4. You want to spray 5 acres. Your equipment holds up to 300 gallons and delivers 18 gallons per acre. The labeling rate is 2 pounds per acre. How much water do you need to add to the tank? How much pesticide should you add to the tank?

Gallons per acre x acres to be treated = Gallons of water needed in tank

AND

Acres to be treated x pounds formulation per acre = Pounds formulation needed in tank

5. Your sprayer tank holds 5 gallons and applies 1.5 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 3 ounces of formulation per 1,000 square feet. How much formulation do you need to make a tankful of spray?

$$\frac{\text{Amount in tank (5 gallons = 20 quarts) x rate per 1,000 square feet}}{\text{Amount equipment applies per 1,000 square feet}} = \text{Amount form. needed in tank}$$

6. You want to apply 3 pounds of active ingredient per acre. Your formulation is 60 percent WP. How much formulation do you need per acre?

$$\frac{\text{Pounds of a.i. per acre x 100}}{\text{Percent a.i. in formulation}} = \text{Pounds formulation per acre}$$

7. Your directions call for a spray containing 1.5 percent active ingredient. You need to mix 5 gallons of spray for the job. The pesticide is an 80 percent SP and you will use water as the diluent. How much formulation do you need to add to the tank?

$$\frac{\text{Gallons in tank x percent a.i. needed x weight of water/gal (8.3)}}{\text{Percent a.i. in formulation}} = \text{Pounds form. needed in tank}$$

8. The labeling rate is 1.5 pints of pesticide formulation per 100 gallons of water. Your spray tank holds 25 gallons. How much pesticide formulation do you need to add to the tank?

$$\frac{\text{Gallons in tank x pints per 100 gal.}}{\text{100 gallons}} = \text{Pints formulation needed in tank}$$

9. Your sprayer tank holds 3 gallons and applies 1.5 quarts of spray per 1,000 square feet. The labeling directions indicate a rate of 6 tablespoons per 1,000 square feet. How much formulation do you need to make a tankful of spray?

$$\frac{\textbf{Amount in tank (3 gallons = 12 quarts) x rate per 1,000 square feet}}{\textbf{Amount equipment applies per 1,000 square feet}} = \textbf{Amount needed in tank}$$

10. The recommendation is for 2 pounds of active ingredient per acre. You purchased a 6 EC that contains 6 pounds of active ingredient per gallon. Your tank holds 300 gallons and is calibrated to apply 30 gallons per acre. How many acres per tankful can you treat? How much formulation would you need for a full tank?

$$\frac{\textbf{Pounds a.i. to apply per acre}}{\textbf{Pounds a.i. per gallon}} = \textbf{Amount per acre}$$

AND

$$\frac{\textbf{Gallons in tank}}{\textbf{Gallons per acre}} = \textbf{Acres per tankful}$$

AND

Acres per tankful x gallons per acre = Gallons to add to tank

11. You want to make 200 gallons of a 2 percent spray, using water as the diluent. You have a 4 EC formulation (the pesticide label tells you that this is 4 pounds of active ingredient per gallon). How many gallons of the 4 EC should you add to the tank?

$$\frac{\textbf{Gallons in tank x \% a.i. wanted x weight of water (8.3)}}{\textbf{Pounds a.i. per gallon of formulation x 100}} = \textbf{Gallons of formulation to add to tank}$$

12. The label lists the rate as 3 pounds formulation per 100 gallons of water for dilute application. Your airblast sprayer tank holds 500 gallons. You want to apply a 3x concentration. How many pounds of formulation should you add for a full tank load?

$$\frac{\textbf{Gal. per tank x lbs. per 100 gallons recommended}}{\textbf{100 gallons}} = \textbf{Lbs. needed in tank for hydraulic sprayer}$$

AND

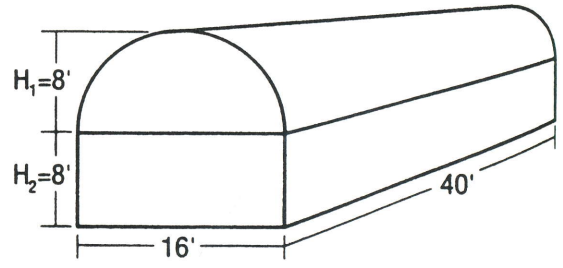
Pounds formulation per tank for hydraulic sprayer x concentration wanted = Pounds of formulation to add to airblast tank

13. How do you calculate the area of a rectangle? A circle? A triangle?

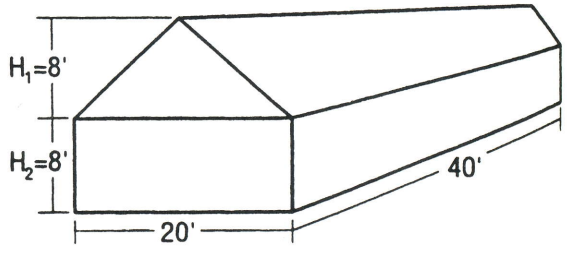
14. How do you calculate the area of an irregularly shaped site?

15. How do you calculate the volume of a space shaped like a cylinder?

16. What is the volume of space of the figure below (half-circle-over-rectangle ends)?



17. What is the volume of space of the figure below (triangle over rectangle ends)?



CHAPTER PART B 4

APPLICATION EQUIPMENT

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Select the right types of sprayers for various kinds of pest management situations.
- Recognize advantages and disadvantages of commonly used sprayer types.
- List some sprayer features that are important to consider when choosing equipment for a job.
- Show that you know the common types of sprayer pumps and some of their features.
- Explain the use of strainers in a sprayer system.
- Identify desirable features of common parts of a sprayer system — tanks, hoses, pressure gauges and regulators and valves.
- Name the three primary types of agitation used in sprayer systems and identify the formulations for which each is suitable.
- Identify the parts of a nozzle.
- Select the right nozzle pattern for various application situations.
- Explain how to clear a clogged nozzle.
- Explain some advantages and limitations of aerosol generators and foggers.
- Show that you know the basic features of equipment that applies dusts and granules.
- Show that you know the basic features of application equipment used in animal pest control.
- Identify the uses for some types of specialized application equipment.

TERMS TO KNOW

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

Agitation - The process of stirring or mixing.

Calibrate - Measure and adjust the amount of pesticide the application equipment will release per unit of area.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full strength but usually diluted before application.

Corrosion - Process of being worn away gradually by chemical action.

Diluent - Anything used to dilute a pesticide.

Dilute pesticide - A pesticide that is not concentrated; one that does not have a high percentage of active ingredient.

Drift - Pesticide movement in air, away from the target site.

Emulsifiable concentrate (EC or E) - A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion (droplets of one liquid dispersed in another liquid).

Foliage - Primarily the leaves; may include stems of a plant.

Formulation - Pesticide product as sold, usually a mixture of active and inert ingredients.

Fumigant - Pesticide that is a vapor or gas or that forms a vapor or gas when applied and whose pesticidal action occurs in the gaseous state.

gpm - Gallons per minute.

Hydraulic - Operated by the pressure created by forcing liquid through a narrow opening.

Hydraulic agitation - Stirring or mixing provided by the high-pressure flow of surplus spray material from the pump.

Mechanical agitation - Stirring or mixing done by rotating paddles or propellers in the sprayer tank.

Mild steel - Steel that contains a very low percentage of carbon; also called "soft steel."

Nontarget - Any site or organism other than the site or pest at which the pesticide is being directed.

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

psi - Pounds per square inch.

Soluble powder (SP) - Dry pesticide formulation that forms a true solution when mixed with water.

Solvent - A liquid, such as water, kerosene, xylene or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Suspension - A substance that consists of undissolved particles mixed throughout a liquid.

Target - The site or pest toward which control measures are being directed.

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

Wettable powder (WP) - A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

The pesticide application equipment is important to the success of any pest management job. First, the right kind of application equipment must be selected then used correctly and maintained well.

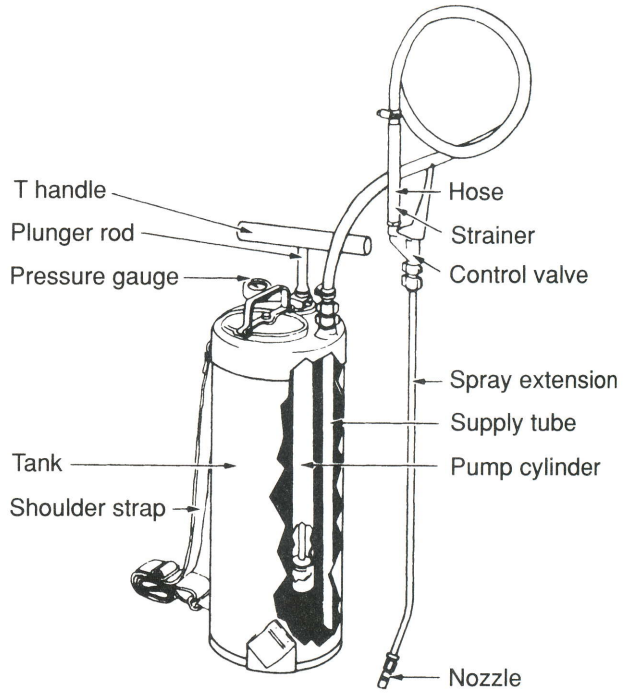
This chapter provides an overview of some things that should be known about choosing, using and caring for equipment. To use pesticide application equipment safely and effectively, **study the manufacturer's directions carefully.** Some pesticide applications – such as airblast spraying, fumigation, aerial application and chemigation – are highly specialized. Special training is necessary to use the equipment these applications require.

SPRAYERS

Sprayers are the most common pesticide application equipment. Sprayers range in size and complexity from simple, hand-held models to intricate machines weighing several tons.

Hand Sprayers

Hand sprayers are often used to apply small quantities of pesticides. They can be used in structures, and they can be used outside for spot treatments or in hard-to-reach areas. Most operate on compressed air supplied by a hand pump.



Compressed air sprayer — This is usually a hand-carried sprayer that operates under pressure created by a self-contained manual pump. The air in the tank is compressed by the pump. The compressed air forces liquid pesticide through the hose and nozzle whenever the control valve is opened. A few types of these sprayers use carbon dioxide cartridges instead of a hand pump for compression. Capacity is usually ½ gallon to 3 gallons.

Bucket or trombone sprayer — These sprayers involve a double-action hydraulic pump operated with a push-pull motion. The pesticide is sucked into the cylinder and pushed out through the hose and nozzle with the return stroke. Pressures up to 150 psi can be generated. The separate tank often consists of a bucket with a capacity of 5 gallons or less.

Backpack (knapsack) sprayer — One type of backpack sprayer is a compressed air sprayer with a harness that allows it to be carried on the operator's back.

Another type of backpack sprayer has a hand-operated hydraulic pump that forces liquid pesticide through a hose and one or more nozzles. The pump is usually activated by moving a lever. A mechanical agitator plate may be attached to the pump plunger. Some of these sprayers can generate pressures of 100 pounds per square inch (psi) or more.

Capacity of both these types of backpack sprayers is usually 5 gallons or less.

Wheelbarrow sprayer — Wheelbarrow sprayers are similar to backpack sprayers but have a larger tank and longer hose line. The tank is mounted on a wheeled cart for easy transport. The capacity of these sprayers is usually less than 25 gallons.

Small Motorized Sprayers

Some small sprayers have all the components of larger field sprayers but usually are not self-propelled. They may be mounted on wheels so they can be pulled manually, mounted on a small trailer for pulling behind a small tractor, or skid-mounted for carrying on a small truck. They may be low-pressure or high-pressure, according to the pump and other components with which they are equipped.

Standard equipment includes a hose and an adjustable nozzle on a handgun. Some models have multi-nozzle booms. These sprayers are suitable for relatively small outdoor areas.

Advantages:

- Larger capacity than hand sprayers.
- Low- and high-pressure capability.
- Built-in hydraulic agitation.
- Small enough for limited spaces.

Limitations:

- Not suitable for general field use.

Estate sprayers — These sprayers are mounted on a two-wheel cart with handles or pushing. Trailer hitches are available for towing the units. Spray material is hydraulically agitated. Some models have 15- to 30-gallon tanks. Pumps deliver 1½ to 3 gallons per minute at pressures up to 250 psi.

Larger models have 50-gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures up to 400 psi. Power is supplied by an air-cooled engine of up to 5 horsepower.

Power backpack sprayer — This backpack-type sprayer has a small gasoline-powered engine. The engine drives the pump, which forces the liquid pesticide from the tank through a hose and one or more nozzles. The engine also drives air blowers, which help propel the spray droplets. This model can generate high pressure and is best suited for low-volume applications of dilute or concentrated pesticide.

Power wheelbarrow sprayer — This sprayer, like the manually operated wheelbarrow sprayer, has a tank mounted on a wheel for easy transport. It may deliver up to 3 gallons per minute and can develop pressures up to 250 psi. The 1½ to 3 – horsepower engine is usually air-cooled. The tank size ranges from 12 to 18 gallons. The spray mixture may be either mechanically or hydraulically agitated.

Large Power-driven Sprayers (Low Pressure)

These sprayers are designed to distribute dilute liquid pesticides over large areas. They deliver a low to moderate volume of spray – 5 to 60 gallons per acre – at working pressures ranging from 10 to 80 psi.

These sprayers usually are mounted on tractors, trucks or boats, but some are self-propelled. Roller pumps and centrifugal pumps are most often used and provide outputs from 5 to more than 20 gallons per acre. Tank sizes range from less than 50 gallons to 1,000 gallons. The spray material usually is hydraulically agitated.

Advantages:

- Medium to large tanks permit relatively large area to be covered per fill.
- Versatility.

Limitations:

- Low pressure limits pesticide penetration and reach.

Boom sprayers — Low-pressure sprayers often are equipped with sprayer booms ranging from 10 to 60 feet in length and containing several nozzles. The height of the sprayer boom must be easily adjustable to meet the needs of the job. Boom supports should allow the boom to be set at any height from 12 to 72 inches above the surface being sprayed. Many nozzle arrangements are possible, and special-purpose booms are available.

Low-pressure sprayers often are equipped with booms ranging from 10 to 60 feet in length, containing several nozzles and that can be easily adjusted in height to meet the needs of the job.

Some booms are designed with sleeves, air curtains or shields to reduce drift.

Boomless sprayers — Low-pressure sprayers that are not equipped with booms generally have a central nozzle cluster that produces a horizontal spray pattern. The resulting swath is similar to the pattern made by a boom sprayer. These sprayers are useful in irregularly shaped areas because they can move through narrow places and avoid trees and other obstacles. Some low-pressure sprayers are equipped with a hose and handgun nozzle for applications in small or hard-to-reach areas.

Large Power-driven Sprayers (High Pressure)

These sprayers are used to spray through dense foliage or thick animal hair, to the tops of tall trees and into other areas where high-pressure sprays are necessary for adequate penetration and reach. Often called hydraulic sprayers, they are equipped to deliver large volumes of spray — usually 20 to 500 gallons per acre — under pressures ranging from 150 to 400 psi or more.

These sprayers usually are mounted on tractors, trailers, trucks or boats, or are self-propelled. Piston pumps are used and provide outputs up to 60 gallons or more per minute. Large tanks (500 to 1,000 gallons) are required because the application rate is usually 100 gallons per acre or more.

Mechanical agitators are usually standard equipment, but hydraulic agitators may be used. When fitted with correct pressure unloaders, these sprayers can be used at low pressures.

High-pressure sprayers may be equipped with a hose and single handgun nozzle for use in spraying trees and animals. These sprayers also may be fitted with a boom for broadcast applications.

Advantages:

- Provide good penetration and coverage of plant surfaces.
- Usually well built and long-lasting if properly cared for.

Limitations:

- Large amounts of water, power and fuel needed.
- High pressure may produce fine droplets that drift easily.

Airblast Sprayer

Airblast sprayers use a combination of air and liquid to deliver the pesticide to the surface being treated.

These sprayers usually include the same components as low-pressure or high-pressure sprayers, plus a high-speed fan. Nozzles operating under low pressure deliver spray droplets directly into the high-speed airstream. The air blast shatters the drops of pesticide into fine droplets and transports them to the target. The air blast is directed to one or both sides as the sprayer moves forward, or it may be delivered through a movable nozzle.

The trailer-mounted airblast sprayer uses a combination of air and liquid to deliver the pesticide to orchard trees.

Most airblast sprayers are trailer-mounted, but tractor-mounted models are available. Tank capacity ranges from 100 to 1,000 gallons. Most of these sprayers can be adapted to apply either high or low volumes of spray material as well as concentrates. Mechanical agitation of the spray mixture is the norm. An airblast sprayer may cover a swath up to 90 feet wide and reach trees up to 70 feet tall.

Advantages:

- Good coverage and penetration.
- Mechanical agitation.
- High capacity.
- Can spray high or low volumes.
- Low pump pressures.

Limitations:

- Drift hazards.
- Use of concentrated pesticides may increase chance of dosage errors.
- Hard to confine discharge to limited target area.
- Difficult to use in small areas.
- High power requirement and fuel use.

Other Sprayers

Ultra-low-volume (ULV) sprayers — These sprayers use special pesticide concentrates. ULV sprayers may be hand-held or mounted on either ground equipment or aircraft.

Advantage:

- No water is needed, so less time and labor are involved.

Limitations:

- Drift hazards.
- Coverage may not be thorough.
- High concentrates present safety hazards.
- Use of concentrated pesticides may increase chance of dosage errors.
- Few pesticides are labeled for ULV.

Controlled droplet applicators (CDA) — These applicators use a spinning disk (or cup) that breaks the liquid into uniform-sized droplets by centrifugal force. The droplets may be carried to the target by gravity or by an airstream created by a fan. Power to spin the disk or cup is provided by a small electric or hydraulic motor. Atomization is produced by the spinning disk rather than by pump pressure and nozzle. CDAs range in size from a small hand-held type to large tractor-mounted and trailer-mounted units.

Controlled droplet applicator.

Advantages:

- Requires a low volume of water.
- Produces a narrower range of droplet sizes than conventional nozzles and so reduces drift.
- Droplet size can be adjusted by speed of rotation.

Limitations:

- Droplets moving into the canopy by gravity may not penetrate well.
- Potential for drift may be high.

Electrostatic sprayers — Electrostatic sprayer systems give the pesticide a positive electric charge as it leaves the nozzles. Plants naturally have a negative charge, so the positively charged pesticide is attracted to the plants. The spray is directed horizontally through or above the crop, depending on the pesticide being applied.

Advantages:

- Pesticide adheres to foliage well, so less pesticide is needed per acre.
- Coverage is more even than with other types of equipment.
- Minimizes the likelihood of drift.

Limitation:

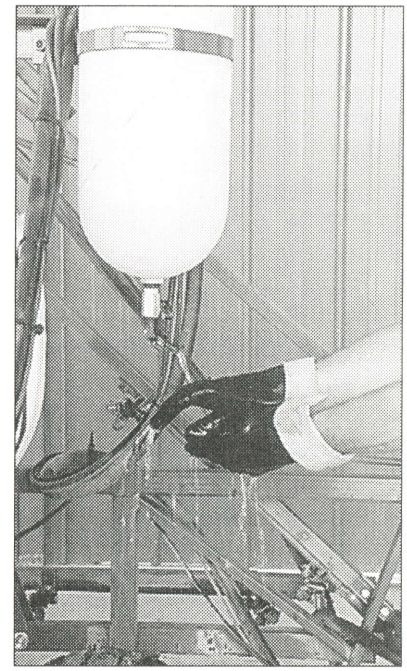
- Useful only for application to foliage.

SPRAYER PARTS

Large Tanks

Tanks should have large openings for easy filling and cleaning and be made of corrosion-resistant material such as stainless steel or fiberglass. Tanks should be designed to allow the use of strainers during filling and to allow mechanical or hydraulic agitation devices to be installed.

The tank should have a large drain, and other outlets should be sized to the pump capacity. If you use dual tanks, make sure the plumbing allows both tanks to have agitation and adequate withdrawal rates. Each tank should have a gauge to show the liquid level. All tanks should have shutoff valves for storing liquid pesticide temporarily while other sprayer parts are being serviced.



Many tractors or sprayers have the capacity to carry clean auxiliary water for personal decontamination and other purposes.

Pumps

The pump must have enough capacity to supply the needed volume to the nozzles and to the hydraulic agitator (if necessary) and to maintain the desired pressure. The pump parts should resist corrosion, and they should be abrasion-resistant if abrasive materials such as wettable powders will be used. Select gaskets, plunger caps and impellers that resist the swelling and chemical breakdown caused by many liquid pesticides. Consult your dealer for available options.

Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Some pumps will be damaged if operated when dry or with restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and for cooling the heat caused by friction and pressure.

Roller pumps — Roller pumps are the most widely used of all sprayer pumps. They provide moderate volumes (8 to 30 gpm) at low to moderate pressure (10 to 300 psi). Often used on low-pressure sprayers, roller pumps are self-priming. The pump case is usually cast iron or a nickel-iron alloy.

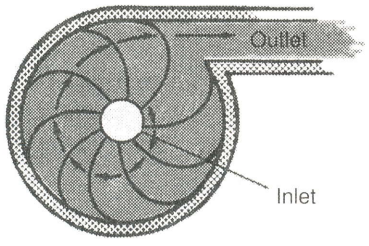
The rollers, made of nylon, Teflon or rubber, wear rapidly in wettable powders but are replaceable. A pump subjected to such wear should have a capacity about 50 percent greater than that needed to supply the nozzles and agitator. This reserve capacity will extend the life of the pump.

Roller pumps are usually the best choice for emulsifiable concentrates, soluble powders and other pesticide formulations that are not abrasive.

Gear pumps — Gear pumps are used on sprayers with low operating pressures. They provide low to moderate volume (5 to 65 gpm) at low to moderate pressures (20 to 100 psi). Gear pumps are self-priming, but the self-priming ability is rapidly lost as the pump wears.

Gear pumps are designed for use with formulations that use oil as a diluent. They wear rapidly when wettable powders are used. The parts are generally not replaceable. The pump is not affected by most solvents because all parts are metal. The pump case may be bronze with stainless steel impellers or it may be made entirely of bronze.

Centrifugal pumps — Centrifugal pumps are adaptable to a wide variety of spray applications. Generally, they deliver high volume (up to 200 gpm) at low pressures (5 to 70 psi); however, two-stage pumps develop high pressures (up to 200 psi). Pressure regulators and relief valves are not necessary.

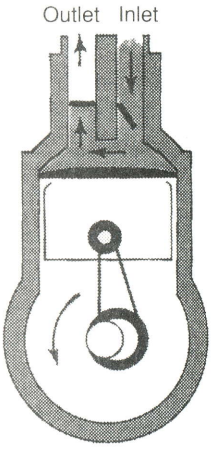


Centrifugal pump.

Centrifugal pumps are not self-priming and must be mounted below the tank outlet or provided with a built-in priming system. Centrifugal pumps are well adapted for spraying abrasive materials because the impeller does not contact the pump housing. Many models are easily repairable. The pump case is usually iron; the impeller is iron or bronze.

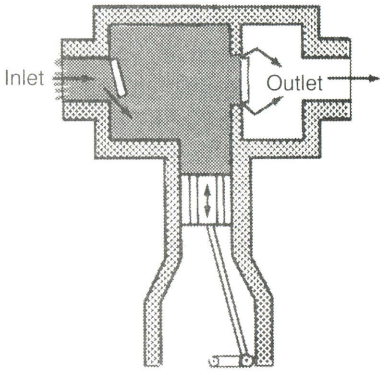
Diaphragm pumps — diaphragm pumps are generally used to deliver low volume (3 to 10 gpm) at low to moderate pressures (10 to 100 psi), but they also can be used for high-volume, high-pressure applications.

Diaphragm pumps withstand abrasion from wettable powder mixtures much better than gear, roller or piston pumps because the spray mixture does not contact any moving metal parts except the valves. Diaphragm pumps are self-priming. The rubber or neoprene diaphragm may be damaged by some solvents; the pump case is usually iron.



Diaphragm pump.

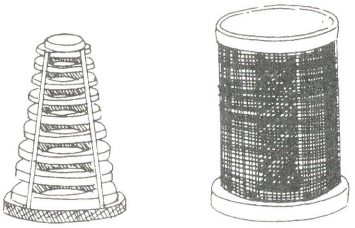
Piston pumps — Piston pumps deliver low to medium volumes (2 to 60 gpm) at low to high pressures (20 to 800 psi). Used for high-pressure sprayers or when both low and high pressures are needed, piston pumps are self-priming. They have replaceable piston cups made of leather, neoprene or nylon fabric, which make the pump abrasion-resistant and capable of handling wettable powders for many years. The cylinders are iron, stainless steel or porcelain-lined. The pump casing is usually iron.



Piston pump.

Strainers (Filters)

Pesticide mixtures should be filtered to remove dirt, rust flakes and other foreign materials from the tank mixture. Proper filtering protects the working parts of the sprayer from undue wear and avoids time loss and uneven application caused by clogged nozzle tips.



Filtering should be progressive, with the largest mesh screens in the filler opening and in the suction line between the tank and the pump. In general, strainers should be placed:

- On the filler opening (12 to 25 mesh).
- On the suction or supply line to the pump (15 to 40 mesh).
- Between the pressure relief valve and the boom (25 to 100 mesh).
- On the nozzle body (50 to 100 mesh).

A shutoff valve is needed between the tank and the suction strainer to allow the strainer to be cleaned without draining the tank. Replace damaged or deteriorated strainers. Strainers are your best defense against nozzle plugging and pump wear. Check nozzle catalogs for the proper screen size for each nozzle.

Hoses

Select neoprene, rubber or plastic hoses that:

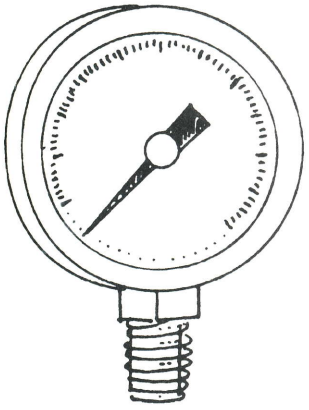
- Have a burst strength greater than the peak operating pressures.
- Have a working pressure at least equal to the maximum operating pressure.
- Resist oil and solvents present in pesticides.
- Are weather-resistant.

Suction hoses should be reinforced to resist collapse. They should be larger than pressure hoses, with an inside diameter equal to or larger than the inlet part of the pump. All fittings on suction lines should be as large as or larger than the inlet part of the pump.

Keep hoses from kinking or being rubbed. Flush hoses after use and wash them often to prolong life. Replace hoses at the first sign of surface deterioration (cracking or splitting).

Pressure Gauges

Pressure gauges should measure the pressure at the nozzle but usually are plumbed to monitor the line pressure of your spraying system. They must be accurate and have the range needed for your work. For example, a 0 to 100 psi gauge with 2-pound gradations would be adequate for most low-pressure sprayers.



Check frequently for accuracy against an accurate gauge. Excess pressure will destroy a gauge. If yours does not zero, replace it. An oil-filled gauge is recommended because it is highly accurate. Use gauge protectors to guard against corrosive pesticides and pressure surges.

Pressure Regulators

The pressure regulator controls the pressure and, therefore, the quantity of spray material delivered by the nozzles. It protects pump seals, hoses and other sprayer parts from damage caused by excessive pressure.

Keep the bypass line from the pressure regulator to the tank fully open and unrestricted. The bypass line should be large enough to carry the total pump output without excess pressure buildup. The pressure range and flow capacity of the regulator must match the pressure range you plan to use and the capacity of the pump. Never attach mechanical agitation devices to the bypass line discharge.

Pressure regulators are usually one of three types:

Throttling valves simply restrict pump output, depending on how much the valve is open. These valves are used with centrifugal pumps, whose output is very sensitive to the amount of restriction in the output line.

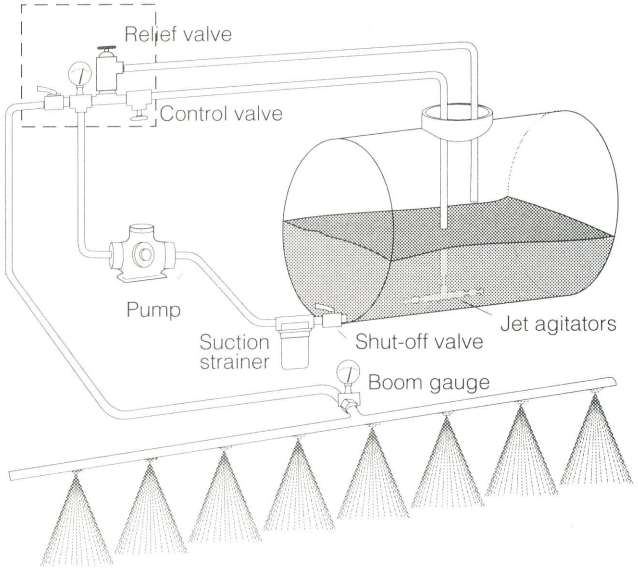
Spring-loaded bypass valves (with or without a diaphragm) open or close in response to changes in pressure, diverting more or less liquid back to the tank to keep pressure constant. These valves are used with roller, diaphragm, gear and small piston pumps.

Unloader valves work like a spring-loaded bypass valve when the sprayer is operating. However, when the nozzles are shut down, they reduce strain on the pump by moving the overflow back into the tank at low pressure. These valves should be used on larger piston and diaphragm pumps to avoid damage to the pump or other system components when the nozzles are cut off.

Agitators

Every sprayer must have agitation to keep the spray material uniformly mixed. The type of agitation needed depends on the pesticide formulation.

Bypass agitators — Bypass agitation uses the returning liquid from the pressure relief valve to agitate the tank. Bypass agitation is sufficient for soluble powders and for liquid formulations such as solutions and emulsifiable concentrates that do not require much agitation.



Do not use bypass agitation for wettable powders or in tanks larger than 55 gallons unless the system has a centrifugal pump. Centrifugal pumps usually have large enough outputs to make bypass agitation adequate in tanks smaller than 100 gallons.

Hydraulic (jet action) agitators — Hydraulic agitation is provided by the high-pressure flow of surplus spray material from the pump. Hydraulic agitation is required for wettable powder and flowable formulations in small tanks and for liquid formulations in 100-gallon or larger tanks with gear, roller, piston or diaphragm pumps.

The jet or jets for a hydraulic agitator are located at the bottom of the tank. The agitator is connected to the pressure side of the pump. Never place jet agitator nozzles in the bypass line.

Mechanical agitation — Wettable powder formulations are best mixed and kept in suspension with mechanical agitation. The mechanical agitator usually consists of flat blades or propellers mounted on a shaft that is placed lengthwise along the bottom of the tank.

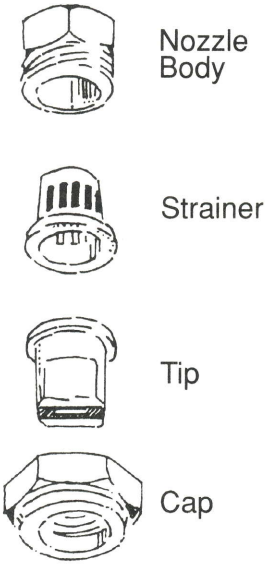
Control Valves

Quick-acting cutoff valves should be located between the pressure regulator and the nozzles to provide positive on-off action. These control valves should be rated for the pressures you intend to use and should be large enough not to restrict flow when open. Cutoff valves to stop all flow or flow to any section of the spraying system should be within easy reach of the sprayer operator.

There are many kinds of control valves. Mechanical valves must be accessible to the operator's hand; electrically operated valves permit remote control of flow. For tractors or self-propelled sprayers with enclosed cabs, remote-controlled valves permit all hoses carrying pesticides to be kept safely outside the cab.

Nozzles

Most nozzles have four major parts: the nozzle body, the cap, the strainer (screen), and the tip or orifice plate. They also may include a separate spinner plate. Successful spraying depends on the correct selection, assembly and maintenance of the nozzles.



The nozzle **body** holds the strainer and tip in proper position. Several types of tips that produce a variety of spray patterns may be interchanged on a single nozzle body made by the same manufacturer.

The **cap** is used to secure the strainer and the tip to the body. The cap should not be overtightened.

The nozzle **strainer** is placed in the nozzle body to screen out debris that may clog the nozzle opening. The type of nozzle strainer needed depends on the size of the nozzle opening and the chemical being sprayed.

Special nozzle screens equipped with a check valve help prevent nozzle dripping. Check valves should be used in situations where a sprayer must be stopped and started frequently, such as in small target areas or near sensitive crops or areas. The operator must check these spring-loaded ball valves frequently to be sure they are working properly.

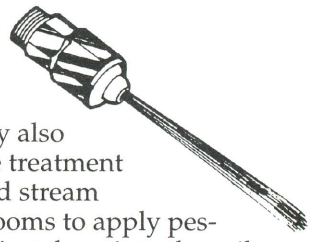
Nozzle tips break the liquid pesticide into droplets. They also distribute the spray in a predetermined pattern and are the principal element that controls the rate of application. Nozzle performance depends on:

- Nozzle design or type.
- Operating pressure.
- Size of the opening.
- Discharge angle.
- Distance of nozzle from the target.

Nozzle Paterns

Nozzle patterns are of three basic types: solid stream, fan and cone. Some special-purpose nozzle tips or devices produce special patterns. These include "raindrops," "flooding," and others that produce wide-angle fan- or cone-shaped patterns.

Solid stream nozzles — These nozzles are used in handgun sprayers to spray a distant or specific target such as livestock or tree pests. They also are used for crack and crevice treatment in and around buildings. Solid stream nozzles may be attached to booms to apply pesticides in a narrow band or inject them into the soil.



Fan pattern nozzles — At least three types of nozzle tips have fan patterns. They are used mostly for uniform spray coverage of surfaces _ for example, broadcast soil applications of herbicides or insecticides.

The **regular flat fan** nozzle tip makes a narrow oval pattern with tapered ends. It is used for broadcast herbicide and insecticide spraying at 15 to 60 psi. The pattern is designed to be used on a boom and to be overlapped 30 to 50 percent for even distribution. Spacing on the boom, spray angle and boom height determine proper overlap and should be carefully controlled.

The **even flat fan** nozzle makes a narrow oval pattern. Spray delivery is uniform across its width. It is used for band spraying and for treating walls and other surfaces. It is not useful for broadcast applications. Boom height and nozzle spray angle determine the width of the band sprayed.

The **flooding** (flat fan) nozzle delivers a wide-angle flat spray pattern. It operates at very low pressure and produces large spray droplets. Its pattern is fairly uniform across its width but not as even as the regular flat fan nozzle pattern. If used for broadcast spraying, it

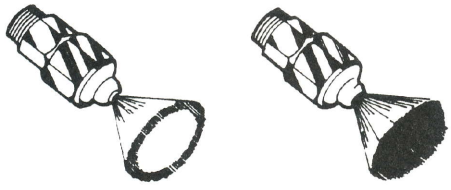
should be overlapped to provide double coverage. It is often used for applying liquid fertilizers or fertilizer-pesticide mixtures or for directing herbicide sprays under plant canopies.

Cluster nozzles are used either without a boom or at the ends of booms to extend the effective swath width. Cluster nozzles are a combination of a center-discharge and two or more off-center-discharge fan nozzles. Coverage may be variable because the spray pattern is not uniform.

Since no boom is required, these nozzles are particularly well suited for spraying hedgerows, fencerows and other hard-to-reach locations where uniform coverage is not critical.

Cone pattern nozzles — Hollow and solid cone patterns are produced by several types of nozzles. These patterns are used where penetration and coverage of plant foliage or other irregular targets are desired. They are most often used to apply fungicides and insecticides to foliage, although some types are used for broadcast soil applications of herbicides or fertilizers or combinations of the two.

When cone pattern nozzles are used for airblast sprayer broadcast application, they should be angled to spray between 15 and 30 degrees from the horizontal and should be spaced at the top of the manifold so the spray pattern will overlap up to 100 percent.



The **side-entry hollow** cone or **"whirl-chamber"** nozzle produces a very wide-angle hollow cone spray pattern at very low pressures. It has a large opening and resists clogging. Because of the wide spray angle, the boom can be operated low, reducing drift. These nozzles may be used in place of flat fan nozzle tips in broadcast applications.

Core-insert cone nozzles produce either a solid or hollow cone spray pattern. They operate at moderate pressures and give a finely atomized spray. They should not be used for wettable powders because their small passages clog easily and they wear rapidly because of abrasion.

Disk-core nozzles produce a cone-shaped spray pattern, that may be hollow or solid. The spray angle depends on the combination of disk and core used and also, to some extent, on the pressure. Disks made of very hard materials resist abrasion well, so these nozzles are recommended for spraying wettable powders at high pressures.

Adjustable cone nozzles change their spray angle from a wide cone pattern to a solid stream when the nozzle collar is turned. Many manual sprayers are equipped with this type of nozzle. Handguns for power sprayers have adjustable nozzles that usually use an internal core to vary the spray angle.

Nozzle Materials

Most nozzle parts are available in several materials. Here are the main features of each kind:

Brass:

- Resists corrosion from most pesticides.
- Wears quickly from abrasion.
- Probably the best material for general use.
- May be corroded by liquid fertilizers.

Plastic:

- Will not corrode.
- Resists abrasion better than brass.
- May swell when exposed to some solvents.
- Useful life about equal to that of brass nozzles.

Stainless steel:

- Resists abrasion, especially if hardened.
- Good corrosion resistance.
- Suited for high pressures, especially with wettable powders.
- Lasts longer than brass.

Aluminum:

- Resists some corrosive materials.
- Easily corroded by some fertilizers.
- Useful life much shorter than brass.

Tungsten carbide and ceramic:

- Highly resistant to abrasion and corrosion.
- Best material for high pressures and wettable powders.
- Last much longer than brass.

Sprayer Selection, Use and Care

Choosing the correct sprayer for each job is important. Your sprayer should be:

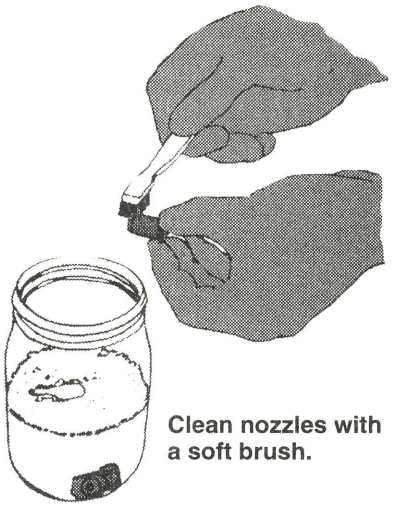
- Designed to do the job you want to do.
- Durable.
- Convenient to fill, operate and clean.

Always read and follow the operator's manual for proper use and care instructions. After each use, rinse the entire system. Check for leaks in lines, valves, seals and tank. Remove and clean nozzles, nozzle screens and strainers with an appropriate brush. Check the accuracy of the pressure gauges frequently.

Be alert for nozzle clogging and changes in nozzle patterns. If nozzles clog or other trouble occurs in the field, be careful not to contaminate yourself while correcting the problem. Shut off the sprayer before attempting any major repairs. Wear PPE while making repairs. Clean clogged nozzles only with a non-metal nozzle-cleaning tool such as a toothbrush. Sharp metal can change or ruin the nozzle orifice opening. Never use your mouth to blow out a nozzle.

It is important to clean and rinse the sprayer thoroughly when changing pesticides. This will minimize the chance for crop injury from residues in the tank.

To prepare spray equipment for storage, follow manufacturer's instructions. If there are no instructions, rinse and clean the system, then fill the tank almost full with clean water and add a small amount of new lightweight oil to the tank. Coat the system by pumping this mixture out through the nozzles or handgun. Drain the pump and plug its openings or fill the pump with lightweight oil or antifreeze. Remove nozzles and nozzle screens and store in lightweight oil or diesel fuel. Store the sprayer out of the sun.



Clean nozzles with a soft brush.

AEROSOL GENERATORS AND FOGGERS

Aerosol generators and foggers convert special formulations into very small, fine droplets (aerosols). Single droplets cannot be seen, but large numbers of droplets are visible as a fog or mist. Aerosol generators and foggers usually are used to completely fill a space with a pesticidal fog. Some insects in the treated area are killed when they come in contact with the poison. Other insects are simply repelled by the mist and return after it has settled.

Thermal foggers, also called thermal generators, use heat to vaporize a special oil formulation of a pesticide. As the pesticide vapor is released into the cooler air, it condenses into very fine droplets, producing a fog.

Other aerosol generators (cold foggers) break the pesticide into aerosols by using mechanical methods such as:

- Rapidly spinning disks.
- Extremely fine nozzles and high pressure (atomizing nozzles).
- Strong blasts of air.

Advantages:

- Penetration in dense foliage.
- Penetration of cracks and crevices.
- Some indoor devices are automatic and do not require presence of applicator.

Limitations:

- Aerosols and fogs drift easily from target area.
- No residual control — pests may return to the area as soon as fog dissipates,
- Risk of explosion in enclosed areas.

Selection, Use and Care

Choose an aerosol generator according to where you will use it – indoors or outdoors. There are truck- and trailer-mounted machines for use outdoors. Most hand-operated or permanently mounted automatic machines are for use indoors, such as in greenhouses.

In general, use and care for an aerosol generator as you would a sprayer. They do require several special precautions, however:

- Be sure that the pesticides used in the aerosol and fog generators are registered for that use.
- Keep the pesticides on the target.
- Because aerosol and fog formulations are easily affected by weather conditions during application, follow special use instructions.
- The operator, other people and animals should stay out of the fog or smoke cloud.

DUSTERS AND GRANULE APPLICATORS

Dusters

Dusters are used only occasionally in outdoor agricultural situations because of the high probability of drift. Dust applications are more common in greenhouses and other enclosed agricultural areas.

Hand dusters — Hand dusters may consist of a squeeze bulb, bellows, tube, shaker, sliding tube or a fan powered by a hand crank.

Advantages:

- Lightweight – do not require water.
- The pesticide is ready to apply without mixing.
- Good penetration in confined spaces.

Limitations:

- Dust may not stick to foliage.
- Dust is difficult to direct.
- Drift potential is high.

Power dusters — Power dusters use a powered fan or blower to propel the dust to the target. They include backpack types, units mounted on or pulled by tractors, and specialized equipment for treating seeds. Their capacity in area treated per hour compares favorably with some sprayers.

Advantages:

- Lightweight — no water required.
- Simply built.
- Easy to maintain.

Limitations:

- Drift hazards.
- Application may be less uniform than sprays.
- Dust may not stick to foliage.

Granule Applicators

Granule applicators distribute granular pesticides by several different methods, including:

- Forced air.
- Spinning or whirling disks (fertilizer spreaders).
- Multiple gravity-feed outlets (lawn spreaders, grain drills).
- Soil injectors (furrow treatments).
- Agricultural aircraft (ram-air).

Granule applicators may be designed to apply the pesticides:

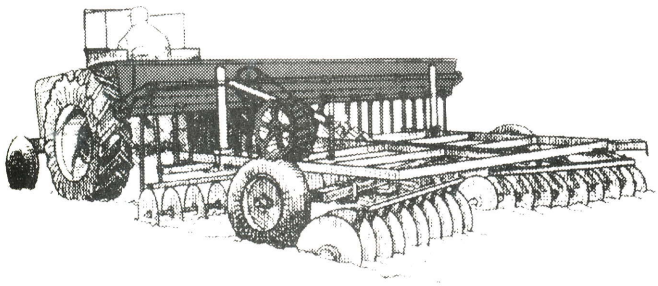
- Broadcast — even distribution over the entire area.
- To specific areas — banding, in-furrow, side-dress.
- By drilling — soil incorporation or soil injection.

Advantages:

- Simple in design.
- Eliminates mixing — no water needed.
- Minimal drift hazard.
- Low exposure hazard to applicator.

Limitations:

- Limited use against some pests because granules will not adhere to most foliage.
- Need to calibrate for each different granular formulation.
- Spinning disk types may give poor lateral distribution, especially on side slopes.
- Weather and ground conditions can affect the flow rate of granules.



Granular broadcast applicator on disc.

Selection, Use and Care

Look for a power duster that is easy to clean. It should give a uniform application rate as the hopper is emptied. Look for both hand and power dusters that direct the dust cloud away from the user.

Choose a granule applicator that is easy to clean and fill. It should have mechanical agitation over the outlet holes. This prevents clogging and helps keep the flow rate constant. Application should stop when drive stops even if outlets are still open.

Both dusters and granule applicators are speed-sensitive, so maintain uniform speed. Bouncing equipment will cause the application rate to vary. Stay out of any dust created by action of the equipment.

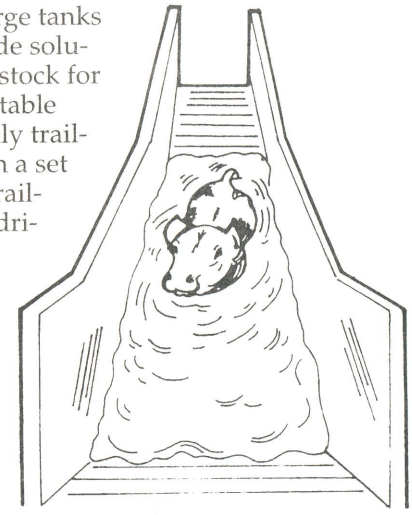
Watch band applicators to see that the band width stays the same. Small height changes due to changing soil conditions may cause rapid changes in band width.

Clean equipment as directed by the operator's manual.

ANIMAL APPLICATION EQUIPMENT

Dipping Vats

Dipping vats are large tanks (vats) of liquid pesticide solutions used to treat livestock for external parasites. Portable dipping vats are usually trailer-mounted tanks with a set of folding ramps and railings. The animals are driven up the ramp onto a platform and forced into the tank so they are completely immersed. Their heads may have to be pushed under the surface.



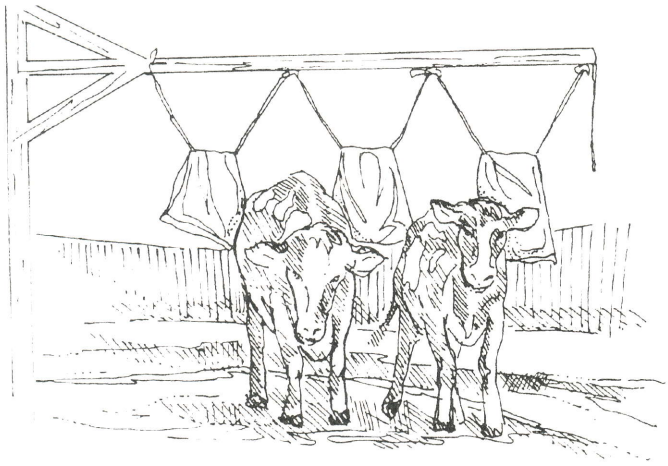
Spray-dip Machines

Spray-dip machines are used to treat livestock for external parasites. A spray-dip machine usually consists of a trailer-mounted chute with solid walls and gates at each end. The chute is located above a shallow tank and is equipped with several rows of large nozzles mounted so that they direct the spray mixture to thoroughly cover each animal. A large centrifugal pump supplies the pesticide to the nozzles. Surplus and runoff spray falls back into the tank, where it is filtered and recycled to the nozzles.

Face and Back Rubbers and Dust Bags

Face and back rubbers and dust bags are containers of dry or liquid pesticide formulations used to control external parasites of livestock. The devices are hung or mounted in areas adjacent to high livestock traffic areas,

such as feeding troughs, waterers and gate entrances. When the animal rubs against the device, the pesticide is transferred to the animal's face, back, sides or legs.



Dust Boxes

Dust boxes are used mainly in raised wire battery-type cages for laying hens or other poultry. These boxes contain a pesticide dust used to control poultry pests, usually mites. Birds wallow in the boxes and pick up the dust on their feathers and skin.

BAIT APPLICATION EQUIPMENT

Bait Stations

Bait stations hold pesticide-treated food that attracts target pests. They are used for insect control around poultry and livestock housing and for vertebrate control around crops, commodities and agricultural buildings.

Bait Applicators

Bait applicators are used to apply pesticides to control moles and other underground vertebrate pests. Some hand-operated models inject the poisoned bait directly into underground burrows. Mechanical models are tractor-mounted machines that form artificial burrows that intersect with natural burrows. When the pests use the artificial burrows, they feed on the bait.

SPECIALIZED APPLICATION EQUIPMENT

You may sometimes use other types of equipment designed for specialized or more precise applications. Some devices are used in conjunction with standard application equipment. Some specialized equipment is intended for application of herbicides. Other specialized application equipment is for applying pesticides through irrigation or watering systems.

Pesticide Injection Systems

With pesticide injection systems, instead of mixing the pesticide with water or other carrier in the sprayer tank, a control console electronically monitors and controls the chemical output of a metering pump. The pump meters the pesticide from its own holding tank and injects it into the line carrying the water to the boom. An in-line mixer device is located on the discharge side of the injector. It blends the carrier with the formulated pesticide before the mixture passes through the boom and is sprayed through the nozzles.

With pesticide injection systems, a control console electronically monitors and controls the chemical output of a metering pump instead of mixing the pesticide with water or other carrier in the sprayer tank.

If a carrier other than water is used, a flow meter and regulator valve are required to regulate the carrier. The carrier rate and flow are monitored and regulated from the same control console that monitors and regulates the rate of flow of the pesticide. The water (or other carrier) spraying pressure and volume are kept constant and the rate of chemical injection is regulated, thereby maintaining the same spray pattern regardless of speed or terrain.

Injection systems eliminate leftover tank solutions and large-tank rinsing. Unused pesticide in the injector tank can be drained back into its original container. The injector tank then requires proper rinsing.

Specialized Application Equipment for Herbicides

Some application equipment is designed to apply herbicides so that the herbicide contacts the weeds but does not contact desirable plants in the treated area. This equipment includes:

- Recirculating sprayers.
- Shielded applicators.
- Wiper applicators.
- Wax bar applicators.

Recirculating sprayers — These devices usually are used to apply contact herbicides to weeds that are taller than the crop in which they are growing. Solid streams of highly concentrated herbicides are directed across rows above the crop. The system prevents the herbicide from contacting the desirable plants. Spray material that is not intercepted by the weeds is caught in a box or sump on the opposite side of the row and is recirculated.

Advantages:

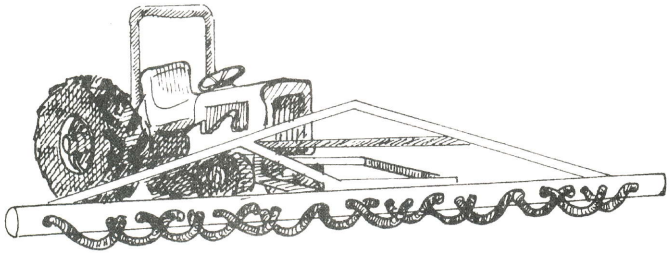
- Uses small quantities of pesticide.
- Less pesticide moves off target and into the environment.
- Permits treatment of weeds that have escaped other control measures.
- Protects susceptible nontarget plants from injury.

Limitations:

- Use is limited to special situations.

Shielded applicators — These applicators direct the herbicide onto the weeds while shielding desirable plants from the herbicide.

Wiper applicators — Sometimes called "wick" or "rope" applicators, these devices are used to apply herbicides selectively to weeds in crop areas. Wicks made of rope, rollers made of carpet or other material, or absorbent pads made of sponges or fabric are kept wet with a mixture of herbicide and water and brought into direct contact with weeds. The herbicide is wiped onto the weeds but does not come in contact with the crop.



Application may be to tall weeds growing above the crop or to lower weeds between rows, depending on the way the wiper elements are designed.

Advantages:

- Simple to operate.
- No drift.
- Uses small amount of pesticide.

Limitations:

- Useful only in special situations.
- Difficult to drain and clean.

Wax bars — Herbicides are sometimes applied with wax bars that are impregnated with herbicides. The bars are dragged slowly over the area to be treated.

Advantages:

- No drift.
- No calibration.

Limitations:

- Highly specialized, not readily available.

Irrigation Application Equipment

Irrigation or watering systems can be equipped to deliver pesticides to a target. Known as chemigation, this is a common method for applying pesticides in many irrigated areas. Accurate calibration and distribution are achieved by metering a large volume of dilute pesticide into the irrigation system. Anti-siphon check valves prevent contamination of the irrigation water source, and switch valves prevent overflow into the slurry feed tank.

Advantages:

- Convenient.
- Field access unnecessary.

Limitations:

- Constant agitation needed in slurry tank.
- Application of more water per acre than recommended on label will cause some pesticides to leach.
- Sprinkler distribution must have appropriate overlap pattern for uniform delivery.
- Injection of pesticides into flood and furrow irrigation systems may result in uneven concentrations of pesticides throughout the field, depending on soil permeability and field contours.

Extension bulletin E-2099, "Using Chemigation Safely and Effectively," provides additional information on applying agrichemicals through irrigation systems.

CHAPTER 4 PART B

Review Questions

Application Equipment

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

1. Match each sprayer type below with the pest control situation in which it would be most useful.

   1. Spot treatment of a few weeds in a small area. ____
   2. Broadcast application of herbicide to a 10-acre field. ____
   3. Broadcast application in an area where the equipment must move through narrow places and around trees. ____
   4. Application of herbicide to a stand of tall trees with dense foliage. ____

   A. Boomless sprayer
   B. High-pressure (hydraulic) sprayer
   C. Hand-operated sprayer
   D. Boom sprayer

2. Match the following types of sprayers with the correct statements about their advantages and limitations:

   1. Simple to operate; pressure and output not steady; little agitation. ____
   2. Larger capacity than hand sprayers; deliver both low and high pressures; not big enough for general field use. ____
   3. Cover large area with each tankful; limited penetration and reach. ____
   4. Good penetration and coverage; need large amounts of water, power and fuel; output drifts easily. ____
   5. Good coverage and penetration using low pump pressures; use of concentrates makes dosage errors more likely. ____
   6. No water needed; use of high concentrates presents safety hazards; few pesticides labeled for this use. ____
   7. Pesticide adheres to foliage well; little drift hazard; useful only for foliage applications. ____

   A. ULV sprayers
   B. Hand-operated sprayer
   C. Large High-pressure sprayers
   D. Large Low-pressure sprayers
   E. Electrostatic sprayers
   F. Airblast sprayers
   G. Small motorized sprayers

3. Match the following types of sprayer pumps with the correct statements about their features:

   1. Provide moderate volumes at low to moderate pressures; self-priming; best with non-abrasive formulations. ____
   2. Used with low-pressure sprayers to spray oil-based formulations; all parts are metal. ____
   3. High volume; not self-priming; good for abrasive formulations. ____
   4. Generally used to deliver low volumes, but also useful for high-volume, high-pressure applications; self-priming; good with abrasive formulations but may be damaged by some solvents. ____
   5. Used for high-pressure sprayers or when both low and high pressures are needed; self-priming; piston cups can be replaced when worn by abrasives. ____

   A. Centrifual pumps
   B. Diaphram pumps
   C. Gear pumps
   D. Piston pumps
   E. Roller pumps

4. Why are strainers used in a sprayer system?

Select the correct answers to complete the following statements about sprayer parts:

5. A good sprayer tank is easy to fill, easy to clean, and:
   a. Is corrosion-resistant.
   b. Has a large drain opening.
   c. Is equipped with a shutoff valve.
   d. Has a gauge to show the liquid level.
   e. All of the above

6. A pump should have enough capacity to supply the needed volume to the nozzles and to:
   a. Empty the tank in 5 minutes or less.
   b. Maintain the desired pressure at the nozzles.
   c. Deliver volume or pressure at least 15 percent greater than the manufacturer's recommendations.

7. The suction hoses on a sprayer system should be:
   a. Larger than the pressure hoses.
   b. Smaller than the pressure hoses.
   c. The same size as the pressure hoses.

8. Pressure gauges can be damaged by:
   a. Excess pressure.
   b. Pressure that is too low.
   c. Corrosive pesticides.
   d. a and c

9. A quick-acting cutoff valve should be located between the:
   a. Pump and the pressure regulator.
   b. Pressure regulator and the nozzles.
   c. Bypass line and the agitator.

10. Match the following types of pressure regulators with the correct description:

1. Valve is manually adjusted; restriction of pump output depends on how much the valve is open. ____	A. Spring-loaded bypass valve
2. Valve opens or closes in response to changes in pressure. ____	B. Unloader valve
3. Valve allows overflow to move back to tank when nozzles are shut down. ____	C. Throttling valve

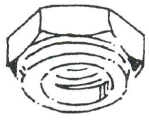
11 What are the three main types of agitation that can be used in spray tanks? Which type is best for wettable powders and other formulations that need a lot of agitation?

12. On the diagram below, label the four main parts of the nozzle.

A. _____

B. _____

C. _____



D. _____

13. What is the best way to clean a clogged nozzle?

14. Why are dusters not used often in outdoor agricultural pest control?

15. In which of the following situations would a granule applicator probably NOT be a good choice?
   a. Broadcast application of pesticide when drift may be a problem.
   b. Application of pesticide to plant foliage.
   c. Aerial application of pesticide.
   d. Soil incorporation of pesticide.

16. Which of the following types of equipment are left in place so that livestock or poultry will be self-treated when their normal activities bring them into contact with the devices?
   a. Spray-dip machines
   b. Dust boxes
   c. Face and back rubbers
   d. Dust bags
   e. Dipping vats

17. Match the following specialized application equipment with the correct descriptions of their functions:

1. Recirculating sprayers ____	A. Apply pesticides through irrigation systems.
2. Shielded applicators ____	B. Directs pesticide above crop to treat taller weeds; collects excess spray material for reuse.
3. Wiper applicators ____	C. Dragged slowly over area to be treated.
4. Wax bars ____	D. Directs pesticide onto weeds but has a barrier that keeps the pesticide from contacting the crop.
5. Chemigation equipment ____	E. Ropes, rollers or pads soaked with pesticide rub against weeds but do not contact crop.
6. Pesticide injection systems ____	F. No tank mixing required; a pump meters concentrated pesticide into the line carry ing water to the boom – mixing occurs before the solution is sprayed through the nozzles.

PART B

CHAPTER 5

CALIBRATION

LEARNING OBJECTIVES

After you complete your study of this chapter, you should be able to:

- Define calibration.
- Calculate application rates.
- Check for uniform output from multiple nozzles or hoppers.
- Name some key factors you must consider when calibrating a sprayer.
- Explain the role of ground speed in the calibration of equipment.
- Use nozzle charts, along with facts about the application situation, to choose the correct nozzle tip for each job.
- Use formulas provided, to calibrate pesticide application equipment correctly.
- Identify the key factors you must consider when calibrating a granular applicator.

TERMS TO KNOW

Active ingredients – The chemicals in a pesticide product that control the target pest.

Band spraying – Application of a pesticide to a strip over or along a crop row.

Broadcast spraying – Uniform application of a pesticide over an entire area.

Calibration – The process of measuring and adjusting the amount of pesticide that a particular piece of equipment will apply to a given area.

Carrier – The primary material used to allow a pesticide to be applied effectively; for example, the talc in a dust formulation or the water mixed with a wettable powder before a spray application.

Diluent – Anything used to dilute a pesticide.

Dilute – To make less concentrated.

Directed spraying – Aiming a pesticide at a specific portion of a plant or target site.

Formulation – Pesticide product as sold, usually a mixture of active and inert ingredients; can be dry (solid), liquid or gas.

gpa – Gallons per acre.

gpm – Gallons per minute $= \frac{GPA \times MPH \times W}{5940}$

mph – Miles per hour. Speed (Mph) $= \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$

Swath width – Side-to-side measurement of the band or strip of pesticide released by the application equipment.

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

Water-based pesticides – Pesticides that use water as the only diluent or carrier.

Calibration is the process of measuring and adjusting the amount of pesticide your equipment will apply to a specific area. Properly calibrated application equipment ensures that the applicator maximizes the value of a pesticide application within legal label rates and without crop injury or pest control failure.

Before you begin to calibrate the equipment, check it carefully to be sure that all components are clean and in good working order. Pay particular attention to the parts that regulate the amount of pesticide being released, such as nozzles or hopper openings.

Calibration does not have to be difficult. It can be as easy as 1-2-3; 1) nozzle flow rate, 2) ground speed, 3) width. Calibration requires some simple mathematics; this chapter provides some standard formulas to help you.

It is not necessary to memorize the formulas. Instead, make a list of the ones you will need in your work (including the steps to solution) and keep it handy. Review the formula each time you calibrate, just as you refer to the pesticide label each time you use a pesticide. As you work through the formula, use a calculator to reduce the chances of making an error. *Double check your calculations!*

The methods described in this chapter are not the only ways to calibrate equipment. Other equally acceptable methods may be used.

CALIBRATING FOR LIQUID PESTICIDE APPLICATIONS

Timed Flow Calibration Method

The following information will take you step by step through the decisions and calculations required to calibrate a pesticide sprayer. The six steps below describe the *Timed Flow Calibration method.*

Nozzle Selection – Two aspects of the nozzle – type (e.g., flat fan, hollow cone) and tip (size) – influence the amount of pesticide applied. The nozzle type is selected first. You choose the nozzle type based on the particular spray job you need to accomplish and to compliment the field conditions. The label may suggest a type of nozzle for best performance with the pesticide product. Table 1. Nozzle guide for broadcast spraying and Table 2. Nozzle guide for banding and directed spraying, suggest which nozzles are best suited for various applications.

> *The nozzle charts that accompany this unit are typical of those that manufacturers commonly distribute, but the nozzles named are not actual products.*

Nozzle Tip (size) – After the type of nozzle has been selected, you're next decision is to choose the nozzle tip (size) based on **gallons per minute (gpm).** To determine the gpm we want from a nozzle tip will require us to solve our first equation in the calibration process. To calculate gpm use the following equation:

$$gpm = \frac{gpa \times mph \times w}{5940}$$

Where:

gpm = gallons per minute, the nozzle flow rate.

gpa = gallons per acre, a management decision that you make based on pesticide label recommendations.

mph = miles per hour, the ground speed you select.

w = spacing between nozzles in inches or band width in inches.

5940 = a constant number, used as a conversion factor for units of gallons per acre, miles per hour and nozzle spacing in inches.

Calculating gpm – Each of the values in the gallons per minute (gpm) equation are determined by you. The gpa is based on pesticide label recommendations, field conditions, spray equipment and water supply. You select the mph to meet field and equipment conditions. The width (w) is expressed in inches and is determined by your nozzle arrangement or the row width.

For an example, let's assume you have determined the following:

Step one: Nozzle type selected = flat fan, 65° angle.

Step two: You have determined these parameters –

- Gallons per acre (gpa) = 12 gpa.
- Miles per hour (speed) = 5 mph.
- Nozzle spacing (w) = 20 inches.

Step three: Solve the gpm equation.

$$gpm = \frac{12\ (gpa) \times 5\ (mph) \times 20\ (inches)}{5940} = \frac{1200}{5940} = 0.2\ gpm$$

Step four: Refer to a manufacturer's table for flat fan nozzles and select one that delivers the gpm (0.2 in our example) you calculated in step 3. Table 3. represents a nozzle selection chart. Table 3. shows that:

- The nozzle tip number 503, will deliver 0.2 gpm at 40 psi with a 50-mesh strainer on that nozzle.
- At 5 mph it will deliver 11.8 gpa.

Note, fine tuning can best be accomplished by adjusting the pressure slightly. It is usually more economical to purchase tips that allow you to operate your equipment at its optimum pressure and speed. Large deviations from the recommended pressure rating may cause changes in the nozzle spray pattern.

Uniform Release – Once you have determined the proper nozzle type and size tip, put these nozzles on the sprayer and operate it with water. (Water is usually used for calibration tests because testing then does not waste chemicals and it is safer for the operator.) Test for leaks, general sprayer problems and uniformity.

Table 1. Nozzle guide for broadcast spraying. (From NCR-520)

	Herbicides				Fungicides		Insecticides	
	Soil-incorporated	Pre-emerge	Post-emerge: Contact	Post-emerge: Systemic	Contact	Systemic	Contact	Systemic
Extended range flat fan	Good	Very Good (at low pressure)	Good	Very Good (at low pressure)	Very Good	Very Good (at low pressure)	Good	Very Good (at low pressure)
Standard flat fan		Good		Good	Good		Good	
Drift guard flat fan	Very Good	Very Good		Very Good		Very Good		Very Good
Twin flat fan			Very Good				Very Good	
Turbo flood wide angle	Very Good	Very Good		Very Good		Very Good		Very Good
Wide angle full cone	Very Good	Very Good						
Flood nozzle wide angle	Good							
Rainbow™ hollow cone	Good	Good		Good				

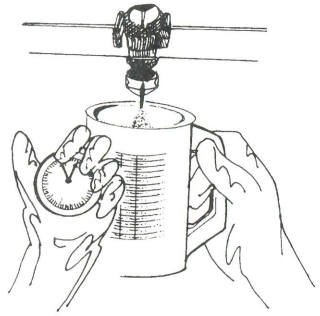
Table 2. Nozzle guide for banding and directed spraying. (From NCR-520)

	Herbicides			Fungicides		Insecticides		Growth Regulator
	Pre-emerge	Post-emerge: Contact	Post-emerge: Systemic	Contact	Systemic	Contact	Systemic	
Even flat fan	Very Good	Good	Very Good	Good	Very Good		Very Good	Good
Twin even flat fan	Good	Very Good	Good			Very Good		
Hollow cone		Very Good		Good		Very Good		
Full cone	Good							Very Good
Disc and core cone				Very Good	Good	Very Good	Good	

Step five: We must test for uniform flow rate from each nozzle. To test nozzles, operate the tractor at the same throttle setting you use when spraying and when making your speed check (speed check described below). This assures that the pump is delivering the same volume as when you're actually spraying.

Catch the spray material from each nozzle in a jar or plastic container for one minute—sometimes referred to as the catch test. Carefully measure the discharge from each nozzle. Is the amount equal to the desired gpm? If the discharge is collected in a container marked with *ounces*, how can we tell if it equals the appropriate amount of *gallons* (gpm)?

We convert the gallons per minute (gpm) flow rate into ounces per minute by multiplying the number of gallons by 128.



1 gallon = 128 ounces

To convert from gallons to ounces, multiply the number of gallons by 128. In most cases it is practical to round to the nearest whole number.

Table 3. Flat Fan Nozzle Tips

Flat Spray Tip No. and strainer screen size	Pressure in psi	65° Series (For Boom Heights of 21-23 inches) Capacity 1 Nozzle in gpm	Gallons Per Acre (20" Nozzle Spacing) 4 mph	5 mph	7.5 mph	10 mph
501 (100 Mesh)	20	.07	5.3	4.3	2.8	2.2
	25	.08	5.9	4.7	3.1	2.4
	30	.09	6.4	5.1	3.4	2.6
	40	.10	7.4	6.0	4.0	3.0
	50	.11	8.3	6.7	4.5	3.4
	60	.12	9.1	7.4	4.9	3.7
502 (100 Mesh)	20	.11	7.8	6.3	4.3	3.2
	25	.12	8.8	7.1	4.7	3.6
	30	.13	9.7	7.7	5.2	3.9
	40	.14	11.1	8.9	6.0	4.5
	50	.15	12.4	10.0	6.7	5.0
	60	.16	13.6	10.9	7.4	5.5
503 (50 Mesh)	20	.14	10.5	8.4	5.6	4.2
	25	.16	11.8	9.4	6.3	4.7
	30	.17	12.9	10.3	6.9	5.2
	40	.20	14.8	11.8	7.9	5.9
	50	.23	16.5	13.2	8.8	6.6
	60	.25	18.1	14.4	9.7	7.2
504 (50 Mesh)	20	.21	15.7	12.6	8.4	6.3
	25	.24	17.6	14.1	9.4	7.1
	30	.26	19	15.4	10.3	7.7
	40	.30	22	17.8	11.8	8.9
	50	.34	25	20	13.2	10.0
	60	.37	27	22	14.4	10.9
505 (50 Mesh)	20	.28	21	16.8	11.2	8.4
	25	.32	24	18.7	12.5	9.4
	30	.35	26	21	13.7	10.3
	40	.40	30	24	15.8	11.9
	50	.45	33	27	17.7	13.3
	60	.49	36	29	19.4	14.6
506 (50 Mesh)	20	.35	26	21	14	10.5
	25	.40	29	23	15.7	11.7
	30	.43	32	26	17.2	12.9
	40	.50	37	30	19.8	14.9
	50	.56	42	33	22	16.6
	60	.61	45	36	24	18.2
507 (50 Mesh)	20	.42	31	25	16.9	12.6
	25	.47	35	28	18.7	14.1
	30	.52	39	31	21	15.5
	40	.60	45	36	24	17.8
	50	.67	50	40	27	20
	60	.73	55	44	29	22

In our example we want a 0.2 gpm flow rate. So, if we use a container marked in ounces, when collecting our nozzle discharge for one minute we will expect:

0.2 gpm x 128 oz./gal. = 26 oz./min (26 oz. collected in the container)

Compare this calculated number of ounces (26 oz/min.) with the amount actually collected in the container. Any nozzles that are not within ± 5 percent of the average output should be cleaned if they're plugged or replaced if worn or do not meet manufacturer's specifications. New nozzles should also be checked.

For our example, ± 5 percent of our desired flow rate (25.6 oz./min.) is determined as follows:

26 oz./min. x .05 = 1.3 oz./min.

26 oz./min. + 1.3 oz./min. = 27 oz./min.

26 oz./min. – 1.3 oz./min. = 25 oz./min.

If the average discharge is not what you anticipated from the calculations, you can adjust the output a bit by raising or lowering the pressure slightly.

Step 5a (this step is used only if a diluent other than water is used): Flow rates of materials other than water will be different than the nozzle flow rate with water. Your spray situation, based on pesticide label directions, may require the use of a diluent other than water. Because most nozzle selection charts provided by manufacturers are based on spraying with water, the figures will not be correct if you are using another diluent. A table such as Table 4 is often provided to adjust the figures to fit your situation.

Adjust the values on the nozzle charts by the conversion factor from the table to determine the correct value for the solution being sprayed.

Example: You have determined from label directions that you would be applying 12 gallons per acre if water were the diluent. The formulation you are using, which is not water-based, weighs 16 pounds per gallon:

12 gpa ÷ .72 (conversion factor from Table 4) = 16.67 gpa.

A nozzle that will pass 16.67 gpa of water will be needed to pass 12 gpa of the heavier, more viscous spray material.

So far, in this timed flow calibration process we have:

- Selected a nozzle type.
- Determined from label directions the gallons per acre (gpa) we want to apply.
- Chosen our desired sprayer speed in mph based on equipment and field conditions.
- Measured our nozzle spacing (width) in inches.
- Calculated the gpm we want to achieve using the equation:

$$gpm = \frac{gpa \times mph \times w}{5940}$$

- Selected a nozzle tip from a manufacturer's catalog that provides the calculated gpm.
- Confirmed that our flow rate from each nozzle is within ± 5 percent of the anticipated flow rate.

Table 4. Diluent Conversion Factors

Weight of Solution	Factors
6.6 lbs per gallon - KEROSENE	1.26
7.0 lbs per gallon	1.09
8.0 lbs per gallon	1.02
8.34 lbs per gallon-WATER	1.00
9.0 lbs per gallon	.96
10.0 lbs pergallon	.91
11.0 lbs per gallon	.87
12.0 lbs per gallon	.83
14.0 lbs per gallon	.77
16.0 lbs per gallon	.72
18.0 lbs per gallon	.68
20.0 lbs per gallon	.65

- Made adjustments for diluents other than water (if necessary).

Measuring Actual Speed: The final step in this calibration process is confirmation of the actual speed of your equipment. The timed flow calibration process eliminates the guesswork and enables you to accurately set up a sprayer to deliver the gpa that you require for an effective application.

Step six: To calibrate accurately, you must know your *actual* speed because tractor speedometers or tachometers may not be precise.

For accurate calibration, operate the equipment at the target site or on similar ground with the tank half full of water. Whether the equipment is hand-carried or mounted on a vehicle, the condition of the ground (surface) is important. A rough and uneven surface generally causes the equipment to be operated at a slower speed.

The equipment manufacturer's directions may offer a range of appropriate speeds. Your knowledge of conditions at the target site (including the drift hazard), plus your experience with the equipment, will help you determine an appropriate speed.

To measure actual speed (step six), mark off measured distances of 100, 200 or 300 feet in the field where the application is to be done. Then run the equipment over this distance at the operating speed, carefully marking the throttle setting or speedometer reading. Record the time required to cover the marked course. Be sure the equipment is moving at full operating speed before you reach the starting point. Make at least two runs; use the average time to do your calculations.

$$Speed\ (mph) = \frac{Distance\ (feet) \times 60}{time\ (seconds) \times 88}$$

The above equation will calculate your mph, but you also may find Table 5 useful. Table 5 converts the time measured to speed in miles per hour.

In summary, steps one through six are called the *timed flow calibration* method. If you know your speed and throttle setting, steps one through five permits you to set up and calibrate the sprayer without going into the field. This calibration method assures that the nozzles will provide the uniform output that is needed. Let's go through one more example of the timed flow calibration method.

Example two – Timed Flow Calibration Method.

Step one: We select a flat fan nozzle for our application.

Step two: We determine the following parameters –

- Gpa = 10 gallons, based on the pesticide label directions.
- Mph = 10 mph, based on our equipment and field conditions.
- Nozzle spacing = 20".

Step three: Solve the following equation to determine the gpm. We calculate gpm so we can select the appropriate size nozzle tip.

$$\text{gpm} = \frac{\text{gpa (10) x mph (10) x w (20)}}{5940} = 0.34 \text{ gallons per minute}$$

Step four: Knowing our desired gpm (0.34), refer to the manufacturer's nozzle chart to select a tip that will deliver this rate. See Table 3. Flat Fan Nozzle Tips. The chart tells us that nozzle 504 delivers 0.34 gpm at 50 psi and requires a 50 mesh screen. Travelling at 10 mph will achieve an application rate of 10 gpa.

Step five: Put the flat fan 504 nozzles with 50 mesh screens on your sprayer and confirm that they release the 0.34 gpm flow rate desired by doing a catch test. Remember that ± 5 percent of our desired flow rate is acceptable. If our catch containers are labeled with ounces, let's convert our gpm to ounces per minute so its more convenient to determine if our discharge is what we need.

0.34 gal/min. x 128 oz/gal. = 43.5 oz./min.

Now determine what ± 5 percent of our desired flow rate is by calculating the following:

43.5 oz./min. x .05 = 2 oz./min.

43.5 oz./min. + 2 oz/min. = 45.5 oz./min.

43.5 oz./min. – 2 oz./min. = 41.5 oz./min.

If the nozzles we have selected do not meet the ± 5 percent of our desired flow rate (41.5 – 45.5 oz./min.) replace them.

Step six: We must confirm the actual speed that our equipment is travelling. Mark off measured distances of 100, 200 or 300 feet in the field where the application is to be done. Then run the equipment over this distance at the operating speed, marking the throttle setting or speedometer reading and recording run times. Be sure the equipment is moving at full operating speed before

Table 5. Time-Distance-Speed

Ground speed in miles per hour	Time required in **seconds** to travel a distance of: 100 feet	200 feet	300 feet		Ground speed in miles per hour	Feet traveled per minute
0.5	136	272	408		0.5	44
1.0	68	136	204		1.0	88
1.5	45	91	136		1.5	132
2.0	34	68	192		2.0	176
2.5	27	54	82		2.5	220
3.0	23	45	68		3.0	264
3.5	20	39	58		3.5	308
4.0	17	34	51		4 0	352
4.5	15	30	45			
5.0	14	27	41	OR		
6.0	11	23	34			
7.0	9.7	19	29			
8.0	8.5	17	26			
9.0	7.6	15	23			
10.0	6.8	14	20			
12.0	5.7	11	17			
15.0	4.5	9	13.6			
20.0	3.4	6.8	10.2			

you reach the starting point. Make at least two runs; use the average time to do your calculations.

$$\text{Speed (mph)} = \frac{\text{Distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Ounces = Gallons Calibration Method

This method of calibration is very easy to use and can be used to check and fine-tune a sprayer quickly but does require driving a distance in the field. Before calibrating the sprayer with any method, you must check nozzle output for uniformity. Correct any nozzles that vary in flow rate by more than ± 5 percent, as described above. Also check that pressure gauges are reliable and the pressure is properly set. Pressure at the nozzle may be different than the pressure at the tractor cab. Be sure you are operating the sprayer so that the nozzle has the manufacturer's recommended pressure. Then proceed as follows:

Step one: For broadcast applications, determine the distance, in inches, between nozzles. For banded applications, determine the band width in inches.

Step two: Locate this width in Table 6. Calibration Distances and read off the corresponding course distance.

Step three: In the field to be sprayed, mark off a course of the proper distance. You may set permanent markers in the field or paint fence posts to make this step easier next time.

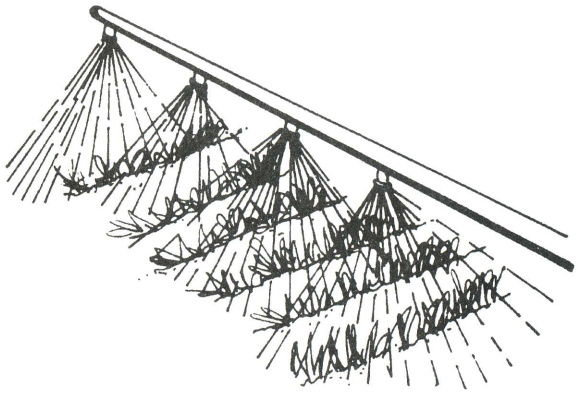
Step four: Fasten a 1-quart container to one nozzle on the sprayer so that it will catch all of the discharge from that nozzle. This assumes that all the nozzles are uniform in their discharge, as described above.

Step five: Start a distance back from the beginning of the course to get up to operating speed, then turn the sprayer ON at the beginning of the course and OFF at the end of the course.

Step six: Measure the volume collected in the container in ounces. Do this several times to be sure the results are reliable. You may average the output from several nozzles to get a more reliable reading.

Step seven: *OUNCES COLLECTED = GALLONS PER ACRE.* The total discharge measured in ounces is equal to gallons per acre (gpa) applied. With either broadcast boom or band sprayer, the gpa is equal to the output from one nozzle. When more than one nozzle is used per row, the combined amount collected from all nozzles directed at the row is equal to the gpa.

If it is not practical to fasten a container to the nozzle (step four) and drive a test course follow steps one through three as above, then follow these alternative steps four through six:



Step four: Select the gear and throttle setting, bring the sprayer up to speed, and measure the time needed to cover the test course. Time the course at least twice, once up and once back.

Step five: If it required 20 seconds to travel the test course, set the throttle at the pressure you will be using while spraying and catch one nozzle's output for 20 seconds (collect nozzle output for time equal to what it was required to cover the test course).

Step six: Measure the amount collected in ounces. The output in ounces is the amount applied in gallons per acre, i.e., if the nozzle output is 15 ounces, the sprayer applied 15 gallons per acre. Repeat steps 5 and 6 for each nozzle.

Example: Ounces = Gallons per acre for broadcast or band application:

The pressure you have selected is 30 psi. The nozzles are spaced 30 inches apart on the boom.

1. The distance to mark off for 30-inch nozzle spacing is 136 feet (from chart).
2. Fasten a 1-quart container to one nozzle on the sprayer so that it will catch all of the discharge from one nozzle.

Table 6. Calibration Distances

Row or Nozzle Spacing (inches)	Calibration Distance (feet)
40	102
38	107
36	113
34	120
32	127
30	136
28	146
26	157
24	170
22	185
20	204
18	227

3. Start a distance back from the beginning of the course to get up to operating speed, then turn the sprayer on at the beginning of the course and off at the end of the course.
4. Measure the amount collected in the container in ounces. The output in ounces is the amount applied in gallons per acre. If the nozzle output is 15 ounces, the sprayer applied 15 gallons per acre.
5. Repeat steps 3 and 4 for each nozzle.

Calibration Considerations

When a nozzle flow rate check (catch test) is done and the amount is not within the ± 5 percent, clean the nozzle, and clean or change the screen. If it still does not meet the discharge range, if it has a ball check valve, check this to be sure it is functioning properly and not restricting or allowing for excessive flow. Replace the nozzle if the problem cannot be corrected.

If you are confident in your calibration, but you end up with too much or too little material applied in the field, consider the accuracy of your acreage. Some operators use aerial photos generated by the Consolidated Farm Services Agency (CFSA, formerly ASCS). These maps only account for elevation changes every 400' and measurements may be higher or lower than the actual acreage that you are treating. If using land surveys, ask whether it was accurate and whether the site has changed, such as new road installations. Was the actual farming acreage measured? Or, did the total acreage include borders, ditches and hedgerows, which would make the actual treatment area less than the reported acreage. These are a few things to consider when the volume of your application is different than what you anticipated after careful calibration. Keep pesticide spray volume records per field to help you mix the correct amount the next time.

CALIBRATING GRANULE APPLICATORS

In all types of granular equipment, the amount of granules applied per unit of area depends on the size of the adjustable opening, the speed at which the equipment travels (or the speed of the hopper agitator), the roughness of the surface of the application site (except for aerial application), and the granular formulation chosen.

Different formulations have different flow rates depending on the size, weight, shape and texture of the granules. Environmental factors such as temperature and humidity also alter granular flow rates. (The flow rate slows as temperature and humidity rise.) Because so many variables can affect the delivery rate, calibrate your equipment for each formulation of product and for different field conditions.

Granular equipment that is wheel-driven delivers granules at a rate geared to the revolutions of the ground wheels. The faster the equipment is moved, the faster the release of granules. As a result, minor changes in equipment speed do not affect the amount of granules deposited per unit area. The only way to change the application rate in this type of equipment is by changing the feed gate settings. Confirm the appropriate tire size with the equipment manual.

Granular equipment with powered dispersal or gravity-flow dispersal distributes the granules at a rate independent of the ground speed of the equipment. The application rate per acre (or other unit area) depends on *both* the metered opening and the equipment speed. Adjustments in flow rates can be made by altering the rate of speed – faster speed means fewer granules delivered per area – or by altering the equipment settings.

Consult the equipment manual for manufacturer's recommended settings to deliver approximate rates of the granules being applied. If the equipment is motorized, select the speed by using manufacturer's suggestions and taking into consideration the condition of the application site. Soft, muddy or uneven surfaces and small areas with many obstacles require slower speeds or may have some wheel slippage.

Calibrate your equipment using the method described below. If the application rate differs more than 5 percent from the desired rate, adjust the equipment and recalibrate.

Broadcast Granular Applicators

Run a precalibration check on the granular application equipment:

- First, fill the hopper to a predetermined height or weight. Settle the material by driving a short distance or by shaking or striking the hopper; then refill the hopper.
- Set the flow rate as recommended by the equipment manual.
- Turn on the applicator and operate on a hard surface to check for uniform distribution along the swath width. If you cover the surface with a tarp before making the test run, you can collect the granules for reuse.

Next, operate the equipment over a measured area to determine whether the equipment is metering granules at the rate per acre you need. Use the "calibration collection method" described in the next column.

Calibration Collection Method

Multiple-outlet broadcast spreaders, band applicators, and soil injection equipment often can be calibrated by collecting the granules in calibration containers graduated in ounces. If the application rate is given in ounces (or pounds) per 1,000 linear feet of row and your equipment is a *ground-driven applicator:*

- Mark off 1,000 feet in the field you wish to treat.
- If the equipment is motorized, bring it up to the speed you have selected before beginning the test run.
- Collect the granules discharged from one tube or opening during the 1,000-foot test run. Ideally, using more catch containers you can collect material from all the tubes at one time. This will save time and allow you to compare the output volumes.

If the application rate is given in pounds per 1,000 linear feet of row and your equipment is **not** a *ground-driven applicator:*

- Make the 1,000 foot test run at the speed you have selected, but do not operate the applicator. Note the time (in seconds) it takes to complete the test run. Then with the equipment standing still, collect the granules discharged for that measured time.
- The amount of granules collected (in ounces or pounds) is the rate per 1,000 linear feet. (If you wish to use only a 100-foot test run, the amount of granules collected multiplied by 10 is the rate per 1,000 linear feet.)

Band Granular Applicators

Use the method described above to calibrate band applicators. However, if the labeling directions give the rate in pounds per acre broadcast, you must use the following formula to determine the rate per acre in bands (just as in band spray applications). Band width and row spacing must be in the same units, i.e., inches:

$$\frac{\textbf{Band width x Pounds per acre (broadcast)}}{\textbf{Row spacing}} = \textbf{Pounds per acre (band) applied}$$

Example:

- Labeling rate = 12 pounds per acre (broadcast).
- Band width = 6 inches.
- Row spacing = 30 inches.

$$\frac{\text{Band width (6 in) x 12 pounds per acre (broadcast)}}{\text{Row spacing (30")}} = 2.4 \text{ pounds per acre (band) applied}$$

If the labeling directions list **pounds to apply per 1,000 linear feet,** you must use this formula to determine your rate:

$$\frac{\textbf{Total pounds used in test run}}{\textbf{Number of rows in swath}} = \textbf{Pounds used per row in test run}$$

$$\frac{\text{Pounds used per row (in test run) x 1,000 ft.}}{\text{Distance traveled in test run}} = \text{Pounds per 1,000 linear feet}$$

Example:

- Number of bands or rows covered in test run = 8.
- Distance traveled in test = 3,000 feet.
- Pounds used in test = 2.3.

$$\frac{\text{Pounds used in test (2.3)}}{\text{Number of rows (8)}} = \text{Pounds used per row in test run (.288)}$$

$$\frac{\text{Pounds used per row (.288) x 1,000 ft.}}{\text{Distance traveled in test run (3,000 ft.)}} = \text{Pounds per 1,000 linear ft. (.096 or 1.5 oz.)}$$

CHAPTER 5 PART B

Review Questions

Calibration

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

NOTE: For the Michigan Department of Agriculture certification exam, you will be provided with all the formulas necessary to solve calibration problems.

1. What is calibration?

2. Explain how to determine whether all the nozzles (or hoppers) on a piece of application equipment are releasing approximately the same amount of pesticide.

3. What factors should be considered when calibrating a sprayer?
   a. Equipment speed.
   b. Nozzle pressure.
   c. Spray volume to be delivered.
   d. Type of carrier.
   e. All of the above.

4. What type of nozzle would you select if you were making a directed systemic insecticide application?
   a. Extended range flat fan.
   b. Even flat fan.
   c. Hollow cone.
   d. Drift guard flat fan.

5. Calculate the gallons per minute (gpm) if you were making a broadcast application with a boom sprayer in the following situation:
   - Nozzle = Flat Fan
   - Nozzle spacing = 20 inches
   - Nozzle pressure = 50 psi
   - Speed = 5 mph
   - Spray volume = 20 gpa.

$$gpm = \frac{gpa \times mph \times w}{5940}$$

6. Using Table 3 in this unit, select the nozzle tips you would use if you were making a broadcast application with a boom sprayer in the following situation:
   - Nozzle spacing = 20 inches
   - Nozzle pressure = 20 psi
   - Speed = 7.5 mph
   - Spray volume = 14 gpa.

   a. Nozzle tip 503, with a 50 mesh strainer
   b. Nozzle tip 504, with a 50 mesh strainer
   c. Nozzle tip 501, with a 100 mesh strainer
   d. Nozzle tip 506, with a 50 mesh strainer

7. What is the gpm for the equipment and nozzle set-up in question 6?
   a. .28
   b. .32
   c. .35
   d. .40

8. List at least three factors that should be considered when calibrating a granule applicator?

9. You are calibrating a granule applicator to apply granules in six 12-inch bands spaced 30 inches apart. The pesticide labeling lists only a broadcast rate – 13 pounds per acre.

   Calculate the correct band application rate per acre.

$$\frac{\text{Band width x pounds per acre (broadcast)}}{\text{Row spacing}} = \text{pounds per acre (band) applied}$$

10. You are calibrating the same granule applicator as in number 9; to apply granules in six 12-inch bands spaced 30 inches apart. In this case your pesticide labeling lists the application rate in **pounds per 1,000 feet**.

    Determine your rate per 1,000 linear feet if after a 3,000-foot test run at the chosen speed, it took 2.1 pounds of formulation to refill the hopper.

$$\frac{\text{Pounds used in test run}}{\text{Number of rows in swath}} = \text{Pounds used per row in test run}$$

$$\frac{\text{Pounds used per row (in test run) x 1,000 ft.}}{\text{Distance traveled in test run}} = \text{Pounds per 1,000 linear feet}$$

GLOSSARY

Abiotic - Not relating to living organisms.

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

Absorption - The uptake of a chemical into plants, animals or minerals. Compare with adsorption.

Acaracide - A pesticide used to control mites and ticks.

Acceptable daily intake - A reference dose for the health-based standard for chemicals in food. For non-carcinogenic pesticides, it is generally 1/100 of the NOEL; for carcinogenic risk, it is 1/1,000,000 of the NOEL.

Acidic - Having a pH less than 7. Any of various typically water-soluble and sour compounds that are capable of reacting with a base to form a salt, that are hydrogen containing molecules or ions able to give up a proton to a base or are substances able to accept an unshared pair of electrons.

Acre-foot - A volume of water equivalent to 1 acre of water 1 foot deep.

Active ingredient - The chemical(s) in a pesticide product that control the target pest.

Acute effect - Illness or injury that may appear immediately after exposure to a pesticide (usually within 24 hours).

Acute exposure - Exposure to a single dose of pesticide.

Acute toxicity - A measure of the capacity of a pesticide to cause injury as a result of a single or brief exposure.

Additive - A chemical added to a pesticide formulation to increase its effectiveness or safety; same as adjuvant.

Adherence - Sticking to a surface.

Adjuvant - A chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety.

Adsorption - The process by which a pesticide bonds with a surface; e.g., a soil surface.

Adulterated - (1) A pesticide whose strength or purity falls below that specified on the label. (2) A food, feed or product that contains illegal pesticide residues.

Aerobe - An organism that requires oxygen for growth.

Aerosol - A suspension of very small particles of a liquid or a solid in a gas.

Agitate - To stir or mix.

Agitation - The process of stirring or mixing.

Agitator - Device that stirs or mixes a pesticide in a tank or hopper.

Algae - Photosynthetic plants that contain chlorophyll, have simple reproductive structures, and have tissues that are not differentiated into true roots, stems or leaves.

Algaecide - A chemical compound that kills algae.

Alkaline - Having a pH greater than 7: the opposite of acidic.

Allelopathy - The production of growth inhibitors by one plant that retard the development of another plant.

Allergic effects - Harmful effects, such as skin rash or asthma, that some people develop in reaction to pesticides that do not cause the same reaction in most other people.

Allergic effects statement - a statement appearing on a pesticide label that states if tests or other data indicate that a pesticide product has the potential to cause allergic effects, such as skin irritation or asthma. Sometimes the labeling refers to allergic effects as "sensitization."

Anaerobe - An organism which does not require oxygen for its growth.

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

Antagonism - An interaction of two or more chemicals such that the effect, when combined, is less than the predicted effect based on the activity of each chemical applied separately.

Anti-siphoning device - An attachment designed to prevent backward flow into the water source.

Antibiotic - Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Antidote - (1) A chemical applied to prevent the phytotoxic effect of a specific pesticide on desirable plants. (2) A substance used as a medical treatment to counteract poisoning.

Aquatic plants - Plants that grow on, in or under water.

Aqueous - Indicating the presence of water in a solution or environment.

At emergence - Treatment applied during the visible, emerging phase of the specified crop or weed.

Attractants - Substances that lure insects to traps or to poison-bait stations; bait.

Avicide - A chemical used to control birds.

Back-siphoning - The movement of liquid pesticide mixture back through the filling hose and into the water source.

Bacteria - Extremely small, single-celled microorganisms that usually lack chlorophyll and reproduce by fission (splitting of the cell into two equal halves).

Bactericide - A pesticide used to control bacteria.

Band application - Placement of a pesticide in a narrow area either over or along the crop row.

Band spraying - Application of a pesticide to a strip over or along a crop row.

Beneficial insects - Insects that are useful to people — e.g. predators and parasites of pest species, bees and other pollinators.

Benthic - Of aquatic habitats; those organisms that live on or in the sediments; bottom-dwelling.

Biennials - Plants that require two growing seasons to complete their life cycle.

Bioaccumulation - The buildup of pesticides or other chemicals in the bodies of animals (including humans), particularly in fat tissue.

Biocide - A chemical able to kill microbial organisms.

Biological control - Control by predators and parasites, either naturally occurring or introduced.

Biological degradation - The breakdown of a pesticide due to the activities of living organisms, especially bacteria and fungi.

Biology - The science that deals with the structure, function, development, evolution, and ecology of living organisms.

Biomass - Volume of living plant material.

Biotic - Relating to living organisms.

Biotype - A population within a species that has distinct genetic variation.

Botanical pesticide - Organic pesticides derived or extracted directly from plants. Examples are nicotine, pyrethrin, strychnine and rotenone.

Brand name - The specific, registered name given by a manufacturer to a pesticide product; same as trade name or proprietary name.

Broad-spectrum pesticide - A pesticide that is effective against a wide range of pests or species.

Broadcast application - The uniform application of a pesticide to an entire field or area.

Calibrate - To measure and adjust the amount of pesticide the application equipment will release per unit of area.

Calibration - The process of measuring and adjusting the amount of pesticide that application equipment will apply to the target area.

Carbamate - A synthetic organic pesticide containing carbon, hydrogen, nitrogen and sulfur that are used as insecticide, fungicide and nematicides. They have similar effects on nerve function as organo- phosphates.

Carcinogen - A substance which has the ability to cause cancer.

Carcinogenic - Capable of causing cancer in animals or humans.

Carrier - A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its application. Also known as the material used to carry the pesticide to the target, e.g., water.

Caution - Signal word associated with pesticide products classified as either slightly toxic or relatively non-toxic.

Cell - The basic structural unit of all living organisms: An organism may be composed of a single cell (e.g. bacteria) or many cells working together (all "higher" organisms, including man).

Certified applicator - A person qualified to apply or supervise applications of restricted use pesticides.

Certified commercial applicator - Any person (other than private applicators) who is certified or registered to use or supervise the use of a restricted use pesticide and who is in the business of applying pesticides for others.

Chelate - A combination of a metal ion and an organic molecule. Combining the two makes the metal ion less reactive with other chemicals in water or in a soil solution.

Chemical name - Name applied to a pesticide active ingredient that describes its chemical structure according to rules prescribed by the American Chemical Society and published in the Chemical Abstracts Indexes.

Chemical degradation - The breakdown of a pesticide by oxidation, reduction, hydrolysis or other chemical means.

Chemical-resistant - Ability to prevent movement of pesticide through the material during the period of use.

Chemigation - The application of an agricultural chemical by injecting it into irrigation water.

Chlorophyll - The green photosynthetic substance in plants that allows them to capture solar energy and convert it to chemical energy.

Chlorosis - Loss of green color (chlorophyll) from foliage.

Cholinesterase - An enzyme that helps to control the transmission of nerve impulses in animals and humans.

Chronic effect - Illness or injury that appears a long time, up to several years, after exposure to a pesticide.

Chronic exposure - Exposure to repeated doses of a pesticide over a period of time.

Chronic toxicity - A measure of the capacity of a pesticide to cause injury as a result of repeated exposures over a period of time.

Closed mixing systems - Systems in which liquid pesticide concentrates are transferred from their original containers to mix or spray tanks through a closed series of hoses, pipes, etc. Such systems are designed to prevent or minimize human exposure to the concentrates.

Collection pad or tray - A safety system designed to contain and recover spills, leaks, rinsates and other pesticide-containing materials.

Commercial applicator - Any persons other than private applicators, certified to apply pesticides.

Common name - (1) When referring to a pesticide, an abbreviated name applied to a herbicide active ingredient; usually agreed upon by the American National Standards Institute and the International Organization for Standardization. (2) When referring to an organism, a name derived from local common usage that is agreed upon by some accepted authority but may not be unique.

Compatibility - Mixable in the formulation or in the spray tank for application in the same carrier without undesirable alterations in the characteristics or effects of the individual components.

Compatibility agents - Chemicals that enhance the effective mixing of two or more pesticide products.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full-strength, but usually diluted before application.

Concentration - The amount of active ingredient or equivalent in a quantity of diluent expressed as percent, pounds per gallon (lb/gal), kilograms per liter (kg/l), etc.

Contact herbicide - A herbicide that causes localized injury to plant tissue where contact occurs.

Contact pesticide - A pesticide that kills pests simply by contacting them.

Corrosion - Process of being worn away gradually by chemical action.

Cross contamination - When one pesticide gets into or mixes with another pesticide accidently; usually occurs in a pesticide container or in a poorly cleaned sprayer.

Cultural control - Control by changing management practices to reduce pest numbers without using pesticides.

Cuticle - Thin, fatty or waxy outer surface on the leaves of some plants.

CZMA - Coastal Zone Management Act.

Danger - Signal word associated with pesticide products that may cause skin irritation, or eye injury more severe than suggested by the acute toxicity (LD50) of the product.

Days to harvest - The minimum number of days allowed by law between the final application of a particular pesticide and the harvest date.

Decontamination - To rid of a polluting or harmful substance.

Deflocculating agent - A material added to a suspension to prevent settling.

Degradation - The breakdown of a pesticide into a simpler compound that is usually, but not always, non-toxic; may be either chemical, physical or biological or any combination of the three.

Delayed effects - Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide or combination of pesticides.

Dermal toxicity - Ability of a chemical to cause injury when absorbed through the skin.

Dermal - Of the skin; through or by the skin.

Diluent - Anything used to dilute a pesticide; often referred to as the carrier.

Dilute - To make less concentrated.

Dilute pesticide - A pesticide that is not concentrated; one that does not have a high percentage of active ingredient.

Directed application - Precise application to a specific area or plant organ, such as to a row or bed or to the lower leaves and stems of plants.

Direct supervision - When a certified applicator is supervising the application of a pesticide and is physically present at the time and the place the pesticide is being applied.

Directed spraying - Aiming a pesticide at a specific portion of a plant or target site.

Dispersible granule - A dry, granular formulation that will separate or disperse to form a suspension when added to water.

Dispersing agent - A material that reduces the attraction between particles.

Distributor products - Products that are produced and registered by a manufacturer or formulator and sold under a different name by a distributor.

Dormant - State in which growth stops temporarily. May refer to plants, plant parts, microorganisms and certain animals.

Dose - (1) Amount, quantity or portion of a pesticide which is applied to a target. (2) A measure of exposure used in animal testing to determine acute and chronic toxicities; usually expressed in milligrams per kilogram body weight.

DOT - U.S. Department of Transportation.

Drift - Pesticide movement in air, away from the target site.

Dust - A finely-ground, dry pesticide formulation in which the active ingredient is combined with an inert carrier such as talc, clay, powdered nut hulls or volcanic ash; dusts are applied in the dry form.

Early postemergence - Applied after emergence during the cotyledonous growth phase of crop or weed seedlings.

Ecology - The science that studies the interrelationships of living organisms and their environment.

Economic damage - The amount of injury that will justify the cost of applied control measures.

Economic injury level - The population density at which a pest causes a reduction in the value of the crop that is greater than the cost of control.

Economic threshold or action threshold - The population density at which management measures should be instituted to prevent an increasing pest population from reaching the economic injury level.

Ecosystem - A system formed by the interaction of a community of organisms with their environment.

Emergence - The event in seedling or perennial growth when a shoot becomes visible by pushing through the soil or water surface.

Emersed plant - A rooted or anchored aquatic plant adapted to grow with most of its leaf and stem tissue above the water surface and not lowering or rising with the water level.

Emulsifiable concentrate (EC or E) - A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion (droplets of one liquid dispersed in another liquid).

Emulsifier - Chemical that allows petroleum-based pesticides (EC's) to mix with water.

Emulsion - A mixture of two or more liquids that are not soluble in one another. One is suspended as small droplets in the other.

Encapsulated pesticide - A pesticide formulation in which the active ingredient is encased in extremely small capsules made of inert synthetic polymers. The pesticide is released gradually over a period of time.

Endangered species - Organisms whose survival as a species has been designated by a Federal agency to be endangered or threatened; a group of organisms on the brink of extinction.

Endangered species - A plant or animal that is in danger of becoming extinct.

Entomology - The science that deals with the study of insects.

Environment - All of our physical, chemical, and biological surroundings such as climate, soil, water and air and all species of plants, animals and microorganisms.

Enzymes - Proteins that increase the rate of specific chemical reactions.

EPA - U.S. Environmental Protection Agency.

EPA establishment number - A number assigned to each pesticide production plant by EPA which must appear on all labels.

EPA Registration number - A number assigned to a pesticide product by EPA when the product is registered by the manufacturer which must appear on all labels for that product.

Epidemic - A temporary widespread outbreak of a disease.

Eradication - Destroying an entire pest population in an area.

Erosion - Movement of soil and associated materials, principally by water and wind.

Exotic - Native to other regions, countries or continents.

Exposure - Coming into contact with a pesticide; getting a pesticide on a surface or in or on an organism.

Eyewash dispenser - Commercially available system for flushing contaminants out of the eyes.

FAA - Federal Aviation Administration.

FDA - Food and Drug Administration.

FEPCA - The Federal Environmental Pesticide Control Act of 1972. This law, including its many amendments replaces and adds to FIFRA. FIFRA remains as the commonly used acronym.

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

Flowable (F or L) - A pesticide formulation in which the active ingredient is impregnated on a diluent such as clay that is then finely ground and suspended in a small amount of liquid; the resulting paste or cream-like formulation is added to water in the spray tank and forms a suspension.

Foaming agent - A material designed to reduce drift, which causes a pesticide mixture to form a thick foam.

Foliage - Primarily the leaves; may include stems of a plant.

Foliar - Applied to the leaves of a plant.

Foliar application - Application of a pesticide to the aerial portions of either a crop or weed.

Food chain - A group of plants, animals and/or microorganisms linked together as sources and consumers of food.

Formulation - Pesticide product as sold, usually a mixture of active and inert ingredients.

Fragmentation - Plant pieces that break off the parent plant and can develop new roots and become re-established.

Fry - Recently hatched fish.

Fumigant - Pesticide that is a vapor or gas or that forms a vapor or gas when applied and whose pesticidal action occurs in the gaseous state.

Fungi - A group of lower parasitic plants lacking chlorophyll.

Fungicide - A chemical used to control fungi.

General use pesticide - A pesticide that is not classified as a restricted use pesticide.

Germination - The process of initiating growth in seeds.

GPA - Gallons per acre.

GPM - Gallons per minute $= \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5940}$

Granules (G) - A dry pesticide formulation made by applying a liquid formulation of the active ingredient to particles of clay or another porous material. Granules are applied in the dry form and have a particle size substantially larger than dusts.

GRAS - Generally Recognized As Safe. Commonly used for risk assessment and to describe tested inert ingredients.

Groundwater - Water beneath the earth's surface in soil or rock.

Growth regulator - A substance used for controlling or modifying plant growth processes without appreciable phytotoxic effect at the dosage applied.

Habitat - The places where a plant or animal lives, feeds and breeds.

Half life - The length of time required for the quantity of a chemical to be reduced by half under a specific set of conditions.

Hazard - The likelihood that an injury will occur as a result of a given level and duration of exposure.

Heat stress - Illness that occurs when the body is subjected to more heat than it can tolerate.

Herbaceous plant - A vascular plant that does not develop persistent woody tissue above ground.

Herbicide - A chemical used to control, suppress or kill plants or to severely interrupt their normal growth process.

Host - A plant or animal on or in which a pest lives or feeds.

Hydraulic - Operated by the pressure created by forcing liquid through a narrow opening.

Hydraulic agitation - Stirring or mixing provided by the high-pressure flow of surplus spray material from the pump.

Hydrolysis - Decomposition of a chemical compound by reaction with water.

Impermeable - Cannot be penetrated.

Incompatibility - When two or more pesticides cannot be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator or harm to the crop or the environment.

Inert ingredients - Inactive components of a pesticide formulation that are used to dilute the pesticide or to make it safer, more effective, easier to measure, mix and apply and more convenient to handle.

Ingredient name - The active ingredients and the amount of each ingredient (as a percentage of the total product) in a pesticide listed by the official chemical name and/or common name for each active ingredient.

Inhalation toxicity - A measure of the capacity of a pesticide to cause injury when absorbed through the lungs.

Inorganic - Of mineral origin; does not contain carbon.

Inorganic pesticides - Pesticides of mineral origin; they do not contain carbon.

Insecticide - A chemical used to control insects.

Insoluble - Does not dissolve in liquid.

Integrated pest management (IPM) - An ecological approach to pest management in which all available techniques are consolidated into a unified program so that pest populations can be managed to avoid economic damage and minimize adverse effects.

IPM - Integrated pest management.

Invert emulsion - An emulsion in which water is dispersed in oil -rather than oil in water; invert emulsions are normally quite thick and thus less susceptible to drift.

Invertebrates - A class of animals that lack spinal cords.

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

Label - The information printed on or attached to the pesticide container or wrapper.

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

Larvicide - A pesticide used to kill insect larvae.

Late postemergence - Applied after the specified crop or weeds are well established.

LC_{50} - The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor. It is generally expressed as micrograms per liter as a dust or mist but in the case of a gas vapor as parts per million (ppm).

LD_{50} - The dose (quantity) of chemical(s) calculated to be lethal to 50 percent of the organisms in a specific test situation. It is expressed in weight of the chemical (mg) per unit of body weight (kg) of the test organism. The toxicant may be fed (oral LD_{50}) or applied to the skin (dermal LD_{50}).

Leaching - The movement of pesticide in water or another liquid downward through soil or other medium.

Lethal - Causing or capable of causing death.

Liability - Legal responsibility.

Life cycles - The series of stages an organism passes through during its lifetime.

Local effects - Effects which occur at the site where the pesticide makes initial, direct contact with body (i.e. skin, eye, nose, mouth, trachea, esophagus, stomach, GI tract, etc.). Local effects may occur immediately or may take longer to appear. These may include such effects as: local (contact site) skin irritation (rash, irritation, ulceration) or local irritation of mucous membranes of eyes, nose, mouth, throat, etc.

Macrophyte - A large or macroscopic plant that is easily seen without the aid of a microscope.

Material Safety Data Sheets (MSDS) - These data sheets contain specific information on toxicity, first aid, personal protection equipment, storage and handling precautions, spill and leak cleanup and disposal practices, transportation, physical data, and reactivity data. MSDS are available from manufacturers.

Mechanical control - Pest control by physically altering the environment.

Mechanical agitation - Stirring or mixing done by rotating paddles or propellers in the sprayer tank.

Metabolite - A compound derived from metabolic transformation of a chemical by plants or other organisms.

Metamorphosis - The series of changes in shape, form or size through which insects and insect-like organisms pass in their growth from immature stages to adult stage.

MDA - Michigan Department of Agriculture.

MDNR - Michigan Department of Natural Resources.

Microbial pesticide - Bacteria, viruses and fungi used to cause disease in some pests.

Microbicide - A chemical able to kill microorganisms. Includes bactericides, algaecides, and fungicides.

Microorganism - An organism that is so small that it cannot be seen without the aid of a microscope.

Mild steel - Steel that contains a very low percentage of carbon; also called "soft steel."

MIOSHA - Michigan Occupational Safety and Health Administration.

Miscible liquids - Two or more liquids that can be mixed and will remain mixed under normal conditions.

Miticide - A chemical used to control mites.

Mitigate - To lessen, decrease or make less severe.

Mode of action - The way in which a pesticide exerts a toxic effect.

Mold - The vegetative phase in the growth of certain fungi displaying long filamentous extensions.

Molluscicide - A chemical used to control snails, slugs and other mollusks.

Mollusks - Group of animals with soft, unsegmented bodies that are usually, but not always, enclosed in shells.

Monitoring - The process of information gathering and collection through observation of a site or target organism.

Mph - Miles per hour. Speed (Mph) $= \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$

MSHA - Mine Safety and Health Administration

Mutagenic - Capable of producing genetic change.

Mutation - A change, usually harmful, in inherited genetic material.

Mycoplasmas - The smallest known living organisms that can reproduce and exist apart form other living organisms. They obtain their food from plants.

Narrow-spectrum pesticide - A pesticide that is effective against only one or a few species; the term is usually applied to insecticides and fungicides.

Natural enemies - The predators and parasites that attack pest species.

Necrosis - Localized death of tissue usually characterized by browning and desiccation.

Necrotic - Showing varying degrees of dead areas or spots.

Nematicide - A chemical used to control nematodes.

Nematodes - Small, slender, colorless roundworms that live saprophytically in soil or water or as parasites of plants, animals or fungi; plant-parasitic nematodes are so small that they cannot be seen except through a microscope.

Neoprene - A synthetic rubber characterized by superior resistance to penetration by pesticides.

Neurotoxic - A pesticide which is harmful to nerve tissue.

NIOSH - National Institute for Occupational Safety and Health.

No observable effect level (NOEL) - The dose of substance which causes no observable effects.

NOAA - National Oceanic and Atmospheric Administration.

Nonpersistent pesticide - A pesticide that breaks down quickly after it is applied.

Nonselective herbicide - A herbicide that is generally toxic to all species of plants. This toxicity may be a function of dosage, method of application, timing of application or other such factor. Some selective herbicides may become nonselective if used at very high rates.

Nonselective pesticide - A pesticide that is toxic to most plants, insects or animals.

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

Nontarget organisms - All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Noxious weed - A weed specified by law as being especially undesirable, troublesome and difficult to control. Definition will vary according to legal interpretations.

Offsite - Outside the area where the pesticide is being released.

Oil solution - A liquid pesticide formulation in which the active ingredient is dissolved either in oil or some other organic solvent.

Oncogen - A substance having the ability to cause tumors; the tumor may or may not be cancerous.

Oncogenic - Capable of producing or inducing tumors in animals, either benign (non-cancerous) or malignant (cancerous).

Oncogenicity - The ability to cause tumors.

Oral toxicity - A measure of the capacity of a pesticide to cause injury when taken by mouth.

Oral - Of the mouth; through or by the mouth.

Organic - Containing carbon.

Organic matter - Materials and debris that originated as living plants or animals.

Organic pesticides - Pesticides that contain carbon. Most are synthetic; some are derived or extracted from plants.

Organophosphate - A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples used primarily as insecticides and act on nervous system.

OSHA - Occupational Safety and Health Administration in the United States Department of Labor.

Ovicide - A chemical that destroys eggs.

Parasite - An organism living on, in or with another living organism for the purpose of obtaining food.

Parts per million, weight (PPMW) - One part of a substance in one million parts of another substance, by weight; for example, approximately 2.72 lb of active ingredient applied to 1 acre-foot of water will give 1 PPMW.

Pathogen - An organism that causes disease in other organisms.

Pelleted formulation - A dry formulation of herbicide and other components in discrete particles, usually larger than 10 cubic millimeters, and designed to be applied without a liquid carrier.

Penetrant - Chemical that helps a pesticide get through a surface and into an object or organism.

Percolation - Downward seepage of water through the soil.

Perennials - Plants that live for more than two years.

Persistence - A measure of how long a pesticide remains in an active form at the site of application or in the environment.

Persistent pesticide - A pesticide that remains active for a period of time after application and gives continued protection against a pest.

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

Pest - An unwanted organism (plant, animal, bacteria, etc.); any organism that competes with people for food, feed or fiber, impacts aesthetic qualities, or impedes industrial or recreational activities.

Pesticide - A substance or mixtures of substances intended to prevent, destroy, repel or control undesirable organisms.

Pesticide concentrate - A pesticide formulation as it is sold before dilution.

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

Pesticide handling - Directly working with pesticides, such as during mixing, loading, transporting, storing, disposing, and applying or working on pesticide equipment.

Pesticide interaction - The action or influence of one pesticide upon another and the combined effect of the pesticide on the pest(s) or crop system.

Pesticide registration - The status given to a product to allow for its sale and use as a pesticide by the Environmental Protection Agency or by the state to meet a special local need.

Petiole - Stalk of a leaf.

Petroleum-based - Made from petroleum products. Examples are: xylene, refined oil and kerosene.

pH - A measure of the acidity or alkalinity of a solution.

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

Phloem - The living tissue in plants that functions primarily to transport metabolic compounds from the site of synthesis or storage to the site of utilization.

Photic zone - Portion of a body of water in which enough light can penetrate to support aquatic plant growth.

Photodecomposition - Degradation of a pesticide by light.

Photosynthesis - The process in green plants of synthesizing carbohydrates from carbon dioxide and water, utilizing light energy captured by chlorophyll.

Physiology - The branch of biology that deals with the functions and activities of living organisms.

Phytotoxicity - Injury to plants due to chemical exposure.

Piscicide - A chemical used to kill or control fish.

Plant disease - Any harmful condition that makes a plant different from a normal plant in its appearance or function.

Plant growth regulator - A substance used for controlling or modifying plant growth processes.

Plant pathology - The science that deals with the nature and causes of plant disease.

Poison - A chemical that is very highly toxic acutely. Legally, a chemical with an oral LD50 of 50 mg/kg or less.

Porous surfaces - Surfaces that have tiny openings which allow liquid to be absorbed or to pass through.

Postemergence - Applied after emergence of the target weed or crop.

PPB - Parts per billion. One ppb equals 1 pound in 500,000 tons.

PPM - Parts per million. One ppm equals 1 pound in 500 tons.

PPT - Parts per trillion. One ppt equals 1 pound in 500,000,000 tons.

Pre-emergence - Applied to the soil prior to emergence of the target weed or crop. Control of weeds before or soon after they emerge.

Precautionary statements - Pesticide labeling statements that alert you to possible hazards from use of the pesticide product and that sometimes indicate specific actions to take to avoid the hazards.

Precipitate - A solid substance that no longer will remain dissolved in water because of some physical or chemical process.

Predator - An organism that attacks, kills and feeds on other organisms.

Prevention - Keeping a pest from becoming a problem.

Private applicators - Persons using or supervising the use of restricted use pesticides to produce an agricultural commodity on their own or their employer's land, or on lands rented by them.

Propagation - Reproduction by either sexual or asexual means.

Propriety name - Same as brand name.

Protectant - A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury.

Protectant pesticide - Pesticide applied to a target site to prevent pest establishment.

Protectant fungicide - Pesticide applied to prevent the development of some plant diseases caused by fungi.

psi - Pounds per square inch.

Rate - The amount of active ingredient or acid equivalent applied per unit area or other treatment unit.

RCRA - The Resource Conservation and Recovery Act – the federal law regulating the transport, storage, treatment and disposal of hazardous wastes.

Ready-to-use pesticide - A pesticide that is applied directly from its original container consistent with label directions, such as an aerosol insecticide or rodent bait box, which does not require mixing or loading prior to application.

Reciprocity - An agreement between states to allow certified applicators in one state to obtain certification credentials in the other state.

Registered pesticide - A pesticide approved by the Environmental Protection Agency for use as stated on the label or by the state to meet a special local need.

Registered technician - A classification of applicators in Michigan who are authorized to apply general use pesticides for a commercial or private purpose as a scheduled and required work assignment.

Registration - The regulatory process designated by FIFRA and conducted by the EPA through which a pesticide is legally approved for use.

Release - When a pesticide leaves its container or the equipment or system that is containing it and enters the environment. Release can be intentional, as in an application, or by accident, as in a spill or leak.

Reregistration - Requirement by recent legislation that older pesticides be reevaluated against current standards. A Special Review Process is used to evaluate specific questions or concerns about a pesticide and decide whether the registration should be adjusted in any way.

Residual pesticide - A pesticide that continues to be effective for an extended period of time after application.

Residue - The part of a pesticide that remains in the environment for a period of time following application or a spill.

Residue tolerance - The maximum amount of a pesticide that may legally remain in or on a raw farm product intended for consumption by people or livestock.

Resistance (pesticide) - The genetically acquired ability of an organism to tolerate the toxic effects of a pesticide.

Respiration - (1) The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms. (2) The act of breathing.

Restricted entry interval - The length of time that must elapse after a pesticide application before people who are not using personal protective equipment can enter the treated site.

Restricted-use pesticide (RUP)- Pesticides designated by the EPA or the State for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, could occur. A "restricted-use" pesticide may be used only by or under the direct supervision of a certified applicator.

Resurgence - A dramatic increase in the population level of a target pest some time after a pesticide application due to the destruction of its natural enemies by the pesticide; pest numbers may soon surpass pretreatment levels.

Risk - A combination of toxicity and exposure and is the possibility of loss or injury from exposure.

Risk/Benefit - A scientific approach in which the risk posed by a certain substance is weighed against the benefit of its use.

Rhizomes - Lateral roots.

Rinsate - Wash water that contains a small amount of pesticide.

Runoff - Pesticide movement across a surface away from the application site in water or another liquid.

Sanitizers - Chemical compounds that reduce microbial contamination.

Saprophyte - An organism that obtains its food from dead or decaying organic matter.

SARA - Superfund Amendments and Reauthorization Act — amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Scientific name - The Latin name for the genus and species of an organism, designated by taxonomists and universally accepted. Scientific names are often used to avoid confusion which can result from the use of common names which may vary from one area to another.

Scouting - Regular monitoring of a crop or site in a prescribed manner to determine the pest population levels and the extent of pest damage.

Selective pesticide - A pesticide that is more toxic to some kinds of plants and animals than to others.

Selectivity - the ability of a chemical to be more toxic to some species than to others; may be a function of dosage or mode of application.

Semipermeable - Some substances can pass through and others cannot.

Senesce - To decline or fade; to age.

Sensitive areas - Sites or organisms that are particularly vulnerable to harmful effects from pesticides.

Signal words and symbols - Standardized designations of relative levels of toxicity which must, by law, appear on pesticide labels. The signal words used are DANGER, or DANGER-POISON with skull and crossbones, or WARNING, or CAUTION.

Site - The crop, animal or area infested by a pest and to which a pesticide is applied.

Slurry - A thick suspension of a finely-divided pesticide in a liquid.

Soft and hard water - A water quality parameter where soft waters exhibit total hardness less than 50 mg calcium carbonate per liter (parts per million); hard waters have total hardness greater than 100 mg calcium carbonate per liter; moderately hard waters are those between 50 and 100 mg calcium carbonate per liter.

Solubility - The ability to dissolve; such as the capacity of a pesticide to dissolve in a specific solvent.

Soluble - Able to be dissolved in another substance, usually a liquid.

Soluble powder (SP) - Dry pesticide formulation that forms a true solution when mixed with water.

Solution - A homogeneous mixture of one or more substances (solutes) in another substance (solvent), which is usually a liquid. The solutes are completely dissolved and will not settle out or separate under normal conditions.

Solvent - A liquid, such as water, kerosene, xylene or alcohol, that will dissolve a pesticide (or other substance) to form a solution.

Special local need (SLN) - An existing or imminent pest problem within the state which cannot be adequately controlled by the use of any available federally registered pesticide product. The EPA can approve temporary use of a pesticide to alleviate the need.

Species - The basic unit of taxonomic classification, designating a group of closely related individuals that are capable of interbreeding.

Spot treatment - Application of pesticides applied to restricted area(s) of a whole unit; e.g., treatment of spots or patches of weeds within a larger field or water body.

Spray drift - Movement of airborne spray from the intended area of application.

Spreader - A chemical that increases the area that a given volume of liquid will cover on a solid or on another liquid.

State Management Plan - A written plan that establishes guidelines for activities that will protect groundwater from pesticide contamination. Required by the EPA so that states may register pesticides that pose a threat to groundwater quality.

Statement of practical treatment (first aid) - Instructions on how to respond to an emergency exposure involving a pesticide product.

Sterilant - A pesticide that renders a pest incapable of reproduction.

Sterility - The inability of a living organism to reproduce.

Sticker - An adjuvant that increases the ability of a pesticide to stick to treated plant surfaces.

Stomach poison - A pesticide that kills when it is eaten and swallowed by a pest.

Stomata - Minute openings on the surfaces of leaves and stems through which gases (oxygen, carbon dioxide, water vapor) and some dissolved materials pass into and out of plants.

Sublethal - Pertaining to a dose level that is less than an amount necessary to cause death.

Substrate - The surface on which an organism lives.

Supervise - The act or process of a certified applicator in directing the application of a pesticide by competent person under his or her instruction and control and for whose actions the certified applicator is responsible, even though the certified applicator is not physically present at the time and the place the pesticide applied.

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

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

Surfactant - A material that improves the emulsifying, dispersing, spreading, wetting or other surface modifying properties of liquids.

Susceptibility - The sensitivity to or degree to which an organism is injured by a pesticide treatment. (See tolerance.)

Susceptible - Capable of being diseased or poisoned; not immune.

Suspended registration - An emergency suspension of a pesticide registration stops all manufacture, distribution, sale and use of the pesticide until all court proceedings are concluded.

Suspension - A substance that consists of undissolved particles mixed throughout a liquid.

Swath width - Side-to-side measurement of the band or strip of pesticide released by the application equipment.

Symptom - (1) Any detectable change in an organism resulting from the activities of a pathogen or other pest. (2) An indication of pesticide poisoning.

Synergism - The combined activity of two or more pesticides that is greater than the sum of their activity when used alone.

Synthetic - Man-made; manufactured.

Systemic effects - Effects which occur at sites other than the point of entry into the body following absorption and distribution through the circulatory system, possible chemical reaction within the body or contact with critical targets sites, or organs.

Systemic pesticide - A pesticide that is taken into the blood of an animal or sap of a plant.

Tank mix - A mixture in the spray tank of two or more pesticide products for simultaneous application.

Tank-mix combination - Mixing two or more pesticides or agricultural chemicals in the spray tank at the time of application.

Target - The site or pest toward which control measures are being directed.

Target pest - The pest toward which management measures are being directed.

Taxonomy - The classification of living organisms into groups based on similarities and relationships.

Teratogen - Any substance which can cause the development of malformations such as in birth defects.

Terrestrial - Living or growing on land; not aquatic.

Thickeners - Drift control agents such as cellulose, gels, and swellable polymers which cause the formation of a greater proportion of large spray droplets.

Tip-and-pour - Built-in measuring device that fills with a given amount of pesticide when the container is tilted.

Tolerance - (1) Capacity to withstand pesticide treatment without marked deviation from normal growth or function. (See susceptibility.) (2) The concentration of pesticide residue that will be legally allowed in or on agricultural products.

Toxicity - Measure of a pesticide's ability to cause acute, delayed, or allergic effects.

Toxicology - The study of the principles or mechanism of toxicity.

Toxin - A poisonous substance produced by a living organism.

Trade name - A trademark applied to a pesticide formulation by its manufacturer.

Translocated herbicide - A pesticide that kills plants by being absorbed by leaves, stems or roots and moved throughout the plant. Translocated herbicides may be either phloem mobile or xylem mobile, but the term is frequently used in a more restrictive sense to refer to herbicides that are applied to the foliage and move downward through the phloem to underground plant parts.

Translocation - The internal movement of food, water, minerals or other materials (e.g. pesticides) from one part of a plant to another.

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

USDA - United States Department of Agriculture.

Vapor drift - The movement of chemical vapors from the area of application. Note: Vapor injury and injury from spray drift are often difficult to distinguish.

Vapor pressure - The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vascular plant - A plant (macrophyte) with specialized conductive tissue.

Vascular system - The conducting tissue of plants, composed principally of xylem and phloem.

Vector - Means through which a disease causing organism is transmitted from one place to another.

Vegetative reproduction - Production of new plants from vegetative plant parts such as rootstocks, rhizomes, stolons, tubers, cuttings, etc., rather than from seed.

Vertebrate - An animal with a jointed backbone.

Virus - An obligate parasite often consisting only of a piece of genetic material surrounded by a protein coat.

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

Volatility - The degree to which a liquid or solid changes into a gas (vapor) at ordinary temperatures when exposed to air.

Warning - Signal word associated with pesticide products considered moderately toxic.

Water-based pesticides - Pesticides that use water as the only diluent or carrier.

Water-dispersible granules - A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water-soluble concentrate (WS) - A liquid pesticide formulation in which the active ingredient is soluble in water and is formulated either with water or another solvent such as alcohol which mixes readily with water.

Watershed - The area of land draining into a body of water.

Weed - A plant growing where it is not desired; any plant that is objectionable or interferes with the activities or welfare of humans.

Wettable powder (WP or W) - A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

Wetting agent - (1) Substance that serves to reduce interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces (See surfactant). (2) A substance in a wettable powder formulation that causes it to wet readily when added to water.

WPS - Worker Protection Standard for agricultural pesticides.

Xylem - The tissue in higher plants which transports water, dissolved salts, and other materials (e.g. pesticides) from the roots to aerial portions of the plant.

Answers to Review Questions

Part A
Chapter 1: Principles of Pest Management

1. c
2. Identifying the pest allows you to determine basic information about it, including its life cycle and the time that it is most susceptible to being controlled.
3. b
4. b
5. Use of threshold information can improve your pest control strategy by helping you make a decision about when to begin management strategies.
6. c
7. Monitoring is important to many pest control strate gies because it helps determine if the threshold has been reached and whether control measures have been effective.
8. Integrated pest management utilizes all appropriate economical strategies to manage pests and their damage to acceptable levels with the least disruption to the environment.
9. Pest management tactics may include: host resis tance, biological control, cultural control, mechanical control, sanitation and chemical (pesticide) control.
10. The failure of the pesticide to control the pest might have been caused by :
    1. Pest resistance.
    2. Choosing the wrong pesticide.
    3. Misidentifying the pest.
    4. Applying the wrong amount.
    5. Applying the pesticide incorrectly, including applying at the wrong time.
    6. Weather problems: too dry, wet, hot or cold.
11. Pest resistance can be reduced by using integrated pest management and rotating the types of pesticides used.

Part A
Chapter 2: Laws and Regulations

1. b
2. d
3. d
4. True
5. d
6. MDEQ SARA Title III office, (517) 373-8481. Also, partial lists are printed in Extension bulletin E-2575.
7. d
8. If the injury involves any of the following: medical treatment, loss of consciousness, restriction of work or motion, transfer to another job.
9. True
10. d
11. True
12. B
13. MDA
14. Private applicators, commercial applicators and registered technicians.
15. b
16. True
17. False
18. c and d
19. a
20. True
21. MDA investigates pesticide misuse and EPA investigates pesticide failures.
22. MDNR
23. True
24. MIOSHA
25. b
26. d
27. e
28. a
29. f
30. c

Part A
Chapter 3: Pesticides

1. e
2. 1) Type of pest managed: algaecides control algae; insecticides control insects; rodenticides control rodents, etc.

   2) Chemistry: inorganic or organic, botanical, micro-bial, organophosphate, carbamate, etc.

3) Mode of action: sterilant, stomach poison, root inhibitor, etc.

4) Formulation: emulsifiable concentrate, fumigant, ready-to-use aerosol, dust, etc.

3. Insects; weeds; slugs and snails.
4. False: sterilants render pests incapable of reproduction.
5. e
6. Contact pesticides kill pests simply by contacting them. Systemic pesticides are absorbed by the host and move in the sap or blood and can kill the pest without harming the host.
7. a
8. True
9. c
10. False
11. d
12. True
13. Think about the characteristics of each formulation and consider which of the formulation's advantages and disadvantages are important in your application situation. Also, consider if you have the right application equipment, if the formulation can be applied safely, and if the formulation can reach the target pest and remain active long enough for effective control.
14. c
15. Finely ground active ingredients mixed with a liquid, along with inert ingredients, to form a suspension.
16. The wettable powder would be the better choice in the first situation, because EC's are corrosive and may cause pitting, discoloration or other damage to treated surfaces. Wettable powders are difficult to mix in very hard or very alkaline water, so the EC formulation would be the better choice in the second situation.
17. To increase its effectiveness or safety.
18. Foaming agents and thickeners help to reduce drift. Spreaders help to coat the treated surface with an even layer of pesticide. Compatibility agents aid in combining pesticides effectively.

Part A
Chapter 4: Pesticide Labeling and Registration

1. The label is the information printed on or attached to the pesticide container. Labeling includes the label itself, plus all other information you receive from the manufacturer about the product when you buy it.
2. If a pesticide is classified as restricted use, the words "Restricted Use Pesticide" will appear on the front panel of the pesticide label.
3. D,A,B,C
4. Signal words and symbols indicate the likelihood that you will experience acute harmful effects if you are overexposed. Signal words do not tell you any thing about the risks of delayed harmful effects or allergic effects.
5. You should look for precautions about hazards to humans (and domestic animals), environmental hazards and physical/chemical hazards.
6. e, c, b, a, d
7. False
8. d
9. b
10. d
11. False. This statement is required on every pesticide label.
12. a
13. cholinesterase
14. c
15. e
16. e
17. False. This product label requires the entrances to treated areas to also be posted.
18. True

Part A
Chapter 5: Pesticides in the Environment

1. Environment is everything that surrounds us – indoors and outdoors – including natural elements, man-made objects, people and other living organisms.
2. e
3. Ways to avoid point-source pollution include, for example:
   a. Proper management of wash water and spills produced at equipment cleanup sites.
   b. Proper disposal of containers, water used to rinse containers and excess pesticides.
   c. Correctly cleaning up leaks and spills at pesticide storage sites.
   d. Preventing pesticide spills while mixing concentrates or loading pesticides into application equipment.
4. a. Whether there are sensitive areas in the environment at the pesticide use site that might be harmed by contact with the pesticide.

b. Whether there are sensitive off site areas near the use site that might be harmed by contact with the pesticide.

c. Whether there are conditions in the immediate environment that might cause the pesticide to move off site.

d. Whether you can change any factors in your application or in the pesticide use site to reduce the risk of environmental contamination.

5. e
6. a
7. c
8. a
9. a
10. c
11. a
12. b
13. c
14. a
15. d
16. b
17. Refer to pages 61-62.
18. a. Pesticides may be carried off site if they stick to such things as shoes or clothing, animal fur or blowing dust – anything that moves from the use site to another location.

    b. Pesticide residues may remain on treated sur faces, such as food or feed products, when they are taken from the use site to be sold or used.
19. Nontarget plants and animals may be harmed by the pesticide residues that stay in the environment for a period of time after the release. These can be residues that remain in soil or on surfaces, or they may be residues that build up in the bodies of animals, harming those animals themselves and sometimes other animals that feed on them.
20. a

Part A
Chapter 6: Pesticides and Human Health

1. Toxicity measures the capacity of a pesticides to cause injury. Hazard is the potential for injury.
2. True
3. False
4. Oral, dermal, eye and inhalation.
5. d
6. d
7. Chronic, acute.
8. c
9. False
10. b
11. b, c, e
12. e
13. e
14. Organophosphates: Chlorpyrifos, Diazinon, Malathion

    Carbamates: Aldicarb, Carbaryl, Propoxur. Other examples can be found on page 72.
15. e
16. pesticide label
17. 1-800-764-7661, 1-800-POISON 1
18. See page 70.
19. d
20. See page 70.
21. toxicity, exposure.
22. True
23. e
24. Drink lightly salted water or sports drinks.

Part A
Chapter 7: Personal Protective Equipment

1. Have I read the labeling?

    How can I avoid exposure to pesticides?

    What PPE is required?

    Is the application equipment ready and safe?
2. Long-sleeved shirt, long pants, protective footwear, and gloves.
3. Exposure.
4. Choose pesticides with lower toxicity, and wear the appropriate PPE.
5. False
6. Pesticide label, pesticide producers, PPE manufacturers, MSDS and EPA Chemical Resistance Category Chart (can be found in Appendix B).
7. e
8. False
9. e
10. True

Part A
Chapter 8: Safe Pesticide Handling

1. e
2. e

3. Triple-rinse, power-rinse.
4. e
5. Apply them to a labeled site.
6. e
7. e
8. e
9. True
10. The containment pad must be made of an impermeable material, such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners or no-wax sheet flooring (other materials are acceptable, according to the MDA). The pad should be concave or should have curbs, berms or walls high enough to hold the largest amount of spill, leak or equipment wash water likely to be created at the site. It also must be equipped with a system for removing and recovering spilled, leaked or released material — either an automatic sump system or a manually operated pump.
11. Separate facility; containment for overall storage area; containment of individual containers; located a safe distance from water resources; fire resistant construction; materials; chemical fire extinguisher near door; well ventilated; temperature controlled; adequate lighting; metal shelving with containment; pesticides kept in original containers; legible pesticide labels on all containers; secured; posted as pesticides storage area; waste-handling system in place; spill clean-up kit readily available; decontamination kit/equipment; supply of clean water; first aid kit; emergency plan with emergency contact numbers.
12. e
13. Control; contain; clean-up
14. MDEQ PEAS hotline (800-292-4706) for all uncon-tained spills; National Response Center (800-424-8802) if reportable quantity; clean-up spill or contact private spill response company for assistance; Chemtrec hotline (800-424-9300) for additional assistance; MDEQ Waste Management Division (517-373-2730) for additional assistance; MDA (800-405-0101) Agriculture Pollution Emergency hotline for additional assistance.

Part B
Chapter 1: Laws and Regulations

1. a
2. False
3. e
4. True
5. c
6. a
7. WPS, Right-to-Farm and the federal recordkeeping requirements under the 1990 Farm Bill.
8. 14 days; 2 years
9. e
10. True

Part B
Chapter 2: Pests and Pest Management

1. You cannot make a good decision about how to manage a pest problem until you are sure what the pest is. Pests differ in their life cycles, habitats, behavior and susceptibility to various control methods.
2. d
3. 1. Is the pest causing any harm?
   2. Would the cost of control be more than the economic loss from the damage the pest is causing?
4. e
5. A persistent pesticide remains active for a period of time after application, giving continued protection against the pest.
   A non-persistent pesticide breaks down quickly after it is applied.
6. d
7. Four types of insect mouthparts are:
   1. Chewing (cockroaches, ants, beetles, caterpillars and grasshoppers).
   2. Piercing-sucking (stable flies, sucking lice, bed bugs, mosquitoes, true bugs and aphids).
   3. Sponging (flesh flies, blow flies and house flies).
   4. Siphoning (butterflies and moths).

   [The examples listed here are those cited in this chapter; you may know of others.]
8. b
9. The four stages of complete metamorphosis are egg, larva, pupa and adult.
10. e
11. a
12. A plant disease is any harmful condition that makes a plant different from a normal plant in its appearance or function.
13. f
14. c
15. 1. Overdevelopment of tissue.
    2. Underdevelopment of tissue.
    3. Death of tissue.

16. The parasites that cause plant diseases may be spread by wind; rain; insects, birds, snails, slugs and earthworms; transplant soil; nursery grafts; vegetative propagation (especially in strawberries, potatoes, and many flowers and ornamentals); contaminated equipment and tools; infected seed stock; pollen; dust storms; irrigation water; and people.
17. Symptoms — such as leaf spots, wilts, galls or stunted growth — are the host plant's reaction to the disease agent.

    Signs — such as fungal spores or bacterial ooze — are the visible presence of the disease agent on the plant.
18. 1 – B
    2 – C
    3 – A
19. Weeds have four developmental stages: seedling, vegetative, seed production and maturity.
20. 1 – D
    2 – C
    3 – A
    4 – B
21. Depending on the type, weeds may reproduce by seeds, tubers, bulbs, bulblets, rhizomes, stolons or from root pieces left by cultivation.
22. c
23. d
24. Selective herbicides kill some plants without harming others. They can be used to kill weeds without harming the desirable plants nearby.

    Nonselective herbicides kill all plants in the area where they are applied.
25. b
26. a
27. b
28. It may be necessary to get approval for:
    - Shooting or trapping some animals, such as birds, deer, muskrats and beavers.
    - Using pesticides to control vertebrate pests other than rodents (such as fish, birds and predators).

Part B
Chapter 3: Calculating Dilutions and Site Size

(In most cases, answers have been rounded to the nearest tenth.)

1. $\frac{\text{Gallons in tank (300) x lbs. per 100 gallons (3)}}{\text{100 gallons}}$ = Pounds needed in tank

   (300 x 3) ÷ 100 = 9 pounds needed in tank

2. $\frac{\text{Gallons in tank (50) x pounds per 100 gallons (3)}}{\text{100 gallons}}$ = Amt. needed in tank

   (50 x 3) ÷ 100 = 1.5 pounds needed in tank

   1.5 pounds x 16 ounces per pound = 24.0 ounces needed in tank

3. $\frac{\text{Gallons in tank (500)}}{\text{Gallons per acre (12)}}$ = Acres sprayed per tankful

   500 ÷ 12 = 41.7 acres sprayed per tankful

   Acres sprayed per tankful (41.7) x pounds formulation per acre (2.5) = Pounds needed in tank

   41.7 x 2.5 = 104.3 pounds needed in tank

4. Gallons per acre (18) x acres to be treated (5) = Gallons needed in tank

   18 x 5 = 90 gallons of water needed in the tank

   Acres to be treated (5) x pounds formulation per acre (2) = Pounds formulation needed in tank

   5 x 2 = 10 pounds formulation needed in tank

5. $\frac{\text{Amount in tank (5 gallons = 20 quarts) x rate per 1,000 square feet (3 oz.)}}{\text{Amount equipment applies per 1,000 square feet (1.5 quarts) in tank}}$ = Amount formulation needed

   20 quarts x 3 ounces ÷ 1.5 quarts = 40 oz

   40 oz. ÷ 16 oz. per pound = 2.5 pounds needed in tank

6. $\frac{\text{Pounds of a.i. per acre (3) x 100}}{\text{Percent a.i. in formulation (60\%)}}$ = Pounds formulation per acre

(3 x 100) ÷ 60 = 5 pounds of formulation per acre

7. $\frac{\text{Gallons in tank (5) x percent a.i. needed (1.5) x weight of water per gal (8.3)}}{\text{Percent a.i. in formulation (80) tank}}$ = Pounds form. needed in tank

(5 x 1.5 x 8.3) ÷ 80 = 0.78 lbs. of formulation needed in tank
0.78 pounds x 16 ounces per pound = 12.5 ounces of formulation needed in tank

8. $\frac{\text{Gallons in tank (25) x pints per 100 gal. (1.5)}}{\text{100 gallons}}$ = Pints formulation needed in tank

(25 x 1.5) ÷ 100 = 0.38 pints of formulation needed in tank
0.38 pints x 16 ounces per pint = 6.1 ounces of formulation needed in tank

9. $\frac{\text{Amount in tank (3 gallons = 12 quarts) x rate per 1,000 square feet (6 Tbsp)}}{\text{Amount equipment applies per 1,000 square feet (1.5 quarts)}}$ = Amount needed in tank

(12 x 6) ÷ 1.5 = 48 Tbsp

48 Tbsp ÷ 64 Tbsp per quart = 0.75 quarts (1.5 pints) needed in the tank

10. $\frac{\text{Pounds a.i. to apply per acre (2)}}{\text{Pounds a.i. per gallon (6)}}$ = Amount per acre

2 ÷ 6 = .33 gallon per acre or (⅓)

$\frac{\text{Gallons in tank (300)}}{\text{Gallons per acre (30)}}$ = Acres per tankful

300 ÷ 30 = 10 acres per tankful
Acres per tankful (10) x gallons per acre (1/3 or 0.33) = Gallons to add to tank
10 x 0.33 = 3.3 gallons to add to tank

11. $\frac{\text{Gallons in tank (200) x \% a.i. wanted (2\%) x weight of water (8.3)}}{\text{Pounds a.i. per gallon of formulation (4) x 100}}$ = Gallons of formulation to add to tank

(200 x 2 x 8.3) ÷ 4 X 100 = 8.3 gals. of formulation to add to tank

12. $\frac{\text{Gal. per tank (500) x lbs. per 100 gallons recommended (3)}}{\text{100 gallons}}$ = Lbs. needed in tank for hydraulic sprayer

(500 x 3) ÷ 100 = 15
Lbs. form. per tank for hydraulic sprayer (15) x concentration wanted (3x) = Lbs. of form. to add to airblast tank
15 pounds x 3 = 45 pounds of formulation to add to tank

13. **Rectangle**: Multiply the length (L) by the width (W).
Area = L x W

Circle: Radius (one-half the diameter) times the radius times 3.14.
Area = radius x radius X 3.14

Triangle: Multiply the width at the base (W) by the height (H), and divide by 2.

$$\text{Area} = \frac{W \times H}{2}$$

14. There are three ways:
    1. Reduce the site to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.
    2. Establish a line down the middle of the site for the length, and then measure from side to side at several points along this line. Use the average of the side measurements as the width. Then calculate the area as a rectangle.
    3. Convert the site into a circle. From a center point, measure distance to the edge of the area in 10 or more

increments. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

15. Multiply the height by the area of the circle at the base.

    Volume = height x radius x radius x 3.14

16. Figure the area of the half circle as above, and figure the area of the rectangle ($W \times H_2$). Add these two areas together and multiply by the length of the structure to get the volume.

$$\frac{[H_1 \times H_1 \times 3.14]}{2} + [H_2 \times W] \times L = \text{Volume}$$

Example: $H_1 = 8$ feet
$H_2 = 8$ feet
$W = 16$ feet
$L = 40$ feet

$$\frac{[8 \text{ ft.} \times 8 \text{ ft.} \times 3.14] + [8 \text{ feet} \times 16 \text{ feet}] \times 40 \text{ ft.}}{2} = 9{,}139.2 \text{ cubic feet}$$

17. Triangle-over-rectangle ends: Figure the area of the rectangle $(W \times H_1)/2$, and figure the area of the triangle ($W \times H_2$).

    Add these two areas together and multiply by the length of the structure to find the volume.

$$\frac{[W \times H_1]}{2} + [W \times H_2] \times L = \text{Volume}$$

Example: $H_1 = 8$ feet
$H_2 = 8$ feet
$W = 20$ feet
$L = 40$ feet

$$\frac{[20 \text{ ft.} \times 8 \text{ ft.}]}{2} + [20 \text{ ft.} \times 8 \text{ ft.}] \times 40 \text{ ft.} = 9{,}600 \text{ cubic feet}$$

Part B
Chapter 4: Application Equipment

1. 1 – C
   2 – D
   3 – A
   4 – B

2. 1 – B
   2 – G
   3 – D
   4 – C
   5 – F
   6 – A
   7 – E

3. 1 – E
   2 – C
   3 – A
   4 – B
   5 – D

4. Strainers remove dirt and other foreign materials from the tank mixture, protect the working parts of the sprayer system from wear and prevent nozzle clogging.

5. e

6. b

7. a

8. d

9. b

10. 1 – C
    2 – A
    3 – B

11. The three main types of agitation are:

    _ Bypass agitation.

    _ Hydraulic (jet action) agitation.

    _ Mechanical agitation (best method for keeping wettable powders in suspension).

12. A – body
    B – strainer (screen)
    C – tip
    D – cap
13. First, shut off the sprayer and move it out of the pesticide-treated area. Wear personal protective equipment to keep the pesticide from getting on your skin. Clean the clogged nozzle with a non-metal nozzle-cleaning tool.
14. Because pesticide dusts drift away from the target easily.
15. b
16. b, c and d
17. 1 – B
    2 – D
    3 – E
    4 – C
    5 – A
    6 – F

Part B
Chapter 5: Calibration

1. Calibration is the process of measuring and adjusting the amount of pesticide that a piece of equipment will apply to a given area.
2. Put a container under each nozzle or hopper to collect the output (1) while the equipment runs for 1 minute or (2) while the equipment operates over a measured area. Then check to see if all the containers contain the same amount (within 5 percent).
3. e
4. b
5. gpm = 0.34
6. d
7. c
8. 1. Size of the adjustable opening.
   2. Equipment speed.
   3. Roughness of the surface of the application site.
   4. Size, weight, shape and texture of the granules in the formulation.
   5. Temperature and humidity.

---

9. $$\frac{\text{Band width (12 in.) x 13 pounds per acre (broadcast)}}{\text{Row spacing (30")}} = 5.2 \text{ pounds per acre (band) applied}$$

10. $$\frac{\text{Pounds used in test run (2.1)}}{\text{Number of rows in swath (6)}} = \text{Pounds used per row in test run (0.35)}$$

    $$\frac{\text{Pounds used per row (in test run) 0.35 x 1,000 ft.}}{\text{Distance traveled in test run (3,000)}} = \text{Pounds per 1,000 linear feet (.12 or almost 2 oz.)}$$

APPENDIX A
Convenient Conversion Factors

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

APPENDIX B

EPA CHEMICAL RESISTANCE CATEGORY CHART

For use when PPE section on pesticide label lists a chemical resistance category

The Worker Protection Standard requires that labels of pesticides used on farms, and in forests, nurseries and greenhouses list the type of personal protective equipment (PPE) that must be worn with each product. Labels will refer to chemical resistance categories (A-H) for PPE. Items in these categories are made of materials that the pesticide cannot pass through during the times indicated below the chart. Choose the category of resistance which best matches the handling task duration. The categories are based on the solvents used in the pesticides, NOT the pesticides themselves. Therefore, there will be instances where the same pesticide with two different formulations (WP and EC, for example) will require PPE from two different chemical resistance categories.

CATEGORY LISTED ON PESTICIDE LABEL	TYPE OF PERSONAL PROTECTIVE MATERIAL							
	Barrier Laminate	Butyl Rubber ≥ 14 mils	Nitrile Rubber ≥ 14 mils	Neoprene Rubber ≥ 14 mils	Natural Rubber* ≥ 14 mils	Polyethylene	Polyvinyl Chloride (PVC) ≥ 14 mils	Viton ≥ 14 mils
A (dry and water-based formulations)	high	high	high	high	high	high	high	high
B	high	high	slight	slight	none	slight	slight	slight
C	high	high	high	high	moderate	moderate	high	high
D	high	high	moderate	moderate	none	none	none	slight
E	high	slight	high	high	slight	none	moderate	high
F	high	high	high	moderate	slight	none	slight	high
G	high	slight	slight	slight	none	none	none	high
H	high	slight	slight	slight	none	none	none	high

* includes natural rubber blends and laminates

HIGH: Highly chemical-resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticides at rest breaks.

MODERATE: Moderately chemical-resistant. Clean or replace PPE within an hour or two of contact.

SLIGHT: Slightly chemical-resistant. Clean or replace PPE within ten minutes of contact.

NONE: No chemical-resistance. Do not wear this type of material as PPE when contact is possible.

MICHIGAN STATE UNIVERSITY EXTENSION

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APPENDIX C
Restricted-use Pesticide Recordkeeping Form

Farm or business name and address _____

Treated Area	Pesticide Information	Applicator Information
Date mo/day/yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo/day/yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo/day/yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Treated Area	Pesticide Information	Applicator Information
Date mo/day/yr	Trade name	Name
Crop		
Location	EPA reg. number	Certification number
Size (acres)	Total amt. applied*	
Notes:		

* The total quantity of the pesticide applied, such as pounds, pints, quarts, gallons, etc., of concentrated pesticide. Amount does NOT refer to the percent of active ingredient (a.i.).

Federal law requires that the above record information must be recorded no later than 14 days following the pesticide application and must be maintained for 2 years following the application.

FOR MORE INFORMATION, CALL THE USDA PESTICIDE RECORDS BRANCH
(703-330-7826)
http://www.ams.usda.gov/science/sdpr.htm

APPENDIX D

Compatibility Test for Pesticide Tank Mixes

Applying a tank mix of pesticides, or pesticide and a liquid fertilizer as a tank mix can save time, labor, energy and equipment costs. Pesticide labels MUST be read to determine if the products can be mixed together or with fertilizers and the order in which they should be mixed. A pesticide can be tank mixed if the label does not prohibit its application with the other products or fertilizer and as long as all other label provisions are followed – however, the applicator assumes all responsibility for the application.

Tank Mixing Problems

Problems with tank mixing are caused by the failure of the products to remain uniformly dispersed – *incompatibility*. This incompatibility can be caused by improper mixing, inadequate agitation, or a lack of stable emulsifiers in some emulsifiable concentrates (EC). Some labels specify that it is necessary to check for mixture stability. In many cases a compatibility agent (adjuvant) is needed to make a uniform dispersion of the two types of chemicals and to prevent them from separating out in the spray tank. Some pesticides will not mix with liquid fertilizer even when a compatibility agent is added.

A jar test method can determine if a pesticide will be compatible with liquid fertilizer. The following methods were developed for testing the adjuvant (compatibility agent) Unite, but should work for any compatibility agent with 75 percent or more active ingredients. Method I is applicable for most situations, while method II is suggested where compatibility problems arise because of application of two or more different pesticides with a single source of liquid fertilizer. Method II is also recommended for mixtures involving high phosphate grade fertilizer (6-18-6, 9-18-9, 7-23-5, 10-34-0) and flowable pesticide formulations. Wettable powders should be premixed or slurried in water or fertilizer before adding to the fertilizer tank.

Pesticide Mixing Sequence

If more than one pesticide is going to be added to a tank mix they must be added in the proper sequence. Always add WP formulations first; L or F formulations second; water-dispersable granules (WDG) or dry flowables (DF) third; and solutions (S), surfactants, and EC formulations last. Each product must be well mixed before the next is added. Before adding EC's to liquid fertilizers, premix them with water to form a slurry.

Procedure to Determine Pesticide and Fertilizer Compatibility

Method I

1. Add 1 pint of liquid fertilizer to each of two glass quart jars.
2. Add ¼ teaspoon of the adjuvant to one jar.
3. Add the required amount of pesticide (see tables 1 and 2) to each jar and replace the lid tightly. If more than one pesticide is to be used, follow the mixing sequence described above.
4. Invert the jars several times to mix the chemicals. Allow them to stand undisturbed for a minimum of 30 minutes, preferably 60 minutes.
5. Observe and compare the jars for the formation of large flakes, sludge, clumps, layering, gels, or other precipitates. Observe if the pesticide or pesticides cannot be physically mixed with the liquid fertilizer but remains as oily globules or as a layer on the top or as flakes in the solution or on the bottom of the jar. An emulsifiable concentrate normally will go to the top either as an oily layer or a creamy layer; wettable powder and flowable formulations will either settle to the bottom of the jar, float in the fertilizer column at varying concentrations, or go to the top of the fertilizer solution as a sludge or gel layer depending upon the density of the fertilizer and the pesticide formulation.

   If the jar without the compatibility agent remains dispersed, then no adjuvant is needed. If neither jar is sufficiently compatible, repeat the test using ⅜ teaspoon of adjuvant. If compatibility is not sufficient, then use Method II.

Method II

1. Fill a quart jar with 1 pint of liquid fertilizer.
2. Prepare a premix of adjuvant and herbicide. Add immediately to the liquid fertilizer, secure the lid and mix the contents by inverting the jar several times.

   If the chemicals do not sufficiently mix, repeat this method using ⅜ teaspoon of adjuvant. If compatibility is still not achieved assume the compounds are not compatible and do not use them as a tank mix.

Table 1. Guidelines for liquid pesticide rates for compatibility test.

Gallons of liquid fertilizer applied/A	Teaspoons of liquid pesticide per pint of liquid fertilizer		
	(1 qt/A)	(2 qt/A)	(4 qt/A)
10	2.4	4.8	9.6
20	1.2	2.4	4.8
40	0.6	1.2	2.4
80	0.3	0.6	1.2
100	0.2	0.5	1.0

1 teaspoon = 4.93 ml

Table 2. Guidelines for wettable powder pesticide rates for compatibility test.

Gallons of liquid fertilizer applied/A of liquid fertilizer	Teaspoons of wettable powder per pint of liquid fertilizer		
	(1 lb/A)	(2 lb/A)	(4 lb/A)
10	3.5	7.1	14.2
20	1.8	3.5	7.1
40	0.9	1.8	3.5
80	0.6	1.2	2.4
60	0.4	0.9	1.8
100	0.3	0.7	1.4

Table 3. Guidelines for compatibility agent (adjuvant) rates.

Pints of adjuvant per 100 gallons	Teaspoons per pint liquid fertilizer
1	⅛
2	¼
3	⅜
4	½

1 teaspoon = 4.93 ml

To minimize compatibility problems with tank mixes, follow correct mixing procedures. The usual method for tank mixing pesticides is to fill the tank at least one-half to two-thirds full with carrier before adding any pesticide or adjuvant. If a compatibility agent is necessary, always add it before adding the pesticides. The order of adding various formulations is very important and should be as follows: WP formulations first; L or F formulations second; water-dispersable granules (WDG) or dry flowables (DF) third; and solutions (S), surfactants, and EC formulations last. Each product must be well mixed before the next is added. Before adding EC's to liquid fertilizers, premix them with water to form a slurry.

To assure a uniform spray mixture at all times, keep the mixture agitated during application and do not allow it to stand overnight without agitation. If possible, apply all of a tank mixture in one day.

References:

Garber, Lester, H. *Mixing Agricultural Chemicals.* Crop Chronicle, 1984.

Jordan, T.M., *Compatibility Test for Herbicides and Liquid Fertilizer.* Weed Science, Purdue University Extension Service, Department of Botany and Plant Pathology, West Lafayette, Indiana 47907.

Devisetty, B. N., et al. *Compatibility Agents for Liquid Fertilizer-Pesticide Combinations.* Special Technical Publication, 764. American Society for Testing and Materials, Philadelphia, PA, 1982.

APPENDIX E

Michigan State University Extension Offices

COUNTY EXTENSION OFFICES

Alcona County
320 S. State,
Harrisville 48740-0800
989-724-6478

Alger County
101 Court Street,
Munising 49862-1103
906-387-2530

Allegan County
County Building Annex,
Allegan 49010-1349
616-673-0370

Alpena County
603 South 11th Avenue,
Alpena 49707-2645
989-354-3636

Antrim County
County Building,
Bellaire 49615-0427
231-533-8818

Arenac County
County Building,
Standish 48658-0745
989-846-4111

Baraga County
Courthouse Annex,
L'Anse 49946-1002
906-524-6300

Barry County,
220 West Court Street,
Hastings 49058-1824
616-945-1388

Bay County
515 Center Avenue,
Bay City 48708-5994
989-895-4026

Benzie County
Government Center,
Beulah 49617-0349
231-882-0025

Berrien County
1737 Hillandale Road,
Benton Harbor 49022-9230
616-944-4126

Branch County
Courthouse Annex,
Coldwater 49036-1990
517-279-4311

Calhoun County
County Building,
Marshall 49068-1518
616-781-0784

Cass County
201 East State Street,
Cassopolis 49031-1352
616-445-8661

Charlevoix County
319B North Lake Street,
Boyne City 49712-1101
231-582-6232

Cheboygan County
County Building,
Cheboygan 49721-0070
231-627-8815

Chippewa County
300 Court Street,
Sault Ste. Marie 49783-2139
906-635-6368

Clare County
County Building,
Harrison 48625-0439
989-539-7805

Clinton County
County Courthouse,
St. Johns 48879-2347
989-224-5240

Crawford County
County Building,
Grayling 49738-1743
989-344-3264

Delta County
2840 College Avenue,
Escanaba 49829-9591
906-786-3032

Dickinson County
Community Services Center,
Iron Mountain 49801-2765
906-774-0363

Eaton County
Suite One,
Charlotte 48813-1047
517-543-2310

Emmet County
3434 Harbor-Petoskey Road,
Harbor Springs 49740-9587
231-348-1770

Genesee County
County Building #2,
Flint 48504-2376
810-244-8500

Gladwin County
County Library Building,
Gladwin 48624-2025
989-426-7741

Gogebic County
104 South Lowell,
Ironwood 49938-2044
906-932-1420

Grand Traverse County
Suite A,
Traverse City 49684-2208
231-922-4620

Gratiot County
214 East Center Street,
Ithaca 48847-1446
989-875-5233

Hillsdale County
20 Care Drive,
Hillsdale 49242-5039
517-439-9301

Houghton\Keweenaw Counties
1500 Birch Street,
Hancock 49930-1062
906-482-5830

Huron County
Room 104, County Building,
Bad Axe 48413-1317
989-269-9949

Ingham County
121 East Maple Street,
Mason 48854-0319
517-676-7207

Ionia County
100 Library Street,
Ionia 48846-1605
616-527-5357

Iosco County
P.O. Box 599,
Tawas City 48764-0599
989-362-3449

Iron County
2 South 6th Street,
Crystal Falls 49920-1400
906-875-6642

Isabella County
County Annex Building,
Mt. Pleasant 48858-2306
989-772-0911-302

Jackson County
1699 Lansing Avenue,
Jackson 49202-2296
517-788-4292

Kalamazoo County
Room 302,
Kalamazoo 49007-3777
616-383-8830

Kalkaska County
County Government Center,
Kalkaska 49646-9436
231-258-3320

Kent County
836 Fuller Avenue NE,
Grand Rapids 49503-1902
616-336-3265

Lake County
Route 3,
Baldwin 49304-2235
231-745-2732

Lapeer County
1575 Suncrest Drive,
Lapeer 48446-1138
810-667-0341

Leelanau County
116 East Philip Street,
Lake Leelanau 49653-9782
231-256-9888

Lenawee County
Suite 2020,
Adrian 49221-3867
517-264-5300

Livingston County
820 East Grand River Avenue,
Howell 48843-2432
517-546-3950

Luce County
County Building, Room 26,
Newberry 49868-1208
906-293-3203

APPENDIX E continued

Michigan State University Extension Offices

Mackinac County
Courthouse,
St. Ignace 49781-1495
906-643-7307

Macomb County
Verkuilen Building,
Clinton Township 48036-
810-469-5180

Manistee County
6433 Eight Mile Road,
Bear Lake 49614-9712
231-889-4277

Marquette County
200 West Spring Street,
Marquette 49855-4630
906-226-4370

Mason County
Suite 4,
Scottville 49454-1221
231-757-4789

Mecosta County
14485 Northland Drive,
Big Rapids 49307-2368
231-592-0792

Menominee County
S904 U.S. Highway 41,
Stephenson 49887-0157
906-753-2209

Midland County
220 West Ellsworth St.,
Midland 48640-5194
989-832-6640

Missaukee County
6180 West Sandborn Road,
Lake City 49651-9330
231-839-4667

Monroe County
963 S. Raisinville Road,
Monroe 48161-9754
734-240-3170

Montcalm County
617 North State Road,
Stanton 48888-0308
517-831-7500

Montmorency County
Courthouse Annex,
Atlanta 49709-0415
989-785-4177

Muskegon County
635 Ottawa Street,
Muskegon 49442-1016
231-724-6361

Newaygo County
817 South Stewart Avenue,
Fremont 49412-9201
231-924-0500

Oakland County
Dept 416,
Pontiac 48341-1032
248-858-0885

Oceana County
210 Johnson Street,
Hart 49420-0151
231-873-2129

Ogemaw County
205 S. Eighth,
West Branch 48661-1207
989-345-0692

Ontonagon County
Courthouse,
Ontonagon 49953
906-884-4386

Osceola County
301 W. Upton Avenue,
Reed City 49677-0208
231-832-6139

Oscoda County
Courthouse Annex,
Mio 48647-0069
989-826-1160

Otsego County
800 Livingston Boulevard,
Gaylord 49735-8321
989-731-0272

Ottawa County
333 Clinton Street,
Grand Haven 49417-1329
616-846-8250

Presque Isle County
151 East Huron Avenue,
Rogers City 49779-0110
989-734-2168

Roscommon County
Courthouse Annex,
Roscommon 48653-0507
989-275-5043

Saginaw County
One Tuscola Street,
Saginaw 48607
989-758-2500

Sanilac County
37 Austin Street,
Sandusky 48471-1244
810-648-2515

Schoolcraft County
Room 218,
Manistique 49854-1485
906-341-3688

Shiawassee County
701 South Norton,
Corunna 48817-1209
989-743-2251

St. Clair County
Room 102,
Port Huron 48060-4015
810-989-6935

St. Joseph County
612 E. Main St,
Centreville 49032
616-467-5511

Tuscola County
362 Green Street,
Caro 48723-1910
989-672-3870

Van Buren County
Suite A,
Paw Paw 49079-1077
616-657-7745

Washtenaw County
705 N. Zeeb Rd.,
Ann Arbor 48107-8645
734-997-1678

Wayne County
640 Temple Street,
Detroit 48201-2558
313-833-3412

Wexford County
401 N. Lake St.,
Cadillac 49601-1891
231-779-9480

MSU Outreach Regional Offices

East Central
2013 W. Wackerly St.,
Midland 48640-2592
989-839-8540

North
Suite 100,
Traverse City 49684-8895
231-929-3902

Southeast
28115 Meadowbrook Road,
Novi 48377-3128
248-380-9104

Southwest
3700 E. Gull Lake Drive,
Hickory Corners 49060
616-671-2444

Upper Peninsula
702 Chippewa Square,
Marquette 49855-4811
906-228-4830

West Central
110 Commerce Building,
Grand Rapids 49503-3117
616-458-6805

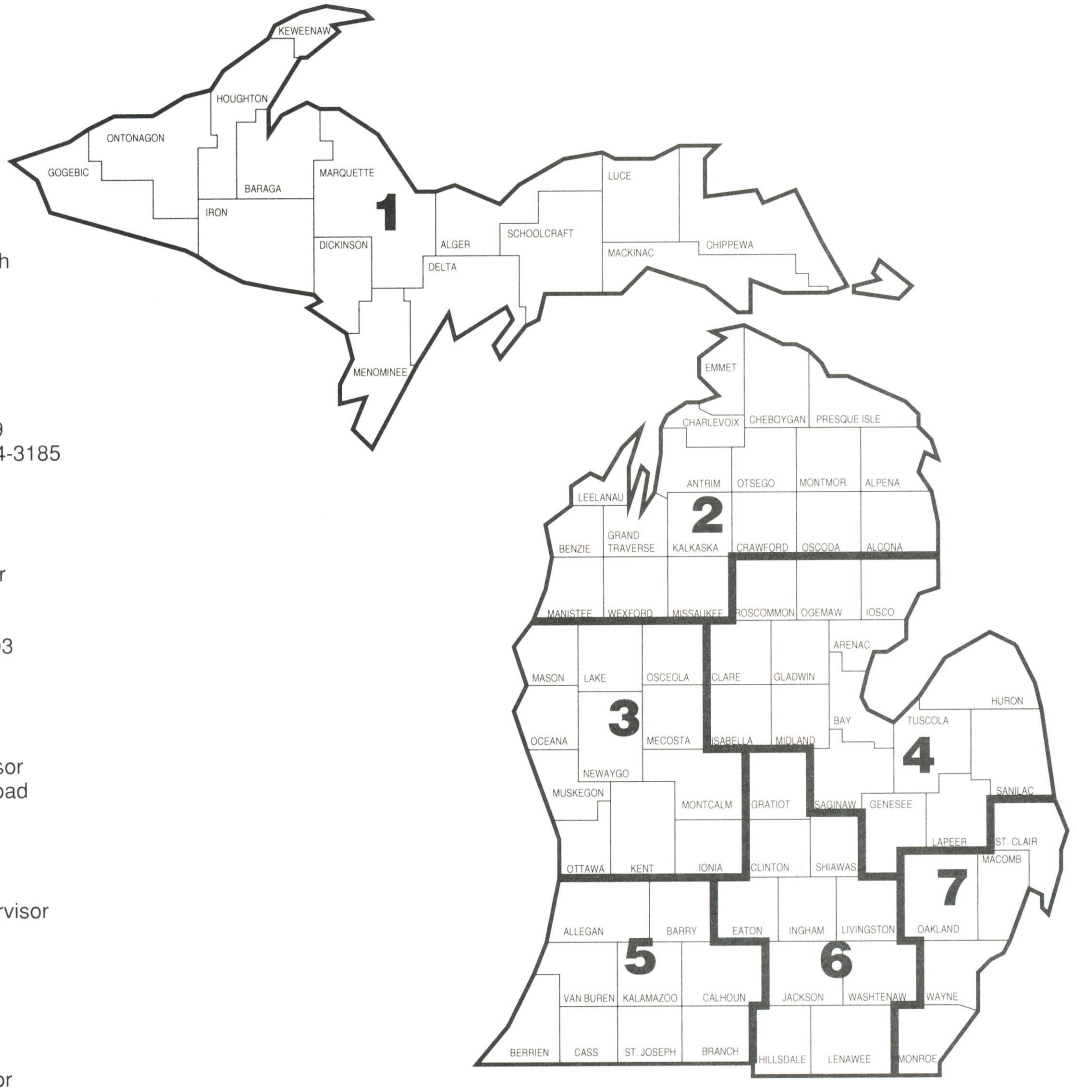
MSU Bulletin Office

10-B Agriculture Hall
Michigan State University
East Lansing, MI 48824-1039
517-355-0240
fax: 517-353-7168

APPENDIX E continued

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE & PLANT PEST MANAGEMENT DIVISION

525 W. ALLEGAN ST.
P.O. BOX 30017
LANSING, MICHIGAN 48909
517-373-1087
Web: www.mda.state.mi.us



REGION 1
Ernie Abel, Supervisor
UP State Fair
2401 12th Avenue North
Escanaba, MI 49829
231-786-4011
FAX 231-786-4196

REGION 2
Ernie Abel, Supervisor
701 S. Elmwood, Ste. 9
Traverse City, MI 49684-3185
231-922-5210
FAX 231-922-5236

REGION 3
Jeff Zimmer, Supervisor
State Office Bldg.
350 Ottawa NW
Grand Rapids, MI 49503
616-356-0600
FAX 616-356-0622

REGION 4
Daniel Keane, Supervisor
1585 Tittabawassee Road
Saginaw, MI 48604
989-758-1778

REGION 5
Michael Hansen, Supervisor
4032 M-139, Bldg. 116
St. Joseph, MI 48905
616-428-2575
FAX 616-429-1107

REGION 6
Jean Meiner, Supervisor
3001 Coolidge Rd.
East Lansing, MI 48823
517-324-3895

REGION 7
Kendra Anderson, Supervisor
One Lahser Center
26400 Lahser Road
Suite 415
Southfield, MI 48034
248-356-1701
FAX 248-356-0374

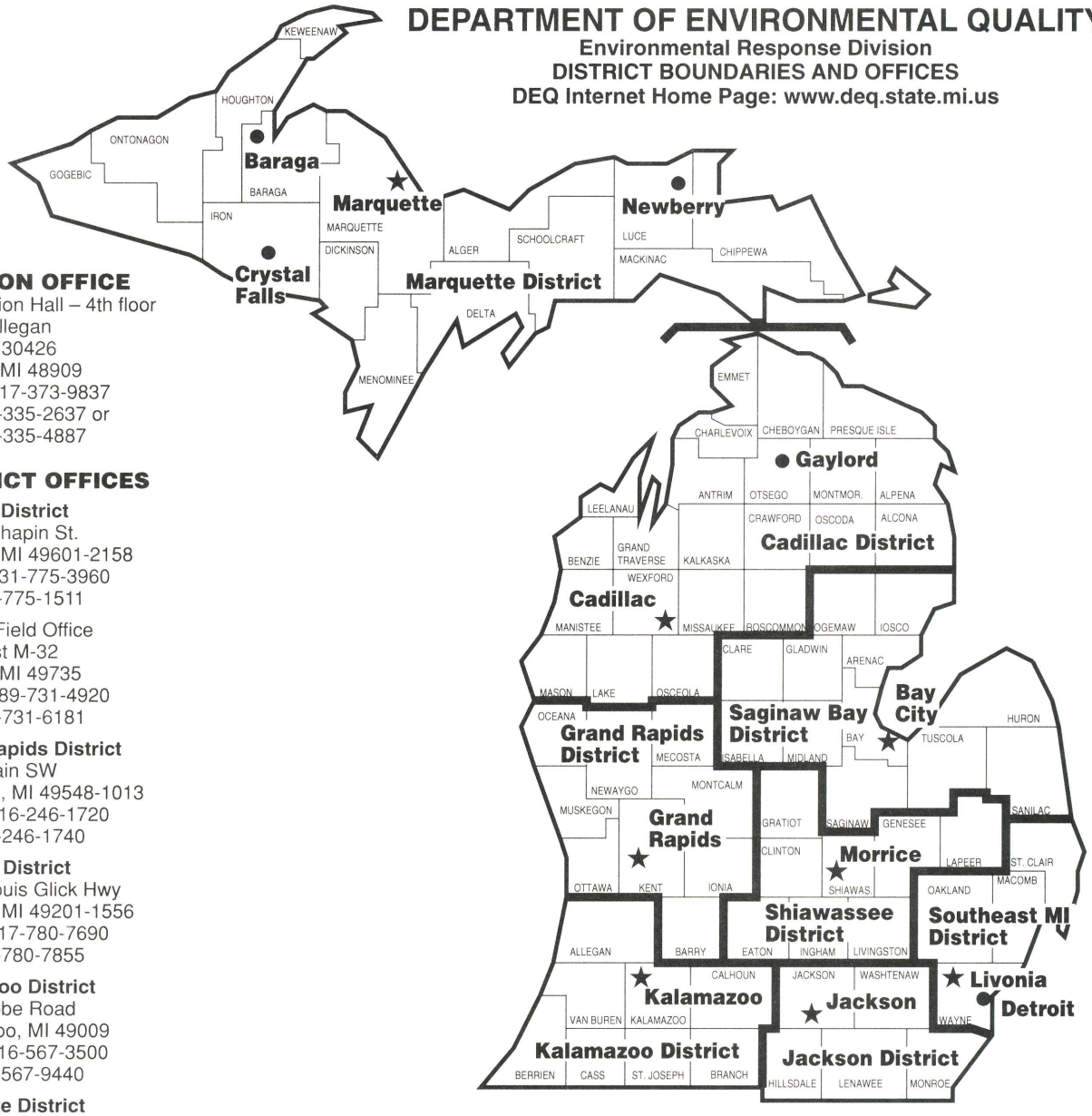
DAYS EXAMS ARE GIVEN

Region 1: Tuesday
Region 2: Wednesday
Region 3: Monday
Region 4: Wednesday
Region 5: Friday
Region 6: Monday
Region 7: Wednesday and Thursday

APPENDIX E continued

DEPARTMENT OF ENVIRONMENTAL QUALITY

Environmental Response Division
DISTRICT BOUNDARIES AND OFFICES
DEQ Internet Home Page: www.deq.state.mi.us



DIVISION OFFICE

Constitution Hall – 4th floor
525 W. Allegan
P.O. Box 30426
Lansing, MI 48909
Phone: 517-373-9837
Fax: 517-335-2637 or
517-335-4887

DISTRICT OFFICES

Cadillac District
120 W. Chapin St.
Cadillac, MI 49601-2158
Phone: 231-775-3960
Fax: 231-775-1511

Gaylord Field Office
2100West M-32
Gaylord, MI 49735
Phone: 989-731-4920
Fax: 989-731-6181

Grand Rapids District
245 Colrain SW
Wyoming, MI 49548-1013
Phone: 616-246-1720
Fax: 616-246-1740

Jackson District
301 E. Louis Glick Hwy
Jackson, MI 49201-1556
Phone: 517-780-7690
Fax: 517-780-7855

Kalamazoo District
7953 Adobe Road
Kalamazoo, MI 49009
Phone: 616-567-3500
Fax: 616-567-9440

Marquette District
1990 U.S. 41 South
Marquette, MI 49855-9198
Phone: 906-228-6568
Fax: 906-228-5245

Baraga Field Office
427 U.S. 41 North
Baraga, MI 49908
Phone: 906-353-6651
Fax: 906-353-7464

Crystal Falls Field Office
1420 U.S. 2 West
Crystal Falls, MI 49920
Phone: 906-875-2071
Fax: 906-875-3336

Newberry Field Office
5100 State Highway M-123
Newberry, MI 49868
Phone: 9067-293-5131
Fax: 906-293-8728

Saginaw Bay District
503 N. Euclid Ave., Suite 9
Bay City, MI 48706-2965
Phone: 989-686-8025
Fax: 989-684-9799

Shiawassee District
10650 Bennett Dr.
Morrice, MI 48857-9792
Phone: 517-625-5515
Fax: 517-625-5000

Southeast Michigan District
38980 W. Seven Mile Road
Livonia, MI 48152-1006
Phone: 734-953-8905
Fax: 734-953-1544

Detroit Office
300 River Place, Suite 3600
Detroit, MI 48207
Phone: 313-392-6480
Fax: 313-392-6488

ENVIRONMENTAL ASSISTANCE CENTER

(for general DEQ information):
Phone: 1-800-662-9278
Fax: 1-517-241-0673
E-mail: deq-ead-env-assist@state.mi.us

FOR POLLUTION EMERGENCIES:
1-800-292-4706

APPENDIX E continued

Michigan Groundwater and Freshwater Protection Act – Sources of information and assistance:

Michigan Department of Agriculture
Environmental Stewardship Division
Constitution Hall
P.O. Box 30017
525 W. Allegan Street
Lansing, MI 48909
Phone: (517) 335-6529
Fax: (517) 335-3131
Internet: www.mda.state.mi.us

PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of February 2002

Human Pesticide Poisoning

POISON CONTROL

From anywhere in the United States, call

1-800-222-1222

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

_____
Phone No.

or

Animal Health Diagnostic Laboratory (Toxicology) Michigan State University:

(517) 355-0281

Pesticide Fire

Local fire department:

_____
Phone No.

and

Fire Marshal Division, Michigan State Police:

M–F: 8–12, 1–5

(517) 322-1924

Traffic Accident

Local police department or sheriff's department:

_____
Phone No.

and

Operations Division, Michigan State Police:

****(517) 336-6605***

* ***Telephone Number Operated 24 Hours***

Environmental Pollution

District Michigan Department of Environmental Quality (MDEQ) Office Phone No.

_____
Phone No.

and

MDEQ Pollution Emergency Alerting System (PEAS):

****1-800-292-4706***

also

****1-800-405-0101***

Michigan Department of Agriculture Spill Response

Pesticide Disposal Information

Michigan Clean Sweep, Michigan Department of Agriculture Environmental Stewardship Division.

Monday– Friday: 8 a.m.–5 p.m.

(517) 335-6529

National Pesticide Information Center

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

7 days a week; excluding holidays

6:30 a.m. – 4:30 p.m. Pacific Time Zone

1-800-858-7378

FAX: 1-541-737-0761

Revised by Carolyn J. Randall, *Pesticide Education Program, Michigan State University Extension*

NOTES

April 1997 edition acceptable for distribution and use - Minor Revisions 3:02-5M-KMF - Ad - Price $5.00 File 27.23, (Pesticide Applicator Certification).