-Low Volume (0.5 gallons per acre or less).**

INTRODUCTION TO EQUIPMENT & CALIBRATION

Then, consider the location and size of the area to be treated and the pest to be controlled. There are two basic types of equipment used to apply public health pesticides: *powered* and *unpowered*.

PESTICIDE APPLICATION EQUIPMENT: Unpowered Equipment

Small, unpowered equipment generally inexpensive, simple to use, and easy to clean and store.

Small areas (less than an acre) can be treated by a single person in a relatively short period of time.

However calibration of small unpowered devices can be difficult, and larger capacity liquid tank sprayers may be difficult for physically smaller technicians to handle.

Unpowered Equipment

Generally suitable for relatively small pesticide applications such as spot treatments of aquatic sites where mosquito larvae are present.

Typical unpowered equipment for liquid pesticides includes some backpack and tank sprayers.

Unpowered Backpack Sprayers (Compression Sprayers)

Come in sizes ranging from about 1-5 gallons.

Sometimes have to have a continuously operated pump lever to maintain pressure in the pesticide tank. Others are pumped up by hand until pressure reaches a certain point.

Can be sprayed until the pressure drops below the level where the sprayer works effectively (then it must be re-pressurized).

Non backpack sprayers are often referred to as “hand can” or by their capacity “3-gallon sprayer”.

Other Types of Unpowered Pesticide Equipment

Pesticides in solid form (granules, slow release briquettes, powders, etc.) can be applied by hand, with small crank operated spreaders, dust cans, or similar devices.

Unpowered Equipment

Small unpowered equipment is inexpensive, simple to use, and easy to clean and store.

Small areas (less than an acre) can be treated by a single person in a relatively short period of time.

Calibration of small devices can be difficult and larger-capacity liquid tank sprayers may be difficult for physically smaller technicians to handle.

Powered Equipment

Powered equipment is essential for large-scale pesticide applications.

Ordinarily is mounted permanently in terrestrial or aquatic vehicles, or is attached to fixed or rotary-wing aircraft.

Not all powered equipment is large – some backpack sprayers may use small 2 cycle engines as a power source, and some of these miniature units have been used for ULV applications.

Powered Equipment

All power equipment works by pumping or blowing product from a storage tank through a distribution line or hose to various types of control mechanisms.

The control mechanisms may be mounted on various devices such as guns, booms, or cylinders that can be aimed.

For liquid products, the pesticide is applied through nozzles which control the shape of the spray pattern, the rate of flow of the spray, and the size of individual spray droplets.

Nozzles are available in many sizes and configurations – solid pesticides are spread using hoppers or air streams to propel the particles.

Foggers and Aerosol Generators

Work by breaking pesticide formulations into very small droplets.

Output may be visible as a cloud or a fog. This cloud is produced in one of two ways:

1. **In thermal fogging, the fog is produced by some type of heating element called a thermal generator, and pesticide is carried on heated oil droplets.**

2. **In cold fogging droplets are produced by atomizing nozzles, spinning disks, or high pressure (this is much less visible).**

Foggers and Aerosol Generators

Large truck-mounted foggers have been sued almost exclusively for control of flying insects such as mosquitoes and gnats.

Small portable foggers have been used for control of roaches and stored product insects in warehouses and similar structures.

Low Pressure Tank & Boom Sprayers

Relatively inexpensive, light in weight, and have enough capacity to cover large areas.

Low pressure sprayers deliver a low volume (0.5-40 gallons per acre) of dilute spray through nozzles with 30-60 pounds per square inch (psi) pressure.

They are designed to apply either undiluted or mixed product from a supply tank, through a single hose or a series of hoses through one or more nozzles.

Low Pressure Tank & Boom Sprayers

For vector control, this type of sprayer is usually mounted to an all terrain vehicle (ATV), an amphibious vehicle, or a low-speed aircraft to treat pastures.

The purpose of the booms is to achieve wider and more even coverage for each pass of the vehicle carrying the sprayer.

Low Pressure Tank & Boom Sprayers

Larval mosquito control products such as the liquid formulations of microbial insecticides, *Bti* and *Bs*, larviciding oils, and some herbicides are most commonly applied using this type equipment.

For most of these products, adequate agitation is not a significant problem. For wettable powder formulations a mechanical agitator may be required.

Low Pressure Tank & Boom Sprayers

Low pressure tank and boom sprayers come in a variety of sizes from small units with 10 or 15 gallon tanks mounted on ATVs to large units with water capacities of 1,000 gallons or more mounted on large flatbed trucks with a series of nozzles designed for roadside weed spraying.

Disadvantages of Low Pressure Tank & Boom Sprayers

They are not useful when high volume is required because their rate of application is low.

They cannot penetrate dense foliage because they operate at low pressure.

They produce visible fogs, which some people find objectionable.

Single-Nozzle Hand-Gun Sprayers

Used more frequently than boom sprayers for *larvicides*, because specific distribution is more important.

Larval mosquito control products such as the liquid formulations of microbial insecticides, *Bti* and *Bs*, Coco Bear oil and some herbicides are most commonly applied using this equipment.

For most of these products, adequate agitation is not a significant problem. For wettable powder formulations a mechanical agitator may be required.

High Pressure Sprayers (Hydraulic Sprayers)

Designed to apply large volumes (40 gallons per acre or more) of liquid at high pressure.

More versatile than low pressure units, high pressure sprayers can deliver large volumes high enough to penetrate dense foliage or reach the tops of tall trees.

Usually well built, have mechanical agitation, and are designed to resist wear.

Disadvantages of High Pressure Sprayers

They are expensive, heavy, and require large amounts of water and fuel.

Because the spray is produced at high pressures, there is a tendency for it to form small droplets subject to drift.

Thus, high pressure sprayers are rarely used in vector control operations.

Air Blast Sprayers

Air blast sprayers are rarely used for vector control, but may occasionally used for fly control.

Use a high speed, fan-driven air stream to disperse the spray.

A series of nozzles inject the spray into the air stream which breaks up the droplets and blows them onto the target. They can either deliver high or low volumes of spray.

Give good coverage and penetration, use low pump pressures and have mechanical agitation.

They can be operated at low volumes and therefore require small amounts of water.

Disadvantages of Air Blast Sprayers

May produce small droplets that may create a drift hazard.

Because of this, they must be used under calm weather conditions.

Typically these are relatively large, heavy machines that are not appropriate for use in small areas.

Low Volume Air Sprayers (Mist Blowers)

Mist blowers are a type of low volume sprayer used to control both larval and adult populations of mosquitoes.

Characterized by relatively low fluid pressures, with flow rates of several ounces per minute.

Dispersal is done using high air velocity – typically the product is run through hoses to a metering device which may or may not be connected to a conventional nozzle.

Some are mounted on trucks and dispense mists of pesticide through nozzles mounted within large open cylinders.

Advantages of Low Volume Air Sprayers (Mist Blowers)

Backpack-type power mist blowers allow rapid and efficient treatment of up to several acres by individual vector control technicians

Need a lower volume of water.

Particularly useful in mosquito control for treating dairy lagoons, roadside sources, and for applying a residual adult control product to individual properties.

Large Mist Blowers

Large units can be mounted on pickup trucks or small trailers, however they are unusable in areas without roads.

Although best suited for liquid applications, some manufacturers equip them with hoppers for dusts and pellets or granules.

Many require two people for operation – one to operate the sprayer while the other drives the vehicle.

Ultra Low Volume Sprayers (ULV) (“Cold Fogging”)

Designed to apply extremely low volumes of highly concentrated pesticides in the form of very small (5-30 micron) droplets into the air. A micron is equal to 1/25,000 of an inch.

Used primarily against adult mosquitoes and require the use of insecticides formulated for this purpose.

These formulations are either sprayed as ready to use or diluted with light oils.

Ultra Low Volume Sprayers (ULV) (“Cold Fogging”)

Most ULV sprayers utilize a small electric pump that can be very finely adjusted to vary droplet size and flow rate.

Many commercial ULV formulations are available for adult mosquito control.

A typical formulation contains a small concentration of pyrethrin (5-10%) combined with a synergist such as PBO (the remainder an oil of some kind).

Ultra Low Volume Sprayers (ULV) (“Cold Fogging”)

With the exception of malathion, ULV products have a low percentage of active ingredient.

ULV sprayers may be mounted in trucks, amphibious vehicles, or in aircraft.

They are currently the most widely used type of sprayer for adult mosquito control.

Ultra Low Volume Sprayers (ULV) (“Cold Fogging”)

Sensible alternative to the old fashioned thermal fogging machines.

Combination of extremely low volumes (often less than one ounce of total liquid volume per acre) and pesticides having very low toxicity for humans and other vertebrates makes them very safe for humans and other non-target organisms.

Effective ULV Spraying Requires Careful Attention to Weather Conditions

Very small droplets of concentrated pesticide tend to drift out of the target zone at high wind speeds. (The higher the wind speeds, the lower the effective swath.)

ULV applications are generally not effective for mosquito control at winds over 10 MPH.

Temperature can affect evaporation of the pesticide.

Because of the effect of weather variation on ULV applications, calibration should be checked frequently for flow rate and droplet size. Many new labels require an annual calibration certification. Consult pesticide label for specific meteorological limitations.

Temperature Inversions

Occur when temperatures at ground level are lower than temperatures at higher altitudes (reverse of the normal temperature situation near the surface of the earth).

During inversions, cold air is trapped by the warm air above it and there is little vertical mixing of air.

The small droplets produced by ULV sprayers remain suspended in the cool air within several feet of ground level.

Effects of ULV Spraying with Temperature Inversions

Desirable for ULV mosquito control applications because at the time of spraying female mosquitoes are host seeking (looking for a blood meal) near ground level, and the risk of damage to non-target organisms is low. Without lateral air movement or a temperature inversion the vertical air currents will carry the small droplets above the level at which they effectively kill mosquitoes.

However, for some agricultural applications and applications of herbicides, spraying under these conditions is undesirable because the spray droplets may remain suspended in the cooler air at ground level and damage non-target organisms.

Solid Pesticide Applicators: Dusters

Come in a variety of configurations, both powered and unpowered.

Some equipment used for application of liquid pesticides can be used for solid materials with the installation of accessory hoppers and other devices.

Solid Pesticide Applicators: Granular Pesticide Spreaders

Eliminate the necessity of mixing the formulation with a solvent.

Designed to apply coarse, dry uniform size particles to soil or water.

Two major types: granular blowers (backpack or truck mounted) and seed or fertilizer spreaders mounted on some piece of equipment.

Advantages of Granular Pesticide Spreaders

Power granular applicators allow vector control technicians to treat habitats where liquid products might not be effective, and allow a single technician to treat many acres in a day.

Power backpack granular blowers are particularly effective in treating areas that are difficult to reach.

Equipment is relatively inexpensive, and there is little drift hazard. Other equipment like seeders can often be modified to spread granules.

Granules are less hazardous to the applicator.

Disadvantages of Granular Pesticide Spreaders

It may be difficult to calibrate power granular applicators because of the difficulty in maintaining constant travel speed while walking or driving.

For units mounted on terrestrial vehicles or on backpacks, the equipment must be re-calibrated for each different product or formulation.

SPRAYER COMPONENTS: Tanks

Typically made of impermeable plastic or stainless steel.

Most have a single tank that holds mixed pesticide ready to be applied. Some larger truck-mounted sprayers have separate tanks for product and clean water with a smaller mixed (injection) tank of mixed product.

Some may contain an agitation device, especially those designed to work with insoluble pesticide formulations such as wettable powders.

Pesticide Tank Recommendations

Should be designed for easy filling and cleaning.

Opening of the tank should be fitted with a cover that can be secured enough to prevent spills or splashes.

Drain should open through the bottom of the tank so that the tank can be emptied completely.

Pesticide Tank Requirements

Must have a label including the EPA registration number of the pesticide, the owner of the equipment and any applicable precautionary statements.

Must have a lockable filler cap.

Must have an easy-to-read accurate sight gauge or other external means of determining the internal level.

Must be fitted with a device that maintains an air gap to prevent back flow from the tank into the water supply (as an alternative, the fill hose can be equipped with an automatic back pressure shut-off device).

Sprayer Components: Agitators

Very few products used for vector control require continuous agitation inside a spray tank.

In-tank agitation may be accomplished by hydraulic or mechanical means.

Hydraulic agitation is achieved by pumping some of the solution back through the tank.

Mechanical systems achieve agitation through the use of some sort of paddle or propeller mounted on a shaft in the spray tank.

Sprayer Components: Pumps

Most equipment used by vector control agencies are purchased as a unit, with a pump already installed.

Choosing the correct pump requires matching it to the spray equipment to be used.

To do this, due consideration must be given to capacity, pressure, and resistance to corrosion and wear.

Electric pumps have replaced gasoline engine-driven ones in all new ULV mosquito control equipment because they are capable of the fine control over pressure and flow rate needed to meet label requirements for application rates.

Sprayer Components: Nozzles

Critical element in the application of liquid pesticides because it determines spray characteristics.

Nozzles affect the application rate, discharge shape (fine mist, cone, fan etc.), droplet size, uniformity, pressure, and carry distance of the pesticide stream used for pesticide applications.

On aircraft, the position of the nozzle may affect the product output and the differential airflow may affect the uniformity of applications.

Sprayer Components: Nozzles

For any given pesticide application and spraying system, consider the nozzle type, size, and condition before selecting.

To achieve maximum effectiveness consider nozzle orientation, nozzle spacing on the boom, and boom/nozzle elevation above the ground.

For nozzles to perform efficiently, they must be cleaned, repaired, and adjusted frequently. Damaged nozzles should be replaced with new ones promptly.

Types of Sprayer Nozzles: Flat Fan

Nozzle used primarily on boom sprayers, which produces a nearly flat fan of spray in several selected angles and deposits an oval pattern on the ground.

Less material is deposited at the outer edges, which requires the fan patterns to be overlapped to produce uniform coverage (depends upon proper spacing of the nozzles on the boom).

When used from trucks or tractors, distance above the ground also has an effect on uniformity of application.

These nozzles are used for broadcast or boom spraying in weed control work.

Types of Sprayer Nozzles: Even Flat Fan

Also used primarily on boom sprayers.

Fills the outer portions of the spray pattern to produce even coverage across the entire width of the pattern.

Not designed for overlapping use on a boom.

Efficient for coverage of a given strip through the field as over a crop row.

Generally best for band spraying of herbicides in row crop work.

Types of Sprayer Nozzles: Cone

Found commonly on unpowered backpack sprayers, unpowered tank sprayers, and boom sprayers.

Spray is produced as either solid or hollow cone patterns.

Cone angle contributes to better coverage of foliage and is one of the most popular nozzles for insect and disease control work.

Types of Sprayer Nozzles: Hollow Cones

Used primarily on unpowered backpack sprayers.

Designed for moderate to high pressures and are used where thorough coverage of crop foliage and uniform distribution is desired.

Little or no spray in the center of the pattern.

Types of Sprayer Nozzles: Solid Cones

Spray is well distributed throughout the pattern and is used for hand spraying, spot spraying and moderate pressure foliar applications.

Types of Sprayer Nozzles: Flooding or Impact

Rarely seen in vector control use except for weed control applications.

Have agricultural uses on farms and in home gardens, where they are used to spray liquid fertilizer solutions.

Normally operate at low pressures with large droplets and can cover a wide area, so it may be unnecessary to use a boom.

This is an advantage on rough terrain or where many obstacles would hinder boom operation.

Types of Sprayer Nozzles: Offset

Lack uniformity of the flat fan.

Can provide reasonable uniform coverage over wide areas for roadside and ditch bank weed control.

Types of Sprayer Nozzles: Atomizing

The nozzles most frequently used in all types of ULV applications, both in ground and aerial spray operations.

Produce a fine mist from liquid pesticides.

In comparison to compression sprayer nozzles, atomization nozzles can be very complex (variety of different equipment).

In some, the atomization is accomplished by rotation of the nozzle by electric motors, others use wind-driven fans to produce rotation in the nozzle mechanisms.

Types of Sprayer Nozzles: Broadcast

Used primarily from vehicles treating roadsides or rights of ways with herbicides.

Can be used either on boom-less or boom-type sprayers.

With boom-type sprayers a boom is used to extend the effective swath – the spray itself is in a wide flat fan pattern.

Types of Sprayer Nozzles: Solid Stream

In vector control, most often seen with handguns, hand can sprayers, and non-powered backpack sprayers when it is necessary to treat sites located at some distance from the operator.

For larval mosquito control operations, best distribution of product is obtained by spraying upward and allowing the droplets to fall down onto the area.

When compared to cone nozzles this application method allows much more rapid and efficient treatment of larger areas.

Types of Sprayer Nozzles: Adjustable

Used frequently for vector control applications, and allow varying the spray pattern from a pinpoint stream to a cone.

Also used in small home garden sprayers.

Particularly useful when treating variable terrain. Example: the pinpoint stream nozzle may be used for a mosquito larval control application to target open areas in tulles or cattails in a pond, with the cone being used to treat flooded hoof prints along the edge.

Nozzle Construction & Use

Nozzles are subject to wear, they must be replaced before excessive wear occurs or they will fail to deliver the accurate amount and pattern of spray.

Rate at which a nozzle wears depends on:

1. **The formulation of the material sprayed.**
2. **The nozzle design.**
3. **The material used to construct the nozzle.**

Characteristics of Nozzle Materials

Brass: Inexpensive, but wears quickly from abrasion. Good for limited use.

Stainless Steel: Corrosion and abrasion resistant and relatively expensive.

Plastic: Very inexpensive. Resists corrosion, but swells when exposed to some solvents. Not recommended for high pressure spray applications.

Tungsten carbide and ceramic: Expensive, but provides long service. Highly resistant to abrasion and corrosion. Recommended for high pressure applications.

Nozzle Selection, Use, & Maintenance

Select nozzles that will provide the desired droplet size, volume of flow, and spray pattern.

After installation of new or repaired nozzles, properly calibrate the spray system to ensure proper application rates.

Avoid spraying tank mixes of pesticides containing hard particulate matter such as sand or metal particles. This greatly accelerates nozzle wear, (even the expensive ones).

Always operate nozzles at the recommended pressure.

Nozzle Selection, Use, & Maintenance

Mount the nozzles securely so their location, relative to the target, is maintained constantly and properly.

Maintain nozzles in peak condition by periodic inspections, adjustments, and cleaning.

Never use a pocket knife or other metal object to clean a nozzle. It will damage the precision-finished nozzle edges and ruin performance. A round wooden toothpick is much better, or remove nozzle tip and back-flush it with air or water.

Don’t blow through a nozzle by mouth especially if it has been used for pesticide application.

SPRAYER MAINTENANCE

Most troubles with sprayers are caused by foreign matter clogging or wearing out screens, pumps or nozzles.

Pump deterioration is brought about by ordinary use but is accelerated by misuse.

The following suggestions will help prolong the useful life of pumps and sprayers:

Sprayer Maintenance
#1: Always Use Clean Water

A small amount of silt or sand can rapidly wear pumps and other parts of the sprayer system.

Use water that looks clean enough to drink (from a well is best.)

Water pumped directly from ponds or stock tanks should be filtered before filling the tank.

To avoid contamination of water supplies, regulations require all application equipment to be equipped with an air-gap separation or back-flow prevention device.

Sprayer Maintenance
#2: Keep Screens in Place

The nozzle screen should be fine enough to filter particles which will plug the tip orifice.

A sprayer system usually has screens in three places: a coarse screen on the suction hose, a medium screen between the pump and the boom or hose, and a fine screen in the nozzle.

Sprayer Maintenance
#3: Only Use Designated Chemicals

Only use chemicals the sprayer and pump were designed to use.

For example, liquid fertilizers are corrosive to copper, bronze, ordinary steel and galvanized surfaces. If the pump is made from one of these materials, it may be ruined by a single application of the liquid fertilizer.

Sprayer Maintenance
#4 Never Clean Nozzles with Metal

To clean nozzles, put on rubber gloves and then remove the tips and screens and clean them in water or a detergent solution using a soft brush.

The orifice in a nozzle tip is a precision-machined opening, cleaning with a pin, knife, or other metallic object can adversely change the spray pattern and capacity.

Use a round wooden toothpick if no brush is available.

Sprayer Maintenance
#5: Flush Sprayers Before Use

New sprayers may contain metallic chips and dirt from the manufacturing process.

Sprayers which have been idle for a while may contain bits of rust and dirt.

Put on rubber gloves and then remove the nozzles and flush the sprayer with clean water.

Clean all screens and nozzles thoroughly before using the sprayer.

Sprayer Maintenance
#6: Clean Sprayer Thoroughly After Use

After use, flush the sprayer with water or flushing solution to clear lines and nozzles to prevent corrosion and material drying in the system.

Be sure to wear appropriate protective equipment and that discharged cleaning water will not contaminate water supplies, streams, crops, plants or where puddles may be accessible to children or animals.

Best way to use cleaning water is as a diluent in a sprayer tank for application of the same pesticide used in the sprayer before cleaning.

CALIBRATION OF PESTICIDE EQUIPMENT

Calibration of pesticide spray equipment is a legal requirement.

It is a violation of state and federal regulations to apply a pesticide in any manner other than as specified on the label.

Calibration of equipment is important to the success or failure of a pesticide treatment.

It is a waste of time and money to apply any pesticide in an inefficient or ineffective manner.

What is Calibration?

Calibration is the preparation of pesticide application equipment to ensure that a pesticide is being applied appropriately, in the desired area, and with the correct amount of active ingredient.

The only accurate way to determine that the rate of application is consistent with the label requirements.

Calibration in combination with careful preparation of tank mix and proper operation of equipment during actual applications is key to effective and legal treatment.

Calibration of Pesticide Equipment

Although power sprayers may produce consistent results when new, components of the system will affect application rates.

No two pieces of equipment will behave in exactly the same way.

Studies have shown that three factors stand out in pesticide applications that do not conform to label requirements: inaccurate preparation of tank mixes, worn spray nozzles, and improper calibration of spray equipment.

Calibration of Pesticide Equipment

Some pesticide labels contain tables of values for calibrating spray equipment at various dilutions, application rates, and equipment speeds. If this is the case, calibration becomes much easier and usually involves only checking the flow rates for individual nozzles.

Information Needed for Calibration:

The legal application rate as specified on the pesticide label.

Amount of liquid applied by the sprayer per unit of area at a given speed and pump pressure.

The amount of active ingredient contained per unit of liquid in the spray tank.

The capacity of the spray tank.

Assumptions for Calibration

The nozzles are in good repair, are of the proper type, and are made of the proper material.

Nozzle pressure, pattern, and flow rate will remain constant during calibration.

Speed of movement of sprayer (whether vehicle mounted or carried by technician) will be constant during calibration.

General Procedures for Calibration

How to determine sprayer output and nozzle output:

1. **Read the pesticide label and record the allowable and recommended pesticide application rate.**

2. **Use water or appropriate diluent for pesticide to be applied for calibration.**

3. **Adjust nozzles to desired patterns and record nozzle pressures when operating.**

4. **Adjust speed of vehicle and record either MPH or engine RPM and transmission gear used.**

General Procedures for Calibration

5. Fill the spray tank with water.

6. Make trial runs spraying water at speed and pressure selected over one acre, or some fraction of an acre. When done, determine amount of water sprayed and calculate sprayer output in gallons per acre.

7. While still operating the sprayer at a selected pressure, catch and measure output for each nozzle for 1 minute, then calculate an average nozzle output in gallons per minute.

General Procedures for Calibration

8. **Count the number of nozzles to be used and measure the distance in inches between the nozzles on the boom.**

9. **From the sprayer output in gallons per acre, the average speed of the trial run in MPH, and the nozzle spacing in inches, calculate a value for gallons per minute per nozzle based on the following formula:**

Gallons per minute per nozzle = gallons per acre x MPH x nozzle spacing/5,940

General Procedures for Calibration

10. **Check the value you get from the calculation against the flow rate you determined from catching and measuring the output from the nozzles. If the two values are far apart (more than 10%), re-check your calculations.**

11. **You can also perform this calibration in reverse by using the formula:**

    Gallons per acre = (5,940 x gallons per minute per nozzle)/ MPH x nozzle spacing)

Calculation of the Tank Mix

To determine the amount of pesticide formulation needed to add to the tank you will need to know:

The application rate called for on the pesticide formulation label. Typically, this will be stated as pounds per acre.

The percentage of active ingredient in the commercial formulation.

The capacity of the spray unit tank.

The output of liquid (water) of the sprayer from the results of calibration.

The amount of tank mix desired, if less than a full tank of pesticide.

Reconciling Application Rate Units

An important consideration in determining the amount of pesticide formulation needed for a full or partial tank of tank mix is reconciling the units used for the application rate of active ingredient (ai) specified on the label (usually by weight of ai) with the units used for sprayer output (usually liquid volume).

For formulations mixed with water, this formulation can be used:

> **(Gallons of spray wanted) x (percent of active ingredient wanted) x 8.3 / % active ingredient in insecticide formulation**

This formula is different from oils, which have lower specific gravities.

Applications of Solid Pesticides

The principles of calibration are the samefor applications of pellets, powders, and dusts, but the equipment will be different from that used for liquids.

Instead of water, calibration can be with blank (inert) granules or other solids. This type of calibration will be on the basis of weight, so you can place a given weight of solid material in the hopper and measure the amount of material discharged on the basis of weight per unit of time and weight per unit of area.

Applications From Powered Knapsack Sprayers

Calibration will be similar to the general example given, except that movement speed will be more difficult to control, the areas sprayed will be smaller, and a single nozzle will almost always be used.

Calibration values will apply only for the nozzle used and the walking pace of application.

Determination of amount of pesticide needed will need to be done before, and will depend on the percentage of active ingredient in the commercial formulation and the type of diluent (if any) used.

How to Determine Sprayer Output Rate of Powered Knapsack Sprayers

Lay out an area representing an even fraction of an acre. (A rectangle measuring 100 x 109 feet would be one-quarter of an acre.)

Count the amount of water used to spray the plot, multiply by 4, and calculate the output in gallons per acre. Also note the time in minutes it takes to spray the plot.

From this you can calculate the gallons per minute of spray based on your walking pace.

To check the calculation and the flow rate of the nozzle, you can catch and measure the output for one minute and record the result as gallons per minute. This should agree with your earlier value from walking the test plot.

Applications From Unpowered Compression Sprayers

Used frequently for treatments of small terrestrial or aquatic sites for various kinds of pests, such as treatment of small ditches for control of mosquito larvae.

Challenges to Calibrating Hand-Carried & Hand Pumped Sprayers

Flow rate varies with pressure, and pressure varies widely with these kinds of devices.

Some have pressure gauges, others do not.

Since the travel speed of the sprayer will be the travel speed of the human carrying the sprayer, maintaining constant speed is difficult.

End result however is the same: to make sure the application conforms to the pesticide label requirements.

How to Estimate Application Rate of Hand-Carried Sprayers

(Similar process used for the powered backpack sprayer):

Measure a small plot that represents some even fraction of an acre (a plot 50 x 55 feet would be about 1/16 of an acre)

Measure the time and number of gallons it takes to spray the plot.

While spraying, walk in a manner that would be the same as you would walk making a real treatment, and keep the tank pumped up in a routine consistent with the actual application.

How to Estimate Application Rate of Hand-Carried Sprayers

Calculate values based on gallons per minute and gallons per acre as before. Do the trial spray several times to check the consistency of applications.

When doing the actual applications it will be necessary to estimate the size of your target area. In difficult areas where the spraying will be intermittent, you may have to actually keep track of the time spent while actually spraying with a stop watch.

ULV Applications from Air or Ground-Based Sprayers

Calibration for applications using ULV methods is more complicated than most other types because sprayers must be calibrated for both flow rate and droplet size.

ULV Flow Rate

Should be checked after all nozzles are inspected for damage and completely cleaned.

Check the one or more nozzles with the pump operating at the appropriate pressure.

Check all lines and screens for obstructions to make sure insecticide will be free-flowing.

If a battery-powered electric pump is used, the battery should be first checked to make sure it is fully charged.

Calculating ULV Flow Rate

The flow rate of the nozzles can be controlled at the pump with most equipment by adjusting a knob or screw at the pump.

To measure flow rate, either water or mineral oil should be collected in a graduated cylinder for a set period of time.

This should be repeated several times and an average value determined for each nozzle.

Finally, an average value should be calculated for all the nozzles combined.

ULV Droplet Size

The range of droplets produced using ULV equipment is characterized by a measurement is called: *volume median diameter* (VMD).

Labels for pesticide formulations designed for ULV applications will contain information on the required range of VMD values for both ground and aerial application.

Modern analytical equipment like “hot wires” or laser beams can make the measurements and provides complete profiles for the droplet spectrum.

Older manual methods involve waving a glass microscope slide under by hand through the pesticide stream and then examining the slide under a microscope (the droplets are measured and counted by hand).

ULV Calibration

To adjust the range of droplet sizes, the speed and volume of high pressure air moving past the nozzle are adjusted.

Generally the higher the speed and volume of air, the smaller the droplets produced.

For after-spray assessments, the use of dye cards (placed in the path of the sprayer) are used to collect spray particles and then analyzed in the laboratory to determine if the proper droplet sizes were achieved in an application.

Frequency of Calibration

For ULV sprayers, flow rate should be checked regularly, depending on how often the machine is used.

Droplet size should be tested at least annually prior to the spray season, and after any repairs to the machine.

In the unusual event that the ULV spray nozzle itself is damaged, it must be professionally machined or replaced.

Operation of Spray Equipment After Calibration

Consistent and uniform distribution of pesticide is necessary for successful applications.

Remember that at a given pump pressure, if you reduce speed significantly, you will increase the pesticide application rate.

Observe pressure readings frequently and make necessary adjustments to maintain constant pump pressure throughout the application.

Chapter 9: Pesticide Application Problems

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INTRODUCTION: PESTICIDE APPLICATION PROBLEMS

There are several important problems related to pesticide use that should be understood by every applicator. These problems include pesticide drift, pesticide residues, phytotoxicity, destruction of beneficial species of animals and plants, resistance of pests to pesticides, and environmental pollution.

There are many ways in which these undesirable effects can be reduced or eliminated. Each depends upon knowledge of the proper handling and use of pesticides, the components of the environment susceptible to contamination, the pesticides most likely to cause contamination, and preventive measures.

PESTICIDE DRIFT

Airborne particles produced during application of a pesticide moving outside the intended treatment area.

Except with ULV applications, this is an undesirable side effect associated with aerial and ground pesticide applications.

Severity depends on the physical form of the material, the method of application, weather conditions, and to a lesser degree, movement of the substrate to which the product was applied (both soil and water).

Pesticide Drift: ULV Application

Both desirable and necessary.

Pesticide labels specify that ULV applications must be done during weather conditions that favor pesticide drift (weather inversion or lateral winds below 10 MPH).

The longer the effective drift of the product, the greater the efficacy.

Factors of Pesticide Drift

Formulation of the Product (Dusts are more likely to drift, granules least likely).

Pressure of Sprayers (High pressure sprayers are more likely to produce fine droplets that are more likely to drift).

Improper or worn nozzles or excessive pressures.

Size of the Droplet. Small droplets can drift farther than larger ones.

Evaporation (especially among certain herbicide formulations).

Drift Should be Avoided Because:

It wastes resources, including pesticides, fuel, and technician time.

It spreads pesticides into the surrounding environment where they may become illegal residues on food crops, cause health problems, damage wildlife, and have other undesirable effects.

It can damage sensitive crops.

It has been the cause of many damage claims for crop losses.

PESTICIDE RESIDUES

When a pesticide (or an altered chemical form of it by weathering, metabolic degradation, or other processes) remains on a treated crop, animal, or object.

May result from direct application, from drift from nearby fields, from uptake from contaminated soil, or from other sources.

Desirable in some situations to produce prolonged effective pest control.

In other situations, residues can be a source of unwanted and illegal contamination (e.g. on food or feed crops at harvest).

Pesticide Residues

Pesticide residues are generally meant to include pesticides that are detectible in or on places other than their intended target.

Fresh water reservoirs, stream bed sediments, and harvested food would be examples of places that would be tested for pesticide residues.

Pesticide Residues

Pesticide residues are usually measured and tolerances expressed in parts per million (ppm) to parts per billion (ppb) on a weight basis.

Example: One ppm is one milligram in a kilogram, or one ounce of salt in 62,500 pounds of sugar, or one pound of pesticide in one million pounds of raw agricultural commodity.

Pesticide Tolerances

The residue levels allowed on food crops at harvest are legally set by the federal and state regulatory agencies and are called tolerances.

Tolerances are simply the maximum amounts of pesticide permitted to be present on or in raw agricultural commodities.

These tolerances represent levels of pesticide residues which scientists have determined may safely remain on the food crop without injury to the consumer. Tolerances vary according to the pesticide and the crop.

Pesticide Tolerances

When pesticide tolerances are found to exceed legal tolerances, the agricultural commodities involved may be seized and destroyed. Ordinarily, such situations would arise from the application of agricultural pesticides on crops, but it could happen even where pesticide applications are not specifically targeted at a crop pest, such as the application of pesticides on rice fields for mosquito control.

Persistence of Compounds

Most organochlorine pesticides (e.g., DDT, chlordane) are very persistent.

Most of the organophosphates (e.g., parathion, malathion) and pyrethroids are much less persistent.

Pyrethrins, and carbamate pesticides are non-persistent.

Persistence of Compounds

Some factors that influence the persistence of a chemical and the possibility that residues may remain are:

1. **The amount of chemical applied.**
2. **The formulation.**
3. **The pH (acidity or alkalinity) of the water diluent and of the target tissue, soil, or water.**

Persistence of Compounds

4. The nature of the surface to which it is applied.

5. Exposure to weathering from wind, rain, etc.

6. Chemical breakdown from high temperatures and humidity.

7. Photochemical reactions from sunlight.

8. Biological reactions.

CERTIFIED ORGANIC CROPS & FARMS

Organic farming is a form of agriculture which does not permit the use of synthetic fertilizers and pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms.

As far as possible, organic farmers rely on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests.

Certified Organic Crops and Farms

Vector control technicians working near these farms need work closely with the landowner to prevent vectors from coming from the property, and to avoid jeopardizing the organic status of the crop.

If a pesticide excluded for use on organically produced commodities is accidentally applied to an organic crop, the crop may no longer qualify to be sold asorganic. If this occurs in connection with a vector control operation, the producer can pursue a settlement from the vector control program for his loss.

PHYTOTOXIC EFFECTS OF PESTICIDES

Phytotoxicity is the injury or death of a plant due to exposure to a chemical.

Plants may be injured or killed by various kinds of chemicals, including salts, fertilizers, or pesticides.

Sometimes, plant injury is intentional, as when an herbicide is applied to a weed. In other cases, the plant injury is an accidental side effect of pesticide use.

Phytotoxicity can effect any part of a plant, including roots, stems, foliage, blossoms, or fruit.

Phytotoxic Effects of Pesticides

The degree of phytotoxicity caused by pesticides may vary in response to a number of factors.

Some toxicants (active ingredients) are particularly damaging to plants. Other components of the pesticide mixture, such as the diluent, may cause plant damage. The plants themselves may vary in susceptibility to injury by various chemicals.

The phytotoxic reaction may vary with the species of plant, with the age of the plant, or with the weather at the time of exposure.

DAMAGE TO BENEFICIAL INSECTS

In California, the beekeeping industry maintains millions of honey bee colonies. Each year honey bees pollinate billions of dollars worth of crops in the state.

To protect these valuable insects from losses due to pesticide poisoning, it is necessary to know where colonies are located before conducting a pesticide application.

Wild bees and beneficial insect predators and parasites can be affected by pesticide applications.

Honey Bee Protection

For vector control technicians, protecting domestic bees is primarily a concern when doing ULV adult mosquito control. The pesticides most commonly used for these applications (pyrethrins and pyrethroids) are toxic to bees.

ULV applications usually done in the evening or morning when honey bees are inactive.

Honey Bee Protection

Under California law beekeepers may request notification of intended pesticide usages, and the applicator is required to provide such notice.

Vector control agencies that have signed the Cooperative Agreement with the California Department of Public Health are exempted from regulations that require notification of pesticide applications.

Agencies can be held financially responsible for lost hives and damaged crops.

RESISTANCE TO PESTICIDES

Pesticide resistance is the ability of pests to avoid the <u>lethal</u> effects of pesticides.

This can happen through spontaneous mutations in populations resulting in genes that confer pesticide resistance, or because a small proportion of the population carries a gene for pesticide resistance naturally.

Resistance to Pesticides

Resistance develops because the parts of the population that carry the gene for susceptibility are killed off, and soon, a disproportionate segment of the population carrying the gene for resistance predominates.

Resistance develops gradually to the point where pesticide applications begin to fail after repeated exposure to the same pesticide (or pesticide family).

Occasionally, resistance to pesticides other than the pesticide responsible for resistance may occur. This is called cross-resistance. Its occurrence is usually seen among chemically related pesticides where the mode of action is identical or very similar.

Selective Pressure

Selective pressure is the repeated exposure of a population of pests to treatments of the same pesticide over time resulting in a change in the genetic makeup of that population.

In this scenario, the population is selected to favor resistant genes at the expense of susceptible genes, and the population becomes resistant to that pesticide.

Recognizing Resistance

Early signs of resistance may sometimes be recognized in the field. These include increasing difficulty in controlling a pest, increasing numbers of formerly minor pests, and increasing trouble with insect transmitted disease.

Developing resistance can be very subtle and may go unnoticed for a time.

Suspected resistance should be reported to your supervisor immediately.

Pesticide Resistance Management

Based on the genetic principles of development of pesticide resistance in pests, a number of principles have evolved over the years that when implemented can either delay resistance, or avoid it entirely.

1. **Avoid under-dosing in pesticide applications. If this is done repeatedly it encourages survival of individual pests carrying genes for resistance, especially when the effects of the gene are not absolute (protects only partially).**

Resistance Management

2. Do not always treat a given population with the same pesticide. Switch to other products periodically. This is called pesticide rotation.

3. Test populations of vectors for evidence of resistance, and when it is detected, switch to alternate pesticides.

Resistance Management

4. Avoid slow-release applications where pest populations are exposed for long periods of time to sub-lethal doses of one pesticide.

5. Combine pesticide applications with other forms of pest management such as biological control, habitat alteration, and use of biorational pesticides. The use of biorational pesticides is not a guarantee that resistance to these products will not occur, but resistance to biorational pesticides have been far less common than to conventional pesticides.

UNWANTED ENVIRONMENTAL EFFECTS

Unwanted pesticide chemicals in air, soil, water and vegetation are a form of environmental pollution.

Accumulation and storage of pesticides in plants and animals from long lasting insecticides such as DDT is a form of environmental pollution.

Atmospheric Pollutants

Pesticides may enter the atmosphere by being blown away with soil particles in cultivation or as smoke from burning materials.

A major source of atmospheric pesticide pollution is from improper application of sprays and dusts. Spraying during windy periods or with the wrong or improperly maintained equipment are major contributors to this problem.

Once in the atmosphere, pesticides are either degraded to other compounds or trapped in rain, fog or dust. They eventually fall to earth.

Soil Pollutants

Very few persistent pesticides are used in vector control operations any more.

When excess or repeated applications of inorganic or very persistent organic pesticides are made, soil residues can build up until they become a severe problem.

Pesticides in the soil may cause illegal residues in root crops or they may be translocated into the tops of plants. They may also leach into nearby surface or groundwater supplies or they may cause undesired phytotoxicity.

Soil Pollutants

Once in the soil, organic pesticides may be rapidly broken down by natural processes or they may remain unchanged for years.

Pesticides in soils break down through chemical reactions which depend on the structure of the soil, its moisture content, its pH, salinity and other factors.

Microbial decomposition depends on the temperature, moisture, and organic matter in the soil, as well as on the chemical nature of the pesticide itself.

Water Pollutants

Pesticides occur in water as intentional and unintentional additives.

Use of pesticides in water presents special hazards to plants growing in or irrigated with the water, to fish and other animals living in the water.

Specific hazards include non-target toxicity and biological oxygen demand created by decaying vegetation. Fish, animals and people who might drink or bathe in the water may be at risk.

Water Pollutants

It is extremely important that those planning to apply pesticides directly to bodies of water be completely familiar with and follow label directions pertaining to any material being used in or around water - including posting notice of the application when required by the product label.

NPDES Permit

NPDES: National Pollution Discharge Elimination System.

Permit authorized by the Clean Water Act of 1972. Designed to reduce pollution in streams, lakes, rivers, wetlands, and other waterways from point source discharges.

In 2011 this became applicable to pesticide applications, including vector control, to or near Waters of the U.S.

For pesticide treatments to Waters of the U.S., the California State Water Resources Control Board has a permit that is mandatory, and its stipulations must be closely adhered to.

The permit requirements are subject to change. Technicians should check with their supervisors for the most current regulations.

Definition: Waters of the United States

1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

2. All interstate waters including interstate wetlands;

3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:

i. Which are or could be used by interstate or foreign travelers for recreational or other purposes; or

ii. (From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

iii. Which are used or could be used for industrial purposes by industries in interstate commerce;

Definition: Waters of the United States

4. All impoundments of waters otherwise defined as waters of the United States under this definition;

5. Tributaries of waters identified in paragraphs (s)(1) through (4) of this section;

6. The territorial sea;

7. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section; waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States.

Examples: Waters of the United States

Streams, drainage ditches draining into a stream, catch basins draining into a delineated wetland, and rivers <u>are</u> all considered Waters of the U.S.

Dairy Ponds, or catch basins that drain into a sewage treatment plant <u>are not</u> examples of Waters of the U.S.

Technicians should be aware that irrigated agricultural fields usually are not considered Waters of the U.S., until runoff leaves the field.

Biotic Pollution

The direct effects of pesticides on wildlife depend on the kind and formulation of the pesticide, the target pest species, and the species of wildlife exposed. Example: Pyrethrins are highly toxic to fish, but virtually non-toxic to mammals or birds.

Biotic Pollution

Direct effects on wildlife also depend on the exposure of the animals to the pesticide; pesticides with long residual actions may cause wildlife losses for extended periods.

Pesticides with short residual effects may cause large losses but only for a short time.

Recently, residual accumulations of PBO, a synergist commonly used to increase the effectiveness of pyrethrins and pyrethroids, has been detected in stream bottom sediments. Although non-toxic itself, PBO may have the potential to make other pesticide residues in stream bottoms more toxic to aquatic organisms. This has raised the question of a potential role for PBO as a harmful stream pollutant.

Minimizing Environmental Effects

Careful attention to label directions will aid you in the selecting and using of all pesticides in ways that minimize adverse environmental effects.

Remember, apply pesticides:

1. **Only to identified pests**
2. **Only when necessary**
3. **Only where they are needed**
4. **Always at rates permitted by the label**
5. **Only in situations allowed by the label**

Chapter 10: Pesticides as Hazardous Wastes

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INTRODUCTION: PESTICIDES AS HAZARDOUS WASTES

Hazardous wastes are wastes with properties that make them dangerous or potentially harmful to human health or the environment.

Some pesticides are considered by the EPA to fit this definition, and are thus subject to laws and regulations regarding their proper handling, transportation, and disposal.

CLASSIFICATION OF HAZARDOUS WASTES

A number of different federal and state agencies have enforcement responsibilities in regard to various aspects of hazardous waste management.

In 1976 the US Congress passed the Resource Conservation and Recovery Act (RCRA), which directed that EPA develop and implement a program to protect human health and the environment from improper hazardous waste management practices. Details of this program can be found at: http://www.epa.gov/osw/hazwaste.htm.

In California, the Department of Toxic Substances Control (DTSC) (http://www.dtsc.ca.gov/) is responsible for hazardous waste information and enforcement.

The US Department of Transportation enforces regulations for movement of hazardous wastes.

Listed Waste

EPA publishes lists of specific wastes that they consider hazardous. The lists are:

F-List (non-specific source wastes). Materials from common manufacturing and industrial processes such as cleaning solvents.

K-List (source-specific wastes). Certain wastes from specific industries such as petroleum refining and pesticide manufacturing.

P-List and U-List (discarded commercial chemical products). Specific chemical products in an unused form. Some pesticides and pharmaceuticals become hazardous waste when discarded.

M-List (discarded mercury products). Such as fluorescent lamps and mercury switches.

Characteristic Waste

In addition to the EPA list, there are four criteria that are considered by them for chemical substances that may not be on one of their lists:

1. **Ignitability. These substances can create fire under certain conditions, because they are spontaneously combustible or have flash points less than 140 degrees Fahrenheit. Waste oils and used solvents may meet this criterion.**

Characteristic Waste

2. Corrosivity. Acids or bases (pH less than 2 or greater than 12.5, respectively), that are capable of corroding metal tanks, drums, and barrels.

3. Reactivity. Substances that are unstable under normal conditions. They can cause explosions, toxic fumes, gases, or vapors when heated, compressed, or mixed with water.

Characteristic Waste

4. **Toxicity. Toxic wastes are harmful or fatal when ingested or absorbed (e.g. those containing mercury or lead).**

There are 8 characteristics of toxicity defined in California, and if a waste meets even one of the 8, it is considered a toxic hazardous waste. (http://www.dtsc.ca.gov/HazardousWaste/upload/HWMP_DefiningHW1.pdf)

If Uncertain whether a Pesticide Substance is a Hazardous Waste:

1. Call the DTSC at (916) 327-4499.

2. Send an email to the California DTSC: wasteclass@dtsc.ca.gov

3. Examine Material Safety Data Sheets for statements concerning it status as a hazardous waste.

4. Read the pesticide label for information on its status.

5. Write or call the formulator or distributor for information.

ORIGIN OF HAZARDOUS WASTES IN VECTOR CONTROL OPERATIONS

Empty pesticide containers containing hazardous residues.

Rinse water used to clean spray equipment and vehicles.

Pesticides remaining in sprayer tanks after an application.

Unused stocks of outdated and possibly suspended pesticides.

Used motor oil.

Solvents and other fluids used in connection with vehicle maintenance and repair.

PROPER MANAGEMENT OF HAZARDOUS WASTES

The US EPA has established categories for agencies that generate hazardous waste based on the amount of hazardous waste generated each month.

These same categories have been adopted by the California DTSC.

It is important for agencies to know the amount of waste they generate, because the rules for disposal of hazardous waste vary according to the category.

This primarily applies to how long hazardous waste can be stored before it must be disposed of (there is an increased risk potential associated with storage of large quantities of these waste).

EPA Hazard Generator Categories

Hazardous Waste Generated per Month	Category Name & Maximum Allowed Accumulation Time
Less than 220 lbs (about half a drum)	Conditionally exempt from requirement (CESQG)
220 lbs – 2,200 lbs (up to 5 drums)	Small Quantity Generator (SQG) 180 days or 270 days if waste to be transported 200 miles or more
2,200 lbs or more (over 5 drums)	Large Quantity Generator (LQG) 90 days

Containers Used to Collect Hazardous Wastes

Hazardous materials can be placed in their original containers temporarily, but the most common containers used to store hazardous wastes prior to their disposal are 55-gallon steel or plastic drums and inner liners from these drums.

If you have dedicated containers for pesticide hazardous waste, they must contain the label on the left.

Other Info that Should be Placed on Waste Containers:

Date waste was first put in the container.

Federal waste code numbers.

Type of waste contained in the container.

***Even if the waste is not classified as hazardous waste, it is a good practice to label the container with the waste material it contains.**

Empty Containers

Regulations that address the management of empty pesticide containers are very complex.

The DTSC has prepared a fact sheet ‘Managing Empty Containers” that contains an extensive question and answer section.

This fact sheet is available on their website.

CA Exemptions from Management Rule for Hazardous Waste:

1. **Containers that once contained waste that does not qualify as hazardous.**

2. **Containers that meet the definition of "empty" and have been subjected to approved management practices. Containers that are exempt can be disposed of at any appropriate solid waste facility.**

“Empty” Containers

Containers that once held hazardous materials or hazardous wastes and have been emptied by the generator as much as is reasonably possible.

In practice, this means inverting the container until no more liquid or solid material pours out.

These containers may still contain some residual hazardous materials that could cause significant harm, so they are still not considered non-hazardous unless approved management practices are followed.

Empty Container Cleaning Procedures

Containers that held liquid pesticides classified as acute or extremely hazardous waste must be triple-rinsed with a solvent capable of removing the material before they can be considered ready for disposal.

Containers that held solid pesticides, or pesticides that have become viscous and pour slowly, or have dried out or otherwise become caked, must be cleaned, scraped, and rinsed to remove all pesticide residues.

Empty Containers

Management practices required are flexible, depending upon the way empty containers are handled by a particular agency.

Some return empty containers to the original distributor, others may ship containers to a company that reconditions them.

Empty containers of 5 gallons or less can be disposed of at a solid waste facility.

Large Containers

Some mosquito and vector control agencies use special underground tanks to collect hazardous wastes such as rinse water.

Underground storage tanks are not considered containers, and their management is covered under other regulations.

Bulk containers of 110 gallons or more are also controlled by a different set of regulations.

Storage of Containers Full or Partially Full of Pesticides

Containers of pesticides over time can deteriorate to the point where they can rupture, leak, rust, and otherwise lose their original integrity.

Especially if pesticides are stored over long periods of time (years) they should be periodically inspected for signs of deterioration, and if leaking containers are found, their contents should be transferred to a new container.

Storage of Containers Full or Partially Full of Pesticides

Containers should be kept closed at all times.

If containers are used to contain waste, self-closing funnels should be used to add waste.

Waste pesticides should never be allowed to evaporate

Pesticides should always be compatible with the material the container is made of (e.g. if the waste is corrosive, high density plastic containers should be used).

Storage of Containers Full or Partially Full of Pesticides

Wastes that are reactive (e.g., acids and bases) should never be kept in the same container.

Containers for waste pesticides should be stored indoors. Adequate aisle space and ventilation should be provided. (This makes periodic inspections for leaks and container deterioration easier.)

Ignitable and reactive pesticide wastes should be stored at least 50 feet from property boundaries.

Pesticide wastes, depending upon the amount of waste generated per month, have legal time limits they can be stored before disposal.

Required Notifications of Hazardous Wastes

Agencies that generate pesticide hazardous waste should designate an emergency coordinator available 24/7 who must know what to do in case of a poisoning, fire, spill, or other emergency.

The following information should be clearly posted in a prominent place, such as near a telephone in the main district office, or near a telephone in the proximity of the storage site for pesticide hazardous wastes:

- **Local fire department number**
- **Emergency Coordinator's name and telephone number**
- **Locations of fire alarms and fire extinguishers**
- **Location of pesticide spill control materials**

PESTICIDES NOT CLASSIFIED AS HAZARDOUS WASTES

May be disposed of as regular solid waste or trash.

Are regulated by California law.

Must be disposed of according to instructions contained on the product label.

Must be disposed of in a careful manner.

PROPER TRANSPORTATION OF HAZARDOUS WASTES

Those who believe they would like to transport and dispose of hazardous wastes in-house should refer to “Hazardous Waste Transporter Requirements”, August 2007, available on the DTSC website.

Pesticide technicians should know that any person who transports hazardous wastes must hold a valid registration issued by DTSC.

It is unlawful for any person to transfer custody of toxic waste to a transporter who does not hold a valid registration.

If in doubt, there is a list of registered hazardous waste transporters on the DTSC website.

Proper Transportation of Hazardous Wastes

The transportation of hazardous wastes is regulated by the California Department of Toxic Substances Control (DTSC).

No hazardous wastes may be transported without first getting a permit from DTSC.

Most mosquito and vector control districts contract with a licensed operator to remove, transport, and dispose of hazardous wastes because of the complex and expensive requirements for permission to transport hazardous wastes.

PROPER DISPOSAL OF HAZARDOUS WASTES

The actual disposal of hazardous wastes is in the most part handled by commercial firms that specialize in this area.

Agencies that generate less than a threshold amount of hazardous waste in a month are exempt from many of the management requirements.

California mosquito and vector control agencies try to minimize the amount of hazardous waste that requires special handling and management.

How to Minimize the Disposal of Hazardous Waste

Keep the use of pesticides that qualify as hazardous waste to a minimum.

Avoid the use of pesticides that are on the Acutely Toxic Hazardous Waste list of EPA. Nearly all of these products are no longer available for use in California anyway.

As much as possible, completely empty sprayer tanks of pesticide during applications. Avoid coming back from a job with partially-filled tanks.

How to Minimize the Disposal of Hazardous Waste

Do not collect rinse water from pesticide equipment cleaning in tanks but use the rinse water for diluting water-soluble pesticides in spray tanks. This can only be done if the pesticide sprayed in the equipment that was cleaned is compatible with the pesticide to be diluted with the rinse water.

Take advantage of recycling programs for empty pesticide containers offered by many pesticide distributors.

Do periodic inventories of pesticides on-hand, and get rid of outdated or suspended materials. If you have materials that are legal, but no longer used in your program, sell or give them to other agencies that can use them.

Constantly check for leaking containers. Either get rid of these materials, or transfer them to new containers.

Chapter 11: The Future of Pesticide Use in Public Health Programs

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Cultural Practices

Biological Control

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Genetic Control

INTRODUCTION: FUTURE OF PESTICIDES IN PUBLIC HEALTH PROGRAMS

Public health pesticides have been controversial since their first use, and remain so to this day.

One result of this continuing struggle is an arsenal of pesticides that are safer and less disruptive to the environment than ever before.

Technology is improving pesticide application, methods for surveillance of both vector-borne diseases and vector infestations, and the training of pesticide applicators.

Products used today are far less hazardous than was the case 20-30 years ago.

Alternatives to Pesticides

Biological control.

Habitat modification.

Genetic alteration of vector populations.

Selective application of vector control operations. Rely upon education not pesticides:

- **Example: In remote areas of the state where chance of contact of people with vectors is very low, it is more efficient for people to rely on protective clothing and repellents to avoid mosquito bites.**

Integrated Vector Management (IVM)

The preferred modern approach to vector control.

Mirrored the modern approach to management of agricultural pests called Integrated Pest Management (IPM).

Methods include using biorational pesticides, proper cultural techniques, biological control, attractants and repellents, and genetic control.

BIORATIONAL PESTICIDES

An alternative to the use of conventional pesticides such as organophosphates, carbamates, and pyrethroids.

Any pesticide of natural origin that has limited or no adverse effects on beneficial organisms or the environment.

CULTURAL PRACTICES

Many pest problems can be avoided by careful use of the proper cultural techniques. Cultural practices make the environment less attractive for a pest's survival, reproduction, dispersal, etc. Examples:

1. **Dairy barn or chicken house sanitation methods**
2. **Manure management to limit breeding sites for flies**
3. **Marsh management to avoid runoff from highways polluting streams and ground water**

BIOLOGICAL CONTROL

The use of colonized or naturally occurring parasites or predators (natural enemies) to control pest populations.

Example: mosquito fish (*Gambusia affinnis*) are reared and distributed as a supplement to conventional pesticide operations. They are particularly effective in degraded aquatic habitats such as poorly maintained swimming pools and fish ponds.

Not subject to the registration provisions of FIFRA, but may come under restrictions of agencies like the California Department of Fish and Game

ATTRACTANTS AND REPELLENTS

In some cases chemicals may be used effectively to attract agricultural pests to traps, then expose them to lethal doses of a pesticide. They can also be used effectively as a surveillance tool.

Traps that attract agricultural pests to traps and then expose them to lethal doses of a pesticide have had mixed success. Some have been useful in controlling stinging Hymenoptera such as wasps. But those designed to attract mosquitoes and other flying Diptera have had little impact on numbers remaining to bite or annoy people.

ATTRACTANTS AND REPELLENTS

Most successful skin repellents have been those containing DEET, a chemical developed by the US Department of Agriculture more than 50 years ago.

In tropical areas of the world where malaria is a serious problem, insecticidal bed nets, door curtains, and window curtains have shown great promise.

GENETIC CONTROL

Altering the genetic makeup of vectors to reduce their population sizes or change their ability to transmit pathogenic microorganisms (currently an area of intense research).

In a few spectacular cases, massive populations of pest species have been managed and even locally eradicated through the use of genetic techniques.

- **The eradication of the screw-worm fly from the USA**
- **The repeated eradication efforts against the Mediterranean fruit fly from California**

Significant progress has been made and genetic control will hold an important promise for things to come.

Supplemental Information: Conversions

1 acre = 43,560 ft^2

1 mile = 5,280 ft

1 gallon = 128 fl oz = 8 pints = 4 quarts

1 lb = 16 oz

1 fl oz = 2 tablespoons = 6 teaspoons

1 inch = 2.54 cm

At one mph, you travel 88 feet in one minute.