Chapter 9
Pesticide Application Procedures and Equipment

Today’s pest management practices require modern equipment to apply a variety of pesticides. The vast array of equipment on the market must be matched to the pesticide as well as to the size and type of the job to be done. To make an effective, safe, and efficient application, read the label first. In addition, the equipment must be properly selected, operated, calibrated, and maintained. This Chapter describes methods of application, equipment choices, calibration, and equipment cleaning and maintenance.

This pesticide applicator is treating only the canopy to eliminate pests on leaves.
Photo: NRCS
Section 1: Methods of Pesticide Application and Types of Equipment

The pesticide application method you choose depends on the nature the target pest, the characteristics of the target site, the properties of the pesticide, the suitability of the application equipment, and the cost and efficiency of alternative methods. This Section describes different pesticide application methods and equipment.

Learning Objectives:

1. Describe the different common application methods.
2. Explain the difference between types of nozzles.

Terms to Know:

- Enclosed cab
- Pesticide containment pad
Methods of Application

To get the best result using the least amount of pesticide applicators need to think through the application process carefully. Different application methods are appropriate for different crop and pest types, but the method of application should always be consistent with the label directions. Application methods include:

- **Band application**, applying a pesticide in parallel strips or bands, such as between rows of crops rather than uniformly over the entire field.
- **Basal application** directs herbicides to the lower portions of brush or small trees to control vegetation.
- **Broadcast application** is the uniform application of a pesticide to an entire area or field.
- **Crack and crevice application** is the placement of small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets, where insects or other pests commonly hide or enter a structure.
- **Directed-spray application** specifically targets the pests to minimize pesticide contact with non-target plants and animals.
- **Foliar application** directs pesticide to the leafy portions of a plant.
- **Rope-wick or wiper treatments** release pesticides onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds in an ornamental planting bed.
- **Soil application** places pesticide directly on or in the soil rather than on a growing plant.
- **Soil incorporation** is the use of tillage, rainfall, or irrigation equipment to move the pesticide into the soil.
- **Soil injection** is the application of a pesticide under pressure beneath the soil surface.
- **Space treatment** is the application of a pesticide in an enclosed area.
- **Spot treatment** is the application of a pesticide to small, distinct areas.
- **Tree injection** is the application of pesticides under the bark of trees.
Safety Systems

Closed mixing and loading systems, enclosed application systems, and pesticide containment systems are excellent investments for pesticide handlers who handle large quantities of pesticides or handle pesticides that are very hazardous to humans or to the environment. These systems may be required for certain pesticides or for pesticide use in or near sensitive areas.

Closed Handling Systems

Closed mixing and loading systems are designed to prevent pesticides from coming in contact with handlers or other persons during mixing and loading (see Chapter 7, Safe Handling for more information on closed handling systems). The labeling of some pesticides, usually products with a high risk of causing human health effects, may require the use of a closed mixing and loading system. Closed handling systems include mechanical systems of hoses or pipes with pumps, mini-bulk containers, and water-soluble and other types of product packaging.

Pesticide Containment Systems

If you often use the same location to mix and load pesticides or clean equipment, a pesticide containment pad may be necessary. These pads are designed to contain spills, leaks, overflows, and waste water for reuse by the applicator, or disposal by a commercial waste management contractor. If the spray tank contains pesticides, keep it on the pad. These pads make spills easier to clean up, and they may reduce pesticide waste by allowing the rinse water to be reused. They also help prevent environmental contamination.

The containment pad must be made of an impermeable material such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners, or no-wax sheeting. Construct a concave pad or one having curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to occur at the site. It also must be equipped with a system for removing and recovering spilled, leaked, or released material by either an automatic sump system or a manually operated pump.

Enclosed Cabs

An enclosed cab—such as a tractor cab, cockpit, or truck/vehicle cab—surrounds the occupant(s) and may prevent exposure to the pesticides being applied as long as any doors, hatches, or windows are kept closed at all times during the pesticide application. Enclosed cabs are considered a supplement to PPE, not a replacement for it. Wear all PPE specified on the label while working inside the enclosed cab. Remember, outside surfaces of the application equipment and cab are contaminated. Be sure to wear appropriate PPE when getting in and out of the cab and conducting maintenance.

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Application Equipment

The equipment you use to apply pesticides is perhaps as important as the pesticides you choose. The application equipment can range from an aerosol can to hand equipment to power equipment, including aircraft. Many problems—such as pesticide drift, irregular coverage, or failure of the pesticide to reach the target—are due to the equipment. New application techniques and equipment can help reduce these problems. Agricultural application equipment is now quite technically advanced with various on-board systems available to ensure the correct amount of the right pesticide is applied in the right part of the field.

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 agricultural pesticides are applied with sprayers or spreaders. Sprayers are used with liquid solutions or suspensions. Spreaders are used with granular formulations. If you apply pesticides through an irrigation system (chemigation), you need other equipment. See Chapter 2, Pesticide Laws for information on chemigation.

Sprayers

Parts of a Sprayer

Sprayer parts should be made of materials that can withstand the type of product used. For example, some wettable powders can be abrasive while some other pesticide products may have corrosive effects.

Tanks. These 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 the pressure ranges the pump can handle and 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 abrasive or corrosive effects of oil, solvents and pesticide product and formulations used.
- 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 location in the field, 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.

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**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.

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 four places where strainers are used. Each one requires a different size strainer:

- 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 screen.
- For wettable powders, all screens should be 50-mesh or coarser.

**Granular Applicators or Spreaders**

Granular applicators are available for either band or broadcast application. They may be operated as separate units but are often attached to other equipment such as planters or cultivating equipment to combine two or more operations. They usually operate by gravity feed and have an adjustable opening to regulate the flow.
Band applicators use hoses or tubes with deflectors on the bottom. Broadcast applicators use a system of tubes and deflectors or a spinner to spread the granules. The application rate is affected by the ground speed; granule size, shape, and density; field terrain; and even relative humidity and air temperature. When multiple band applicators are used, each individual unit must be calibrated with the specific material to be applied to ensure accurate application.

Rotary and drop spreaders are two common types of granular applicators. Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disk or fan. In a drop spreader, an adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed. Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.

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.

Other Application Equipment

Additional types of application equipment include:

- Bait dispensers for control of rodents, insects, and predators.
- Foggers for indoor pest control and for some insect control outdoors.
- Chemigation systems for greenhouses and field crops.
- Dusters for small-scale disease and insect control.

Types of Nozzles

Nozzles control the amount of material applied, the formation of the droplets and their size, and the distribution and pattern of the droplets. A nozzle’s spray pattern is made up of a wide variety of spray droplet sizes, from very fine to extra coarse.

Nozzles are classified on the basis of the spray pattern and the droplet size they produce. Most nozzles consist of a nozzle body, a strainer or screen, an interchangeable spray tip, and the cap to hold the spray tip on.

The size of the nozzle opening (orifice) in the spray tip affects the droplet size and flow rate. A nozzle that primarily produces coarse droplets is usually selected to minimize off-target drift. A nozzle that mainly produces fine droplets is required to obtain maximum surface coverage of the target. Applicators should base nozzle selection on the target pest, type of application, coverage desired, and potential for drift.
When choosing a nozzle, think about:

- The size of droplets needed.
- The spray pattern desired.
- 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. Make sure that you follow the manufacturer’s recommendation. Some nozzles are designed to be used at higher PSIs. If you don’t follow the manufacturer’s recommendation, too much pressure may make the droplets too small and distort the spray pattern, which may cause drift. Conversely, too little pressure may produce droplets that are too large or an incomplete spray pattern.

- **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 percent to give full coverage.

- **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.

- **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.

- **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 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-degree angle.

### Section 2: Equipment Calibration

**Calibration** is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area. The purpose of calibration is to ensure your equipment is applying the correct amount of material uniformly over a given area. In this Section, the pesticide applicator will learn techniques to ensure equipment is properly calibrated.

**Learning Objectives:**

1. List the three things that effect the application rate of sprayers.
2. Describe the steps in checking the nozzle pattern and flow rate.
3. Describe the steps in calibrating each of the following: broadcast boom sprayer, band sprayer; backpack sprayer, granular applicator.
4. Explain how to calculate the area of a rectangle, triangle and circle.
5. Demonstrate how to calculate amount of pesticide needed for a field at the proper rate.
6. List the safety precautions for cleaning application equipment to protect the application and protect the environment.

**Terms to Know:**

- **Calibration**

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A pressure gauge on a regulator for a boom sprayer.
Photographer: M. J. Weaver
Institution: Virginia Tech
Source: pesticides.org (Virginia Tech)
Equipment Calibration

Calibration is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area. The purpose of calibration is to ensure your equipment is applying the correct amount of material uniformly over a given area.

Charts or tables may be provided to assist the operator in making adjustments to the settings. These recommended settings, however, are only approximate and may not be appropriate for all situations. Therefore, your equipment must be calibrated periodically. This depends on the type of equipment and the frequency of use. The application rate of the sprayer is affected by travel speed, nozzle size, and sprayer pressure.

Before calibrating be sure the equipment is clean, with no pesticide residues and in good working order. Equipment is calibrated by making a trial run on some premeasured area and measuring the output. For example, using a hand-held sprayer, spray a premeasured test area with water using the same pressure and techniques (i.e., travel speed and equipment) you would use when applying the pesticide. After spraying the test area, determine how much water was used. This volume can then be used to calculate the amount of water and pesticide needed to cover the intended application area.

The time invested in calibrating your equipment is time well spent. Accurate calibration to determine the application rate under your operating conditions is important for cost, efficiency, and safety. Calibration should be done every time you switch chemicals or change application rates.

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.

Illustration: National Pesticide Applicator Certification Core Manual, NASDARF
Check the Nozzle Pattern and Flow Rate

The amount of spray that flows through a spray nozzle is determined by nozzle type, 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 percent 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 percent 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 percent 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.

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 tank full will cover.
How to Calibrate a Broadcast Boom Sprayer

1. Fill the sprayer tank at least on-half full of water to simulate actual spraying conditions.
2. Measure the distance, in inches, between nozzles.
3. Locate this width in the table below and note the corresponding course distance.
4. 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.
5. With the sprayer stationary, run the sprayer at the pressure to be used during application. 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 for that nozzle. Repeat for all nozzles.
6. The average output of all the nozzles by:

\[
\frac{\text{Total volume collected of all nozzles}}{\text{Number of nozzles}} = \text{Average output per nozzle}
\]

Average output per nozzle = gallons per acre applied (when using this method of calibration)

Test run distance for sprayer calibration

<table>
<thead>
<tr>
<th>Broadcast Nozzle spacing or band width (inches)</th>
<th>Travel distance (feet)</th>
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<tbody>
<tr>
<td>7</td>
<td>583</td>
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<td>8</td>
<td>510</td>
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<td>40</td>
<td>102</td>
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</tbody>
</table>

If a nozzle flow rate is 5% greater than or less than average of all nozzles there may be flow restriction to the nozzle or the nozzle is worn and should be replaced.
Example:
- A broadcast boom sprayer has nozzles every 20 inches.
- The test run distance for 20-inch spacing is 204 feet (see table).
- Mark 204 feet in the field.
- Average time is 22 seconds to travel that distance.
- With the tractor stationary at application pressure have average of 24 ounces collected from each nozzle in 22 seconds.

The application rate in gallons per acre equals ounces collected, in this case 24 gallons per acre.

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 may increase drift.

Calculating the Broadcast Application Rate
To calculate how much pesticide product to add to a sprayer tank for broadcast applications to apply the correct application rate of the product you need to know:
- Average output of nozzles at application speed used in gallons per acre of spray solution
- Amount of water in sprayer tank
- Labeled rate of application of the product to use

\[
\frac{\text{tank capacity (gallons)}}{\text{nozzle output in gallons per acre}} = \text{acres treated per tankful}
\]

\[\text{acres treated per tankful} \times \text{rate per acre} = \text{amount per tankful}\]
Example:
- Tank capacity = 300 gallons
- Nozzle output = 24 gallons per acre
- Pesticide application rate = 2 pints per acre

\[
\frac{300 \text{ gallons per tankful}}{24 \text{ gallons per A nozzle output}} = 12.5 \text{ A treated per tankful}
\]

12.5 A per tankful \times 2 \text{ pints per A} = 25 \text{ pints of pesticide per tankful}

In this case you need to add 25 pints of the pesticide product to the sprayer holding 300 gallons to achieve a 2 pints per acre rate of application.

**How to Calibrate a Band Sprayer**

1. Measure the width of the sprayed band.
2. Locate this width in the table on page 221, and note the corresponding course distance.
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.
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 (gallons per acre) 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.

**Band Formulas**

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

or

\[
\text{Application rate (pounds per acre)} = \frac{43,560 \times \text{pounds collected}}{\text{distance traveled} \times \text{row width} \times \text{band width (feet)}}
\]
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 pre-marked calibration tube.
4. Select a ground speed and travel a measured course at that speed. The longer the course is, the more accurate the calibration will be.
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.

Granular In-furrow Application Formulas

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

\[
\text{Application rate} = \frac{1,000 \times \text{ounces collected}}{\text{distance traveled in feet}}
\]

or

\[
\text{Application rate} = \frac{43,560 \times \text{pounds collected}}{\text{distance traveled} \times \text{row width in feet}}
\]

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

- Place a vertical strip of tape inside each hopper.
- 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.
- Before and after treating a known acreage, check the levels. This will give you a rough estimate of the amount applied.
How to Calibrate a Handgun or Knapsack Sprayer

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

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.

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.

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.

Example:
- 3 gallons of clean water in backpack sprayer.
- Spray 1,000 square foot test area.
- 2 gallons remain in the sprayer. Used 1 gallon.
- 1 gallon of spray applied per 1,000 square feet equals 43.56 gallons per acre (1 x 43.56).

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

For precise application, you need to know the size of the area to be treated. The following examples show how to determine the size of rectangular, triangular, and circular areas.

Rectangle Areas

Area = length x width

Area in square feet (sq. ft.)
1,320 ft. x 120 ft. = 158,400 sq. ft.

Area in acres (A) = \(\frac{158,400 \text{ sq. ft.}}{43,560 \text{ sq. ft/A}}\) = 3.6 A

Note: 1 acre (A) = 43,560 sq. ft.

Triangle Areas

You are applying a pesticide to a triangular area that has a base of 325 feet and a height of 150 feet. What is the area?

Area = \(\frac{\text{base} \times \text{height}}{2}\)

Area in square feet = \(\frac{325 \text{ ft.} \times 150 \text{ ft.}}{2}\) = 24,375 sq. ft.

Area in acres = \(\frac{24,375 \text{ sq. ft.}}{43,560 \text{ sq. ft/A}}\) = 0.6 A

Circle Areas

If you have a circular area that has a 90-foot diameter, the radius (r) is 45 ft., what is the area?

Area = \(3.14 r^2\)  
Note: 3.14 (\(\pi\)) is a constant. 
Radius is 1/2 diameter.

Area in square feet = 
3.14 x 45² = 6,358.5 sq. ft.

Area in acres = \(\frac{6,358.5 \text{ sq. ft.}}{43,560 \text{ sq. ft/A}}\) = 0.15 A

Maintaining and Cleaning Equipment

There are three 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. If you mix a pesticide in equipment that has

Adapted from the National Pesticide Applicator Certification Core Manual, NASDARF
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.

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. Well maintained equipment is less likely to have something go wrong that could put the applicator or others at risk of pesticide exposure.

To protect the environment. Pesticide residues in, on, or released by application equipment can harm non-target organisms and wildlife. Keeping equipment well maintained reduces the chance for a burst hose or other equipment failure resulting in a pesticide incident that may contaminate soil or water or crops.

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.

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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, consider pesticide incompatibility, changes in effectiveness, and possible crop injury.

Chapter 7, Safe Handling, 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.
8. Always flush a new sprayer with clean water 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**

Pesticide users must wear all safety equipment specified on the label during mixing, loading, application, and cleanup. The use of other safety systems also helps prevent pesticide exposures, spills, and environmental contamination. These include closed mixing and loading systems (mechanical systems and water-soluble packaging), enclosed cabs, and pesticide containment systems (containment pads).

The equipment must be able to deliver the correct amount of pesticide to the intended target. A wide variety of pesticide application equipment is available, each suitable to a particular pest control situation. These range from small hand-held or backpack sprayers to large power sprayers. Applicators must understand the parts of the sprayer and how to adjust nozzles, spray volume, and pressure for reducing off-target drift.

Calibrate sprayer and granular application equipment to ensure the correct amount of pesticide is being applied. Before making an application, be sure your equipment is properly calibrated and that you know how to use the label information to calculate the correct amount of pesticide.

What it is all about—harvesting a good crop.
Photo: University of Minnesota Extension

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