

Part 8: Equipment: Selecting, Calibrating, Cleaning

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Key Questions About Pesticide Equipment

- What is the best way to apply a pesticide?
- How do you know what nozzle to use?
- How do you calibrate application equipment?
- Why is it important to keep equipment clean and well maintained?

Different Ways to Apply Pesticides

The type of equipment needed depends on the method used to apply pesticides. There are several different methods. Your goal is to choose a way that will control the pest most efficiently without harming the environment. When choosing a method of application, consider the product being applied, the targeted pest, and the cost of other methods.

Pesticides can be applied directly on the plant (called foliar application) or on the soil. Types of application include the following:

Directed-spray application: spraying a pesticide directly at the target plants.

Spot treatment: applying a pesticide to a small area or spot in a field.

Broadcast application: covering an entire field or area with the pesticide (before or after plants emerge).

Band application: placing the pesticide in a strip or band over a row or on the soil next to the row (before or after crop or weed emerges).

Furrow application: placing an insecticide or fungicide in a narrow line or furrow in the soil directly over the seed at planting time. Some insecticides can kill seeds if applied this way, so be sure to check the label.

Aerial application: spraying a field from the air to provide better coverage than ground applications. This can be important when the crop canopy has closed or with certain fungicides or other pesticides that require good coverage to be effective.

A broadcast or band application can be mixed into the soil. This is called *soil incorporation*.

Types of Application Equipment

Adapted in part from Applying Pesticides Correctly: A Guide for Private and Commercial Applicators. U.S. Department of Agriculture and U.S. Environmental Protection Agency.

The equipment you use to apply pesticides is perhaps as important as the pesticides you choose. Many problems—such as pesticide drift, irregular coverage, or failure of the pesticide to reach the target—are due to the

equipment used. New application techniques and equipment can help reduce these problems.

When choosing equipment ask:

- Will it apply the pesticide effectively?
- Will the application cause excessive drift?
- Will it do the job at a reasonable cost?
- Is it easy to operate and clean?

Most pesticides are applied with sprayers or spreaders. Sprayers are used with liquid solutions or suspensions. Spreaders are used with granular formulations.

The most common types of equipment are described below, including:

- A brief description of how the equipment works.
- The types of crops or pests for which the equipment is best suited.
- Advantages and disadvantages.

If you apply pesticides through an irrigation system (chemigation), you need other equipment. See Part 9—Chemigation for information on chemigation equipment.

Sprayers

Hydraulic sprayers

Hydraulic sprayers use a liquid, usually water, to move the pesticide out to the target area. The liquid is called a “carrier” because it carries the pesticide. The usual procedure is to mix the pesticide with enough liquid to get a volume that can be controlled accurately and that will provide the coverage wanted. The solution is then forced out under pressure as a liquid spray. Hydraulic sprayers operate at low or high pressures.

Low-pressure sprayers operate at pressures of 10 to 80 pounds per square inch (psi). They use roller pumps or centrifugal pumps. They are used with herbicides and insecticides, but are not generally used with fungicides because the droplets are too large.

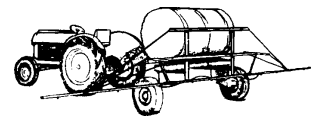
Low-pressure sprayers are useful on field and forage crops and pastures that can be covered by a low-pressure spray. They are not good for thick foliage because the pressure is not strong enough to penetrate the leaves.

High-pressure sprayers operate at pressures as high as 700 psi. They use piston pumps and can deliver up to 25 gallons of spray per minute. If they are fitted with a proper pressure regulator, they can also be used at low pressures.

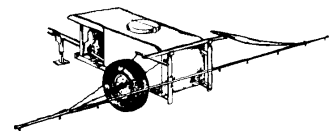
Because they may penetrate dense foliage, high-pressure sprayers are used mainly on fruits and vegetables. They are also ideal for spraying tall trees, reaching target plants that are far away, and cleaning equipment with a high-pressure water spray.

Advantage: can be used at low pressures if fitted with proper regulators.

Disadvantages: expensive to buy and operate; uses large amounts of water; produce small droplets that may drift.



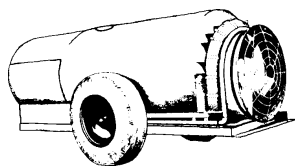
Low pressure sprayer



High pressure sprayer

Air-blast sprayers

Air-blast sprayers use a blast of air instead of large amounts of water to move the spray. Nozzles direct the pesticide solution into a fast-moving airstream created by a fan. The airstream breaks the spray into fine droplets and carries them to the target area.



Air blast sprayer

The most common uses for air-blast sprayers are in orchards and in narrow row crops where a boom sprayer cannot be used.

Advantages: easier to operate than high-pressure sprayers; uses less water; uses lower pump pressures.

Disadvantages: requires large tractors; produces a finer spray that is more subject to drift and is difficult to confine to a limited target area.

Hand sprayers

Most hand sprayers use compressed air to force the spray through a nozzle. They hold 1 to 5 gallons and use low pressures. The different types of hand sprayers include:

Pressurized cans (aerosols): capacity usually less than 1 quart; not reusable.

Trigger pump sprayer: capacity ranges from 1 pint to 1 gallon; hand-squeezed pump.

Hose end sprayer: attaches to a hose; capacity 1 quart of concentrate, but because it mixes with water, may deliver 20 gallons of diluted pesticide before refilling.

Push-pull hand pump sprayer: capacity 1 quart or less; hand-operated plunger creates suction to siphon out pesticide.

Compressed air sprayer: capacity usually 1 to 3 gallons; pressure created by a self-contained manual pump.

Backpack sprayer: capacity less than 5 gallons; similar to push-pull sprayer, except it is a self-contained unit (tank and pump) and is carried on the operator's back; a mechanical agitator plate may be attached to the pump plunger.

Bucket or trombone sprayer: capacity 5 gallons or less; pressures up to 150 psi; double-action hydraulic pump with separate tank.

Wheelbarrow sprayer: capacity less than 25 gallons; similar to backpack sprayer but with a larger tank and longer hose line; tank is mounted on a wheel for easy transport.



Hand sprayer

Hand sprayers are used for spot treatments, home and garden pest control, small tree and nursery spraying, and other smaller areas.

Advantages: inexpensive; easy to operate; easy to clean and store.

Disadvantages: problems with agitation and screening for wettable powders; the rate of application may change as the operator moves.

Small motorized sprayers

These sprayers have the components of large field sprayers but are not usually self-propelled. They may be mounted on wheels or on a small trailer for pulling behind a small tractor or skid-mounted for carrying on a small truck. They may be low- or high-pressure, depending on the pump and other components.

These models are used in relatively small outdoor areas, such as small orchards, ornamental and nursery plantings, and golf course greens.

Advantages: larger capacity than hand sprayer; low- and high-pressure capability; built-in hydraulic agitation; small enough for limited spaces.

Disadvantages: not suitable for general field use; relatively high cost.

Ultra low volume (ULV) sprayers

These use special pesticide concentrates and may be hand-held or mounted on ground equipment or aircraft.

They are used in agricultural, ornamental, turf, forestry, right-of-way, and some structural pest-control operations.

Advantages: requires less time and labor because water is not needed; equal control with less pesticide.

Disadvantages: coverage is not thorough; hazards of using high concentrates; chance of overdosage; small number of pesticides registered for ULV use.

Spinning disc sprayers

These special sprayers use a spinning disc powered by a small electric or hydraulic motor as the “nozzle” to “fling” out the pesticide with centrifugal force, producing uniform-size droplets. These sprayers range from a small hand-held type to large units mounted on tractors or trailers.

Advantages: low drift; droplet size can be adjusted by speed of rotation; low-pressure pump and components.

Disadvantages: relatively high cost; not suitable for windy conditions.

Recirculating sprayers

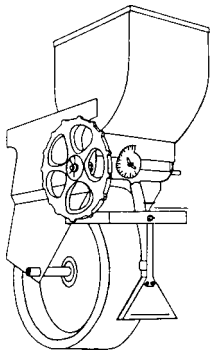
Recirculating sprayers direct solid streams of highly concentrated herbicides directly across rows above the crop. Spray material that does not make contact with weeds is caught in a box or sump on the opposite side of the row and recirculated.

These sprayers are used to apply contact herbicides to weeds that are taller than the crop in which they are growing.

Advantages: uses small amounts of pesticide; treats weeds that have escaped other control measures; less pesticide moves into surrounding environment; protects susceptible nontarget plants from injury.

Disadvantages: only for special situation; relatively high cost.

Granular Applicators (Spreaders)



Granular applicator

Granular applicators are used mainly for applying pesticides to the soil in a broadcast or band application.

A granular applicator consists of a hopper for the granules, a mechanical agitator at the base of the hopper, a meter to control the flow of the granules, and a spreading device. Drop-through spreaders drop the granules through a gate. Rotary spreaders use a spinning disc or fan to distribute the granules. They may be hand- or power-driven.

Choose a unit that is easy to clean and fill. It should have good agitation over the outlet holes and should spread the granules uniformly. The granule flow should stop when the forward motion stops, even if the outlets aren't closed.

Seed Treaters

Seed treaters are used to coat seeds with a pesticide. The amount of pesticide the seeds receive is important—too little will not control the pest but too much can injure the seed.

There are three basic types of commercial seed treaters.

Dust treaters mix seed with a pesticide dust in a mechanical mixing chamber until every seed is thoroughly covered.

Slurry treaters coat seeds with wettable powder pesticide formulations in the form of a slurry. Only a small amount of water is used with the pesticide so that the seed does not start to germinate or deteriorate.

Liquid or direct treaters are designated to apply a small amount of pesticide solution to a large quantity of seeds.

Advantages: allows more choice in the variety to be treated and in the pesticides to be used; treats only as many seeds as you need.

Disadvantages: requires purchase of equipment instead of just buying pretreated seeds; pretreated seeds are easier to use; more chance of seed injury.

Animal Application Equipment

Three kinds of equipment are generally used to treat livestock for external parasites: dipping vats, spray-dip machines, and face and back rubbers.

Dipping vats are large trailer-mounted tanks containing liquid pesticide mixtures. The animals are driven up a ramp and forced into the tank so that they are completely immersed. The animal's head may have to be pushed under the surface. It is very important to maintain the proper concentration of pesticide in the vat.

With **spray-dip machines**, a pesticide mixture is sprayed on each animal from a trailer-mounted chute equipped with nozzles. Surplus spray falls into a shallow tank where it is filtered and recycled back to the nozzles.

Face and back rubbers are bags or other containers of dry or liquid formulations that are hung in areas where there is high livestock traffic. When the animal rubs against them, the pesticide is transferred to the animal's face, back, side, or legs.

Parts of a Sprayer

Sprayer parts should be made of materials that can withstand the abrasion of wettable powders and the corrosive effects of some pesticides.

Tanks should be made of stainless steel or fiberglass. If the tank is made of mild steel, it should have a protective lining or coating. The tank should have a large opening for easy filling and cleaning and a large drain. It should allow straining during filling and provide for mechanical or hydraulic agitation. All outlets should be sized to the pump capacity. All tanks should have a gauge to show liquid level and a shutoff valve.

Pump. The most commonly used pumps are roller, piston, and centrifugal pumps. For some applications, gear, vane, and diaphragm pumps are also used.

Two things to look for when you choose a pump are: 1) the pressure ranges the pump can handle, and 2) the gallons per minute the pump can supply. It's a good idea to choose a slightly oversized pump. This ensures that the relief valve will operate and also that, even with wear and tear, the pump will still do the job.

Hoses. Select neoprene, rubber, or plastic hoses that:

- Have burst strength greater than peak operating pressure.
- 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. Replace hoses at the first sign of deterioration (cracking or checking).

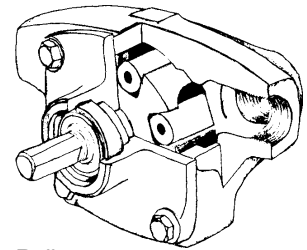
Pressure regulator. The pressure regulator controls the pressure in the system. This protects sprayer parts from damage due to excess pressure. The pressure range and flow capacity of the regulator must match the pressure range you plan to use and the capacity of the pump. The bypass line from the pressure regulator to the tank should be kept fully open and unrestricted and should be large enough to carry the total pump output with excess pressure buildup.

The type of regulator needed depends on the type of pump: **Throttling valves** are used with centrifugal pumps; **spring-loaded bypass valves** are used with roller, diaphragm, gear, and small piston pumps; and **unloader valves** are used on larger piston and diaphragm pumps.

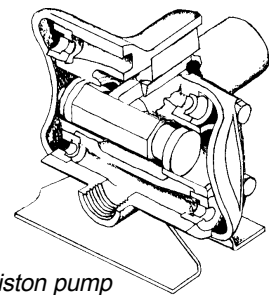
Electronic systems. New systems using electronics have been developed to improve pesticide application. These systems can monitor and guide the spray equipment in various ways.

Some systems sense the travel speed and the total flow of spray to the boom. The operator enters the swath width, and the system continuously displays the application rate.

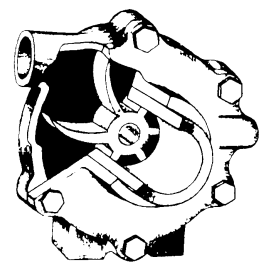
Some systems tell the nozzle flow, the area covered, the total volume sprayed, and the amount left in the tank. Still others maintain a constant application rate regardless of travel speed. There are also monitors that tell when a nozzle has clogged.



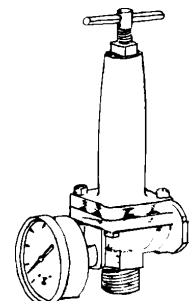
Roller pump



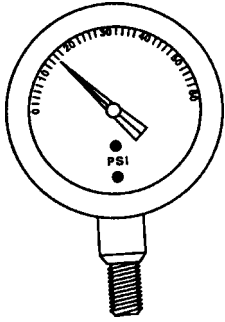
Piston pump



Centrifugal pump



Pressure regulator

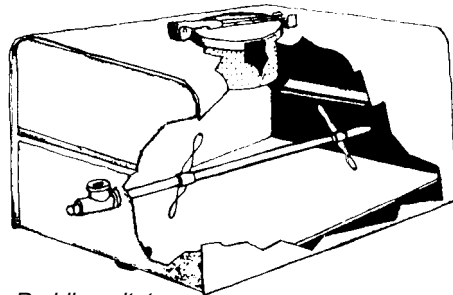


Pressure gauge

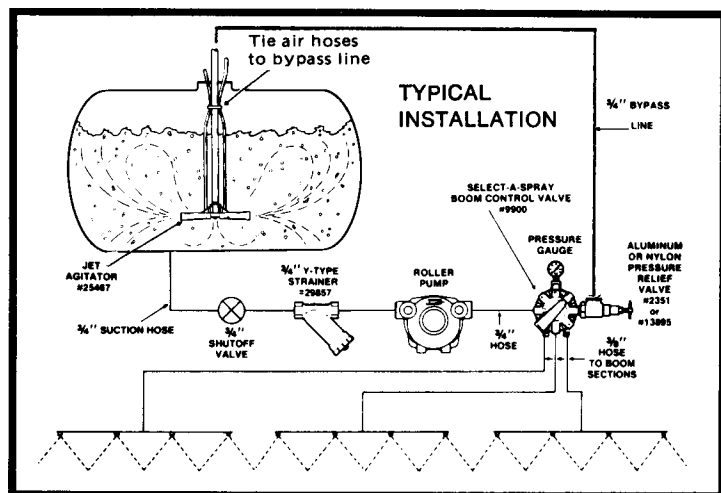
Pressure Gauge. Every sprayer system needs a pressure gauge to tell you how much pressure is being used. The gauge will indicate any failures in the sprayer by showing changes in pressure. Use a gauge designed for the pressure range of the sprayer. A high-pressure gauge will not give an accurate reading of a low-pressure sprayer.

Control Valves. Quick-acting cutoff valves should be located between the pressure regulator and the nozzles to provide on/off action. Cutoff valves should be within easy reach of the operator. These control valves should be rated for the pressures you plan to use. They should be large enough so that they do not restrict flow when open.

Agitator. Many spray mixtures must be agitated (stirred up) to keep the pesticide and carrier mixed. For most mixtures, the liquid returning from the regulator bypass line provides enough agitation. But additional agitation is needed for wettable powders to keep them in suspension. This can be done by using paddles in the tank to stir up the mixture. A more common method is jet agitation.



Paddle agitator



Jet agitator

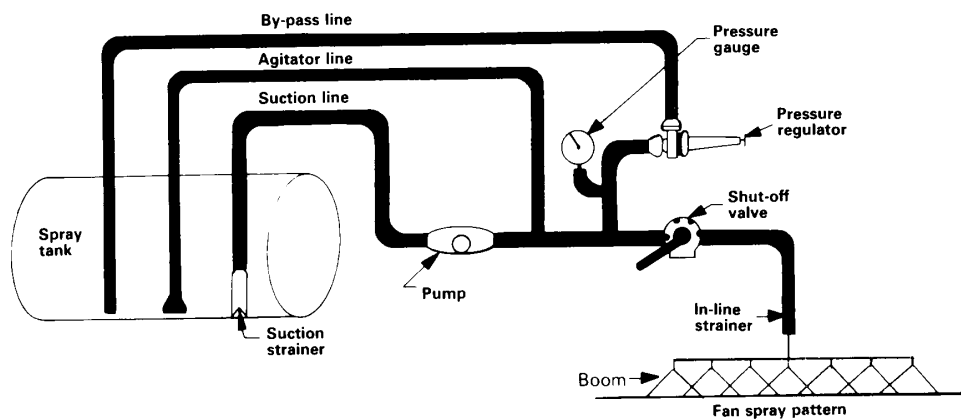
A jet agitator uses a nozzle inside the tank. The nozzle continuously sprays some of the spray mixture in the tank to keep it stirred. The line to the jet agitator is connected between the pump and the shutoff valves to the nozzles. In this way, when spraying is stopped for a few minutes, the agitation will continue inside the tank.

The amount of liquid needed for jet agitation depends on the size of the tank and the formulation. For mixtures that foam at high agitation rates, a control valve on the agitation line may be needed to reduce the amount of flow.

Strainers. Strainers, also called screens, are used to catch anything that could damage or clog the system. There are three places where strainers are used. Each one requires a different size strainer:

Size of strainer to use in sprayer

Placement	Size
At the entrance to the pump intake hose	25 to 50 mesh screen
In the line from the pressure regulator to the boom	50 to 100 mesh screen
In each nozzle	Follow manufacturer's directions
For wettable powders	All screens should be 50-mesh or coarser



Sprayer system

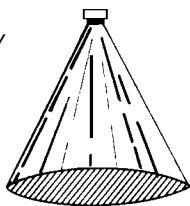
Types of nozzles. When choosing a nozzle, think about:

- The size of droplets needed.
- The spray pattern wanted.
- The rate of application.

The label may recommend a droplet size and spray pattern. Select nozzles that meet those requirements and also provide the rate of application required by the label.

Nozzle charts, found in nozzle manuals available from dealers, show the application rate at certain pressures and ground speeds. You can change the application rate by varying the pressure and ground speed. But there are limits to how much change you can make. Too much pressure may make the droplets too small and distort the spray pattern, which may cause drift. Too little pressure may produce droplets that are too large or an incomplete spray pattern.

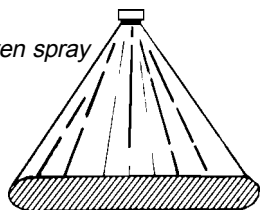
Flat spray



Flat spray nozzles produce droplet sizes that vary from very fine to coarse depending on the nozzle style and pressure. Many advances have been made in nozzle design to aid in the reduction of drift.

Standard flat fan spray nozzles are made to operate in a range of about 30-60 psi operating pressure and produce very few coarse droplets. They require an overlap of 30-50% to give full coverage.

Even spray



Extended range flat fan nozzles were designed to provide uniform spray patterns even if the pressure drops to 15 psi, increasing droplet size and reducing drift. These tips work well for sprayers with automatic rate controllers that will adjust pressure when the ground speed changes.

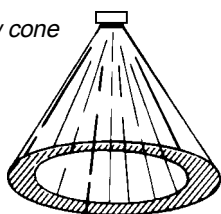
Solid cone spray



Reduced drift flat fan nozzles use a design to create larger droplets at the same operating pressures and flow rates as standard flat fans (30-60 psi). Some newer designs are combining the extended range and the reduced drift technologies to give applicators a nozzle that operates from 15-90 psi with droplet sizes that reduce drift.

Even flat fan nozzles are used for band applications since the spray distribution is the same across the entire spray pattern.

Hollow cone spray



Twin flat fan nozzles have two orifices on each tip. This provides a more thorough coverage on contact post-emergence sprays

Cone nozzles produce smaller droplets in a round pattern. Depending on the design the spray may only be on the outside fringe of the round pattern or throughout the circle. They are used most often in directed sprays to apply insecticides and fungicides since smaller droplets are needed in those applications. Some of the cone nozzles use technologies that will produce even enough patterns for soil incorporated, pre-emergence, and systemic post-emergence herbicides.

Flooding spray











Flooding spray nozzles produce large droplets in a wide pattern. They are used close to the ground and at low pressures. They can be mounted on a boom to provide even coverage. Because they are used close to the ground and produce large droplets, they are excellent for preventing drift.






Spinning nozzles or rotary spray nozzles use spinning cups and centrifugal force to produce evenly sized droplets.

Controlled droplet applicators are one kind of spinning nozzle that has been shown to produce fairly uniform droplets. They spray in a round pattern. If they are mounted on a boom, they should be tilted backward at a 30° angle

Nozzle guide for broadcast spraying.

	Herbicides				Fungicides		Insecticides	
	Soil-incorporated	Pre-emerge	Post-emerge		Contact	Systemic	Contact	Systemic
			Contact	Systemic				
 Extended range flat fan	Good	Very good <small>(at low pressure)</small>	Good	Very good <small>(at low pressure)</small>	Very good	Very good <small>(at low pressure)</small>	Good	Very good <small>(at low pressure)</small>
 Standard flat fan		Good	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							
 Raindrop™ hollow cone	Good	Good		Good				

Nozzle guide for banding and directed spraying.

	Herbicides			Fungicides		Insecticides		Growth Regulator
	Pre-emerge	Post-emerge		Contact	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	

Calibrating Equipment

Before mixing or loading pesticides, calibrate the equipment. Calibration means adjusting the equipment so that it applies the right amount of pesticide in the right place. It should be done every time you switch chemicals or change application rates.

There are several reasons for calibrating equipment:

The settings given on pesticide **labels are only a guide**. Actual settings needed to deliver the rate wanted may differ.

Applicators are not all identical. Small differences in equipment may cause changes in the application rate.

Nozzle wear may increase the application rate and change spray patterns. This may cause streaking, resulting in poor control or drop injury. For this reason, spot-check the calibration rate during the season, even if the pesticide or the application rate has not changed

Even though pesticide granules seem similar, they are not. **Each pesticide has its own flow characteristics**, which can change with moisture and temperature changes. You must calibrate your applicator when these conditions change as well as when you switch pesticides.

There are different ways to calibrate equipment. The important thing is to select a method you understand and perform it faithfully. Four methods of calibrating application equipment commonly used by private applicators are described here:

- Calibrating broadcast boom sprayers.
- Calibrating liquid band sprayers.
- Calibrating handgun and knapsack sprayers.
- Calibrating granular applicators.

The directions given on the following pages include these abbreviations:

GPA = gallons per acre. Application rates for sprayers are usually given in GPA.

MPH = miles per hour. The sprayer speed is measured in MPH.

GPM = gallons per minute. The output of nozzles is stated in GPM.

GPH = gallons per hour. The output of nozzles or pump may be given in GPH.

Check the Nozzle Pattern and Flow Rate

The amount of spray that flows through a spray nozzle is determined by the size of the tip and the nozzle pressure. The flow can be increased by increasing the size of the tip or by increasing the spray pressure. Since it takes large increases in pressure to significantly change the flow, an applicator should always make a nozzle choice that best fits the need of the pesticide being sprayed and then use pressure changes to make the final minor adjustments.

Start your precalibration check of a broadcast boom sprayer by being sure the same size and style of nozzles are used across the entire boom. It is

very easy to mistakenly install a slightly different nozzle during a busy spray season so be sure each letter and number match.

Fill the sprayer about half full of clean water and operate the sprayer at the pressure you intend to use in the field. Stand behind the sprayer and see if the spray angles appear uniform. If a spray pattern shows a heavy stream, a skip, or an abnormal angle, then you should stop the sprayer and clean those tips again. If cleaning does not solve the problem discard that nozzle and replace with a new nozzle of the same size and style.

After replacing the obviously worn nozzles, make sure that there is at least one new nozzle in each section of the boom. Operate the sprayer again and check the water flow coming from one of the new nozzles in each boom section. This can be done quickly by using a flow meter that slips over a nozzle. In a matter of seconds the flow meter indicates the rate of flow in gallons per minute (gpm). An alternative is to collect the amount of flow for a set period of time (such as 60 seconds) and measure the amount of water for each nozzle. The flow should be about equal from each of those new nozzles. If it is over 5% different from the average of the new nozzles, it may mean that a spray hose or other plumbing problem may be constricting the flow to that section of boom or dirty screens are restricting flow to a nozzle.

If the flow from each of the new nozzles is within 5% of the average proceed to check the rest of the nozzles in the boom. If the flow of any nozzle is outside of the 5% range, replace it.

Note: By collecting the nozzle output for 1 minute, you can check how accurate your pressure is at the boom. If you divide the ounces collected in 1 minute by 128 you have the nozzle output in gallons per minute (gpm). Your spray nozzle catalog has a chart that shows what the gpm should be for your nozzle size at several operating pressures. If the measured flow rate varies greatly from the predicted flow rate it may mean you have a faulty pressure gauge or are losing pressure between the pump and booms.

Amount of pesticide per tankful. In addition to calibrating your equipment, you need to calculate how much pesticide will be needed for each tankful. To do this, find out how many acres each tankful will cover. Here are the formulas to use:

$$\text{Acres per tankful} = \frac{\text{tank capacity}}{\text{GPA}}$$

Amount of pesticide to add per tankful = acres per tankful × rate of pesticide per acre

How to Calibrate a Broadcast Boom Sprayer

Step 1. Measure the distance, in inches, between nozzles.

Step 2. Locate this width in Table 2 below and note the corresponding course distance.

Step 3. Mark off this distance in a field to be sprayed. Select the tractor

gear and mark the throttle setting to be used during spraying. Start a distance back from the beginning of the course to get up to operating speed, then record the time it takes to travel the marked distance. Travel the marked distance at least 3 times to get an average time.

Step 4. With the sprayer stationary, run the sprayer at the desired pressure with clean water. Collect the water from a nozzle for the same number of seconds it took to drive the test course. The ounces of water collected will equal the sprayer output in gallons per acre.

Example: A broadcast boom sprayer has nozzles every 20 inches. The test run distance according to Table 2 for a 20 inch spacing is 204 feet. After marking the 204 feet in the field, the applicator finds that it takes an average of 22 seconds to travel that distance. With the tractor stationary,

the applicator turns on the sprayer and finds that an average 24 ounces are collected from each nozzle in 22 seconds. The application rate in gallons per acre equals ounces collected. In this case, it is 24 gallons per acre.

Nozzle spacing or band width (inches)	Course distance (feet)
8	510
10	408
12	340
14	291
16	255
18	227
20	204
22	185
24	170
26	157
28	146
30	136
32	127
34	120
36	113
38	107
40	102

Note: If the desired application rate in the example were 25 gallons per acre, the pressure could be increased so that the output in 22 seconds averaged 25 ounces. For desired changes of more than 10 percent, the applicator should change the speed of the tractor or change the nozzle size and repeat the calibration procedure. Do not change pressures outside of the normal operating range for the nozzle or ones that increase drift.

How to Calibrate a Band Sprayer

Step 1. Measure the width of the sprayed band.

Step 2. & Step 3. Same as those steps for the broadcast sprayer.

Step 4. With the sprayer stationary, run the sprayer at the desired pressure with clean water. Collect the water from all of the nozzles in the band for the same number of seconds it took to drive the test course. The ounces of water collected will equal the sprayer output in gallons per acre.

Note: The method for calibrating the band sprayer determines the GPA within the sprayed band. Keep in mind that there is a difference between the total area of the field and the **treated** area. *If a 60 acre field with 30 inch rows is treated with a 10 inch band, the total field size is 60 acres but only 20 acres are treated. The amount of pesticide put into the sprayer should only be for the 20 treated acres.*

How to Calibrate a Handgun or Knapsack Sprayer

Step 1. Add a measured amount of clean water to the sprayer. Three to 4 gallons should be adequate.

Step 2. Spray a measured area exactly 1,000 square feet (for example, 25 x 40 feet). Maintain a constant nozzle height and walking speed while evenly spraying the entire test area.

Step 3. Measure the amount of water remaining in the sprayer. Subtract this amount from the amount of water with which you started. The difference is the amount you sprayed over 1,000 square feet. Your rate is measured in gallons per 1,000 square feet. Multiply the rate in gallons per 1,000 square feet by 43.56 if you need to know the rate in gallons per acre.

Example: 3 gallons of clean water are added to an empty backpack sprayer. After spraying the 1,000 square foot test area, 2 gallons remain in the sprayer. Three gallons minus 2 gallons = 1 gallon per 1,000 square feet. This also equals 43.56 gallons per acre (1 x 43.56).

Step 4. If the calibrated sprayer does not fit within the recommended guidelines of the pesticide label, it may be necessary to change the speed that you walk or change spray nozzles.

Note: More uniform coverage will be obtained if the applicator makes 2 passes over the same area at perpendicular angles.

How to Calibrate a Granular Applicator

Calibrate a granular applicator in a field that has already been worked, because field conditions as well as ground speed affect the application rate.

1. Set each applicator to the setting suggested in the equipment operator's manual or on the pesticide control label.
2. Fill the hoppers at least half full and run them until they all begin to feed.
3. Remove the feed tubes and attach a calibration bag or premarked calibration tube.
4. Select a ground speed and travel a measured course at that speed. The longer the course, the more accurate the calibration.
5. Collect granules from all spouts.
6. Weigh and record the amount of pesticide collected in each container. Weigh in ounces, using an accurate scale, such as a postage scale. Remember to subtract the weight of the empty container.
7. Calculate the application rate, using one of the following formulas. Note that insecticides and herbicides have slightly different formulas.

Insecticide formulas

For insecticide applications, band width is not considered in calibration. Therefore, insecticides are applied at a constant rate per length of row.

$$\text{Application rate} = \frac{1,000 \times \text{ounces collected}}{\text{distance traveled (feet)}} \\ \text{(ounces per 1000 row feet)}$$

or

$$\text{Application rate} = \frac{43,560 \times \text{pounds collected}}{\text{distance traveled (feet)} \times \text{row width (feet)}} \\ \text{(pounds per acre)}$$

Herbicide formulas

Herbicides are applied in a band at a constant rate. Therefore, band width is critical for proper calibration.

$$\text{Application rate} = \frac{1,000 \times \text{ounces collected}}{\text{distance traveled (feet)} \times \text{band width (feet)}} \\ \text{(ounces per 1000 row feet)}$$

or

$$\text{Application rate} = \frac{43,560 \times \text{pounds collected}}{\text{distance traveled (feet)} \times \text{row width (feet)} \times \text{band width (feet)}} \\ \text{(pounds per acre)}$$

To do a rough check on application rates during the season, you can use this simple method:

1. Place a vertical strip of tape inside each hopper.
2. Fill the hopper one pound at a time. After each pound is added, level the pesticide by shaking the hopper. Then mark the new level on the tape.
3. Before and after treating a known acreage, check the levels. This will give you a rough estimate of the amount applied.

Maintaining and Cleaning Pesticide Equipment

There are two important reasons for maintaining and cleaning equipment:

To save money. Proper maintenance of equipment will reduce the need for replacement parts. Good maintenance makes it easier to control the application of pesticides. Before any sprayer can be reliably calibrated, it must be in good mechanical condition. In fact, inspecting your equipment is the first step in calibration.

To prevent pesticide poisoning. Pesticide application equipment will normally have some residual pesticide left in the tank, hoses, and boom, and on the surface of the equipment. This residue can harm humans, animals, and crops. If someone comes into contact with this residue, it can result in serious poisoning. If you mix a pesticide in equipment that has a residue of a different pesticide, you may damage your crops or injure your livestock. For these reasons, you should clean all pesticide equipment immediately after use.

Inspect Your Equipment

Inspect your equipment frequently—each time you use it. Check hoses and transmission lines for general condition and evidence of leaks. Inspect strainers and screens and clean them if necessary. Make sure there are no loose bolts or connections. Replace any parts that are worn or damaged.

Safety Precautions

Clean all equipment immediately after use. Remember that pesticide residues on equipment can be harmful, so you must use the same safety precautions as when you handle the pesticide itself. Wear protective clothing when you clean equipment that has been used with pesticides.

Pesticide application equipment should be cleaned in an area with a wash rack, cement apron, and sumps to catch the contaminated rinse water. The Minnesota Pollution Control Agency or the Minnesota Department of Agriculture can supply you with details on how to construct such a facility properly and in accordance with state guidelines.

Private pesticide applicators who do not have a washing facility to collect rinse water may clean the sprayer equipment in a field with a crop labeled for that pesticide. If more than a small amount of rinse water is produced when cleaning a sprayer in the field, the rinse water should be collected and reused.

Rinse water can be disposed of by spraying it on a labeled crop, following label directions, or as part of the spray solution for other pesticide applications. It is recommended that no more than 5 percent of a spray solution consist of rinse water. This is, in effect, tank mixing of pesticides. All pesticides in the mixture, including the pesticide in the rinse water, must be labeled for the crop to which the mixture is applied. If any of the pesticide labels prohibit tank mixing, the labels must be followed. When using rinse water as part of a spray solution, be sure to take into consideration pesticide incompatibility, increases or decreases in effectiveness, and possible crop injury.

Part 7—Safe Handling of Pesticides has more detailed information on handling pesticides and disposing of contaminated wastes.

How to Clean Sprayers

1. Check the pesticide label for any specific cleaning instructions.
2. Drain all pesticide solution from the sprayer. Save to use again.
3. Flush the sprayer with clean water.
4. Fill the sprayer with water plus one cup of trisodium phosphate or household ammonia for each 10 gallons of water.
5. Wash the tank and pump parts by running the sprayer for about five minutes with the nozzles closed.
6. If possible, let the cleaning mixture stand in the sprayer overnight. Note: household ammonia will corrode aluminum sprayer parts.
7. Discharge the mixture from the tank, letting some of it out through the nozzles. When you use this procedure, the mixture should flow into a sump so that it does not contaminate the area or the groundwater.
8. Always flush a new sprayer before you use it. When your sprayer will not be used for awhile, coat exposed metal parts with light oil to prevent rust.

How to Clean Granular Applicators

1. Remove all granules and store in the original container.
2. Remove rust on the feeder plates or agitator with a wire brush, a file, or sandpaper.
3. Tighten all nuts and bolts.
4. Oil the equipment following the manufacturer's directions.

How to Maintain and Clean Equipment Parts

Dirt and solid pesticide deposits trapped in strainers, screens, or other equipment parts can affect the output of a sprayer. If the solids are discharged during spraying, there could be a sudden increase in the application rate.

Pumps. Lubricate the pump properly. Fill it with antifreeze or light oil when it is not in use.

Hoses. Keep hoses from kinking or being rubbed. Rinse them often, inside and outside, to prolong life. During the off season, store hoses out of the sun. Check the hose surface for cracks or checking and replace at the first sign of deterioration.

Screens. Remove dirt and pesticide solids that are trapped in strainers or screens. Do not use clogged screens when applying pesticides.

Nozzles. Use a soft brush to clean nozzles. Do not use wire or any metal object to clean nozzles because metal can distort the nozzle and distort the spray pattern. Do **NOT** blow through a nozzle to clear it—you can be poisoned.

Summary

Application equipment includes sprayers and granular spreaders. There are several kinds of sprayers including low-pressure hydraulic, high-pressure hydraulic, air-blast, and hand sprayers. Each type has special uses. Granular applicators are used mainly for soil furrow or band applications.

Choose equipment that will apply the pesticide effectively without harming the environment, that will do the job at a reasonable cost, and that is easy to operate and clean. Choose sprayer parts that are suitable for the pressures, application rates, and spraying patterns you require.

Before mixing or loading pesticides, calibrate equipment to make sure that it will apply the right amount of pesticide in the right place. Formulas are available to help you calculate the correct application rates for each piece of equipment.

Proper maintenance of equipment will ensure good control when applying pesticides and will reduce the need for replacement parts. Inspect equipment regularly for leaks or loose parts.