Supplemental Sections

Chapter **8**

Section A: Application Technology

Section B: Calibration of Application Equipment

The following sections, taken from the Atlantic Canada Agriculture Pesticide Applicator Training Manual, complement Chapter 8 of the Atlantic Canada Pesticide Applicator Core Training Manual (2006 Edition) and deals with *Application Equipment* (Section A) and the *Calibration of Application Equipment* (Section B). Each section contains its unique set of learning objectives and outcomes.

Section A supplies the basic knowledge for understanding pesticide application equipment. Section B supplies the basic knowledge for calibrating pesticide application equipment required to qualify for commercial or professional Agriculture (Class B), Mixing & Loading (Class I) and Mosquito Control (Class H) Pesticide Applicator Certification in New Brunswick.

These supplemental sections are used in New Brunswick ONLY to qualify individuals for the following classifications for Pesticide Applicator Certification:

- Agriculture (Class B)
- Mixing & Loading (Class I), and
- Mosquito Control (Class H)

SECTION A:
PESTICIDE APPLICATION EQUIPMENT

Learning Objectives

Completing this chapter will help you to:

- **Identify types and parts of pesticide application equipment.**
- **Clean and maintain application equipment.**
- **Identify and interpret environmental factors for choosing application equipment.**

When you decide to use a pesticide, you then have to choose the proper equipment to apply the product. This section covers the types of pesticide application equipment. Information on how to adjust and use equipment safely is included. Environmental factors that you should consider are also discussed.

Types of Application Equipment

Pesticide application equipment can be very simple (e.g., hand-operated aerosol cans) or very complex (e.g., self-propelled boom sprayers).

Pesticide application equipment should be chosen based on:

- Size and type of area to be treated
- Crop
- Type of pest
- Pesticide formulation
- Method of application called for on the label

Most commonly used pesticide application equipment can be classed as follows:

- Liquid (spray) applicators
    - Hand operated
    - Motorized / mechanical
- Granular (solid) applicators
    - Hand operated
    - Motorized / mechanical

Liquid Application Equipment

Hand Operated

Spot spraying is often done using hand-operated sprayers. This lets you apply small amounts of pesticide to small areas. Most hand sprayers apply pesticides using compressed air. A hand pump is often used to provide the air. Common examples of hand sprayers include:

- **Pressurized aerosol cans** often contain less than one liter of pesticide. Aerosol cans produce very small spray droplets. They can only be used in small treatment areas.

- **Squirt-gun sprayers** force a pesticide through a gun nozzle. Squeezing a trigger creates pressure. Squirt-gun sprayers do not use a separate pressurized air source. These sprayers give an uneven application. They are mostly used in small areas.

- **Hose-end sprayers** consist of a pesticide tank attached to a garden hose. A preset amount of pesticide is drawn from the tank by suction. It is then mixed with water flowing from the hose. These sprayers can be used to treat larger areas than aerosol cans or squirt-gun sprayers. However, they can be unreliable. Dirty nozzles or changes in water pressure can vary the amount or concentration of pesticide applied.

- **Hand-pump sprayers** have plungers that force air out of a cylinder and into a tank. The pressure in the tank pushes the pesticide mixture out of the sprayer. This group of sprayers includes backpack sprayers.

A major problem with hand-operated sprayers is that pressure and output rate can vary. The risk of applicator exposure can also be high because the applicator works close to the spray.

Motorized & Mechanical

Motorized sprayers are used to apply liquid pesticide mixture to large areas. Pressure is achieved using a power-driven pump. There are several types of motorized and mechanical sprayers.

Field sprayers are generally used to treat large areas. Tank sizes range from 250 to 4,000 liters. Boom widths can be six meters or more. The tank and booms can be mounted several ways:

- On a three-point hitch frame
- On a separate trailer
- Carried on a self-propelled spraying unit

Field sprayers can be equipped with devices to improve control, accuracy, and safety. For example, electronic rate controllers adjust application rate by ground speed. Pesticide injection systems add pesticide to water during an application.

Air-assist sprayers are similar to field sprayers. However, they use an air stream to propel spray to the target. Boom widths are often similar in length to field sprayers. Air-assist sprayers produce finer spray droplets. This improves pesticide penetration and coverage without causing more spray drift. An air-assist sprayer can be more expensive than a field sprayer.

Air-blast sprayers are often used in orchards or on small fruit crops (e.g., apples and blueberries). Tank sizes range from 400 to 3,000 liters. Air-blast sprayers have nozzles placed in the air stream of a high-speed fan. The air stream propels fine spray droplets to the target.

The air stream frequently creates leaf movement. This allows for better pesticide coverage. Air-blast sprayers pose a greater risk of spray drift and applicator exposure than field sprayers.

Soil fumigation equipment is used to apply liquid fumigants. This equipment is similar to small field sprayers with respect to tank and boom size. It uses hose shanks rather than nozzles.

Hose shanks inject liquid fumigant into the soil where it will become a gas (volatilize). Toxic gases can be released during fumigation. Use extreme caution when handling fumigants and fumigation equipment.

Granular Application Equipment

Granular applicators are used to apply granular pesticide formulations. Granules do not drift. Granular application equipment comes in two types:

- **Hand shakers** are designed like saltshakers. These are often used in small areas, or for spot treatment applications.

- **Mechanical applicators**, which spread granules using:

    - Forced air
    - Spinning discs (fertilizer spreaders)
    - Multiple, gravity-feed outlets (lawn spreaders, seed drills)
    - Soil injectors (furrow treatments)
    - Air (aircraft application, pneumatic spreaders)

Granular applications can be used for broadcast work, furrow application, or soil incorporation (drilling or soil injection).

Other Application Equipment

There are a number of other types of pesticide application equipment. These include:

- **Wick applicators** are used to selectively apply liquid herbicides to weeds. The herbicide is poured into a long pipe wrapped in rope or other absorbent material. The herbicide seeps out of the pipe and is absorbed by the wicking material. This can then be wiped onto weeds that grow taller than the crop or between rows. Wick applicators are often used where drift could be a problem.

- **Dust application equipment** is used to apply powders. For example, dust application equipment is used to apply seed treatments to potato seed. This equipment either drops dust onto a crop, or uses air power to propel dust onto the target. Dust treatments create a lot of residue. Drift can be a problem.

When selecting pesticide application equipment, choose a type that will apply the proper amount of product to the target. You should aim for maximum pest control and minimum off-target drift.

Basic Sprayer Components

Sprayers are often complex and have many parts. Each part has a function. Applicators should know the basic parts of a sprayer. Knowing the equipment will help to ensure that pesticides are applied accurately, safely, and as the manufacturer intended. The following is a list of sprayer components:

Tank

The tank holds the spray mixture. Tanks come in a range of shapes, sizes, and materials. A good sprayer tank should be as follows:

- The tank should be made of strong materials that resist reaction and corrosion. Materials can include fiberglass, stainless steel, or polyethylene.
- The tank should be shaped to aid in agitation (mixing).
- The tank should be easy to fill and clean.
- The tank should have graduated markings. This helps to measure the tank contents.
- The tank should have inside baffles to prevent liquid pesticides from sloshing or spilling out of the tank.
- Tank shapes are often oval and cylindrical. Rectangular and flat-bottomed tanks are harder to agitate and clean.
- Tank size should be suited to the sprayer boom width and output.

Pump

The pump creates a flow of spray mixture from the tank to the nozzle. Choose a pump that meets the following application requirements:

- **Output and operating pressure** – Most pumps only work well within a given volume and pressure range. A pump should be chosen based on need. For example, roller pumps provide moderate volumes (100–300 L/ha) at low to moderate pressures (100–2,000 kPa). A centrifugal pump can provide high volumes (2,000 L/ha) at low pressures (50–350 kPa). Choose a pump that is larger than needed. While flow and pressure can be reduced, it is unsafe to exceed the manufacturer's stated range of use.

- **Pesticide properties (formulation type)** – Some pesticides (e.g., emulsifiable concentrates) are corrosive or can cause rubber parts (e.g., gaskets) to swell or break down. Wettable powders are abrasive and these can wear pump parts. When choosing a pump, consider the pesticides to be used.

The power supply

Most tractor-mounted sprayers use a power takeoff (PTO) drive. Some pumps can run on electric power (12V) from the tractor. Others are powered from a ground-drive mechanism.

A pump should be large enough to move the required volume of pesticide mixture to the nozzles at an even pressure. It should also provide enough agitation to keep the spray and carrier mixed.

A carrier is a substance used to assist pesticide application. It dilutes a product to make it easier to apply (or spray).

- **Water is the most common carrier used in liquid pesticide applications.**

Granular applications can use fertilizer or a similar product as a carrier.

Never run a pump dry. Pumps use spray mixture for cooling and lubrication. Never operate a sprayer pump at speeds or pressures greater than called for by the manufacturer. Pumps that are improperly used can wear out quickly. Improper use can also stress moving parts to the point of breakdown. Recommended pump speeds and settings will have to be followed to apply pesticides at the proper rate.

Common pump types include the following:

- **Roller pumps** are widely used because they are not expensive. They can be made from materials like Teflon or nylon. They are best suited for use with emulsifiable concentrates, soluble powders, and other non-abrasive pesticides. Roller pumps provide output volumes between 30 and 190 liters per minute. Pressures range between 100 and 2,000 kilopascals (kPa).

- **Gear pumps** are composed mostly of metal parts, which make them hard to repair. They are best suited for use with oil-solution formulations. Gear pumps operate at an output volume between 20 and 245 liters per minute. Pressures range between 150 and 700 kPa.

- **Piston pumps** can be used for low- or high-pressure applications. Their solid construction resists abrasion and wear. Maintenance costs are often high. Piston pumps that are properly used and cleaned will last a long time. These pumps are most often used with wettable powder formulations. Piston pumps operate with an output volume of 7.5 to 224 liters per minute. Pressures range between 150 and 5,500 kPa.

- **Diaphragm pumps** are designed to use with abrasive pesticide formulations. These operate at a wide range of volumes and pressures. Diaphragm pumps have the same basic parts as piston pumps. However, they are more widely used because of their lower maintenance costs.

- **Centrifugal pumps** are used for a wide range of spray applications. They are not expensive. Output can be as much as 760 liters per minute. Pressures range between 50 and 350 kPa.

Agitator

The agitator mixes the formulated pesticide and the carrier (often water). Agitators prevent suspended pesticides from settling out. The amount of agitation needed depends on the type of formulation. Too little or too much agitation can reduce pesticide performance.

Common types of agitation systems are:

- Mechanical
- Hydraulic
- Air sparging

Mechanical systems use paddles mounted on a shaft near the bottom of the tank. The paddles stir the contents of the tank. Careful maintenance is needed to ensure that shaft bearings do not wear. This can cause pesticide leaks.

Hydraulic systems return a portion of the pump output back to the tank. Return-line or bypass agitation is the simplest method of hydraulic agitation. It is also the least effective. Bypass agitation uses a return line from the pressure regulator valve. Hydraulic agitation does not always work well with wettable powders because they are hard to keep in suspension. To maintain proper mixing, a high-capacity pump should be used.

Good hydraulic agitation can be achieved by using a high-pressure flow of surplus spray mixture from the pump. This passes through a separate line and back into the spray tank.

Liquid usually flows through special nozzles (called jet agitators) in hydraulic agitation systems. These nozzles are found at the bottom of the spray tank. Hydraulic agitation tends to cause less trouble than mechanical agitation.

Air sparging is less common than mechanical or hydraulic agitation. However, it is an effective way to agitate a spray mixture. A compressor supplies air to a discharge tube at the bottom of the spray tank. Air bubbles are released and rise to the surface. The rising air bubbles mix the spray solution.

Filter

The filter on a sprayer prevents debris or particles in the spray mixture from breaking the pump or plugging the nozzles. Plugged nozzles result when you use filters that are damaged or the wrong size for the formulation.

Filters can be installed in different places. Filters in the tank opening prevent debris from getting into the tank when it is being filled. Filters between the tank and the pump protect the pump from damage. Filters behind the pump remove fine particles before they enter spray lines. Filters in nozzle bodies prevent them from clogging.

Follow the manufacturer’s guidelines on filter sizes to protect nozzles and pumps. Small nozzles require finer filters.

Pressure Regulator Valve (PRV)

The pressure regulator valve controls the output rate on most sprayers. The PRV controls the pressure and quantity of spray at the nozzles. It protects pump seals, hoses, and other parts from damage due to too much pressure. The PRV generally controls pressure by sending excess pump output back to the tank through a ‘return’ or ‘bypass’ line. The pressure range and flow capacity of the regulator should match those of the pump.

Electronic control systems use sensors to monitor the flow of the spray and the ground speed of machinery (e.g., the tractor). The operating pressure or ground speed can then be changed to get the desired nozzle output. Changes should remain within the proper range for nozzle and other system components. On some systems, the electronic PRV adjusts the flow of pesticide on its own to suit the ground speed. It can also alert the operator if the production application rate is above or below preset limits.

Pressure Gauge

The pressure gauge measures the sprayer's operating pressure. The pressure gauge is often set at a desired, initial pressure. Watch it closely for changes that can indicate application problems.

Gauges can be liquid-filled or dry. A liquid-filled gauge dampens pressure pulsations, and results in a steady reading. Dry gauges do not dampen pressure pulsations. This makes it hard to get a good reading. However, pulsation dampers can be used on dry gauges. The maximum pressure shown on the gauge should read to about twice the target operating pressure.

The best place to measure the sprayer's pressure is close to the nozzles.

Pipes & Hoses

Pipes and hoses that are under-sized can reduce pump capacity. Flow restrictions cause a drop in pressure. In turn, this can result in an uneven nozzle flow rate. Flow will be hampered by:

- Under-sized boom plumbing, controls, or fittings
- Under-sized or clogged filters
- Kinked or bent hoses

Hoses that draw pesticide from tanks (suction hoses) should be strong enough to resist collapse. They should also have the same diameter as the pump inlet openings. All hoses and fittings have to be able to handle the maximum pressure and maximum output used. This includes those hoses on the return side of the pump.

When replacing hoses and fittings, ensure that they are chemically resistant and able to handle maximum application pressures. Cheap or poor hoses can burst.

Nozzles

Nozzles are used to:

- Meter the amount of spray delivered (nozzle output)
- Break liquid into droplets
- Spread droplets in a given pattern

Nozzles come in a wide range of types and sizes. Check label directions to find out which nozzles are suited to the application of a given pesticide.

Common nozzle types include flat fan and hollow cone. Other nozzles are designed to deal with drift reduction, banding, or soil incorporation applications.

Most sprayers use nozzles that can be changed. Nozzle types vary by output capacity, spray pattern, and operating pressure.

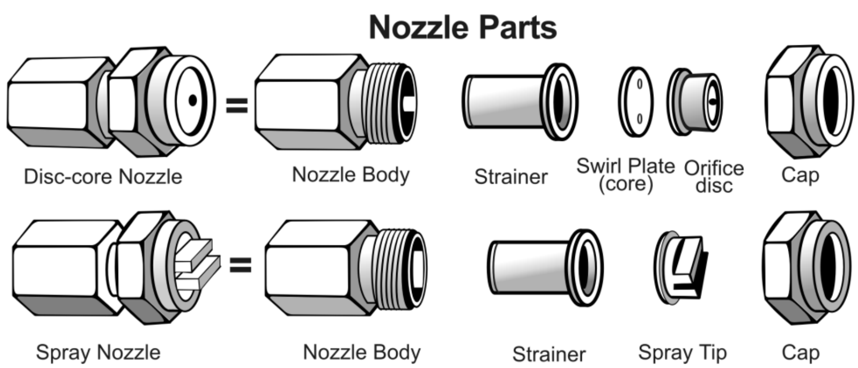


Figure 8-1: Nozzle parts

Most nozzles are composed of four parts: the nozzle body, the strainer (screen), the tip, and the cap.

Parts of the Nozzle

Nozzle body – The nozzle body holds the strainer and tip in place.

Strainer (screen) – The nozzle strainer or screen is placed in the nozzle body, just behind the opening. It filters out debris and prevents the opening from becoming clogged. Screens come in mesh sizes from 20 to 200. A larger number means that spaces in the screen are finer. For example, a 20-mesh screen will allow larger particles to pass through it than will a 100-mesh screen. To work properly, a screen should have mesh smaller than the nozzle opening. Screens should not be finer than 50-mesh when wettable powder formulations are used. Otherwise, they will quickly plug.

Tip – The tip of the nozzle creates the pesticide spray pattern. Tips are defined by their spray pattern. The most common tips used in farming applications are flat fan and hollow cone. Others include full cone, tapered edge, and flooding spray tips. Generally, tips can be inter-changed between nozzle bodies that are made by the same manufacturer.

Cap – The cap is used to secure the strainer and the tip to the body.

Choosing the Proper Nozzle Tip

Nozzle tips are made from a variety of materials. Choice of material often depends on the abrasiveness of the spray mixture to be used. Wettable powders are more abrasive than emulsions. Nozzle materials that wear quicker tend to cost less. The nozzle materials in Table 8-1 are listed in order of increasing rate of wear and decreasing cost.

The initial cost of nozzle replacement might seem high. However, replacing worn nozzles will pay off over time.

Nozzle Spray Patterns

Nozzles can be described by the shape of the spray pattern that they produce. There are many patterns available. Each nozzle type comes in a range of flow capacities and spray angles. Each is suited to a certain type of operation.

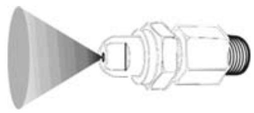
Nozzles should be checked regularly for spray pattern and output. This ensures label rate and on-target application. (*See* Section B: Equipment Calibration.)

Material	***Characteristics***
Brass	Poor wear life; susceptible to corrosion (more so with fertilizers)
Polymer	Good wear life; good chemical resistance; orifice can be damaged if not properly cleaned
Stainless steel	Good wear life; excellent chemical resistance; durable orifice
Hardened stainless steel	Very good wear life; good durability and chemical resistance
Ceramic	Superior wear life; highly resistant to abrasive and corrosive chemicals

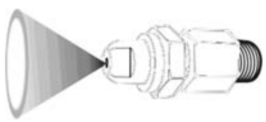
Table 8-1: Nozzle tip types

As nozzle tips wear out, spray patterns change and the application rate increases. Replace a nozzle if flow varies more than ten percent from the manufacturer's specifications or five percent from the sprayer's average nozzle output. Worn nozzles:

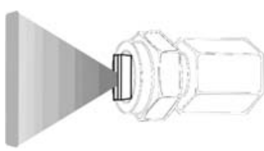
- Produce a poor spray pattern
- Waste chemicals and money
- Result in poor pest control
- Produce higher application rates



Full or solid cone nozzles are used where dense foliage requires a penetrating spray. Full or solid cone nozzles are most often used to apply fungicides or insecticides to row crop foliage when the plants must be fully covered with product.



Hollow cone nozzles are used when spraying at high pressures. They are often used for wettable powders, flowables, and suspensions. Hollow cone nozzles tend to produce a finer, more uniform spray than solid cone nozzles.



Even flat fan nozzles form a narrow oval pattern with a sharp cutoff at the edge. Even flat fan nozzles are used for band spraying. They are often used for applying herbicides. Boom height and nozzle spray angles affect the width of the band sprayed.

Other common nozzles types include the following:

- **Solid stream spray nozzles** vent a solid, directed spray. They are best suited for use when there is a large distance between the applicator and the target.

- **Flooding nozzles** vent a very wide spray pattern, and produce large, low-pressure droplets. They are best suited for general broadcast applications.

Swirl (disc-core) nozzles have a swirl plate (core) between the strainer and an orifice disc. This helps govern droplet size.

Nozzle Performance Characteristics

Each sprayer nozzle is designed to do a specific job with a particular type of pesticide formulation. They should be used as per pesticide label instructions.

Nozzles come with a wide range of performance characteristics. These include the following:

SPRAY ANGLE

Spray angle is the measurement (in degrees) of the spray angle formed by a single nozzle at a given pressure. Nozzles can be purchased in a number of standard spray angles. The most common flat fan nozzle angles are 65°, 80°, and 110°.

Wider nozzle angles provide even application with lower boom heights. Proper boom height depends on the spray angle and the nozzle spacing. Check the nozzle manufacturer's guidelines for the overlap required to achieve an even application.

NOZZLE OUTPUT

Nozzle output depends on the size of the nozzle opening and the spray pressure. With most nozzles, output increases as pressure increases. It takes a large increase in pressure to get a small increase in nozzle output.

Manufacturers often supply tables that show the nozzle output at a number of pressures.

Pressure must be increased four times to double the nozzle output.

VOLUME

The volume of spray to be applied per unit of area is often shown on the label of a pesticide. For example, when spraying a herbicide on a crop, the application rate may be in the range of 300 to 500 liters per hectare (L/ha). Fungicides and insecticides may be applied at 100 to 1,000 L/ha. Some treatments require drenches of at least 1,000 L/ha (e.g., to control cabbage maggot).

DROPLET SIZE

Droplet size is the size of a particle of liquid (measured in microns) that is formed as the spray mix is forced through the nozzle.

Micron

A unit of measurement one one-thousandth of a millimeter.

A nozzle forms a range of droplet sizes, from very small to large. A nozzle pattern tends to be made up of fine to large droplets. More droplets become fine as spray pressure increases.

Pesticide coverage tends to be better and cheaper when using smaller droplets. Unfortunately, spray drift is more likely to occur with small droplets. Evaporation and wind can move the spray away from the target. To improve coverage, increase the volume of spray by changing the nozzles. This is better than increasing spray pressures.

Refer to the manufacturer's specifications for detailed nozzle information. These specifications will provide a pressure range for nozzle use. Specifications will also provide the pressure range needed to maintain proper spray pattern, droplet size, and flow rate. Poor nozzle spray pressure settings, above or below optimum range, will decrease product efficacy and create an environmental hazard.

TeeJet brand nozzles		***Pressure (kPa)***	***Output (L/min)***	***Sprayer output at:***		
65º	***80º***			***6 km/h***	***8 km/h***	***10 km/h***
6500067	8000067	200	0.22	43	32	26
		275	0.25	51	38	31
6501	8001	200	0.32	64	48	39
		275	0.38	76	57	45
65015	80015	200	0.48	97	73	58
		275	0.57	113	85	68
6502	8002	200	0.64	129	97	77
		275	0.76	151	113	91
6503	8003	200	0.97	193	145	116
		275	1.13	227	170	136
6504	8004	200	1.29	258	193	155
		275	1.51	302	227	181

Table 8-2: Sample nozzle output table (TeeJet nozzles)

Granular Application Equipment

Granular application equipment is used to spread dry pellets or granules of pesticide. This equipment differs somewhat from the more traditional or liquid spray equipment. Basic components of granular application equipment include a storage hopper, metering mechanism, and distribution system.

Storage Hopper

The storage hopper holds the granular pesticide. Storage hoppers come in a number of shapes, sizes, and materials. The storage hopper should be strong, resist corrosion, and be shaped to help the granules flow. The hopper should also be easy to fill and clean. It should have graduated markings on the side to measure product.

Agitators can be installed in hoppers to prevent bridging (blockage) of granules. When a number of granules bridge or stick together, they form a clump. Large clumps can block or disrupt the flow of pesticide. The risk of granular pesticide bridging depends on:

- Characteristics of the pesticide formulation
- Shape of the hopper
- Air temperature and humidity during application

Coarse screens can be installed on hoppers to keep out clumps of product, debris, or pieces of the pesticide container. This will keep the drive mechanism from clogging.

Metering Mechanism

The metering mechanism commonly uses either gravity flow or positive mechanisms. These components release the required amount of product from the hopper at the desired rate.

Gravity flow-metering mechanisms simply drop pesticide down from the hopper. Openings can be adjusted in size to change the flow of pesticide. A hopper agitator is often used to provide a steady flow of granules to the opening.

Positive metering mechanisms use an auger or fluted-feed roll at the bottom of the hopper to control the flow of granules from the hopper. Positive metering mechanisms are more accurate than gravity flow-metering mechanisms.

Distribution System

The distribution system moves the granules from the equipment to the field. The type of distribution system often determines its classification. Broadcast application equipment and banding application equipment are common distribution types.

Broadcast application equipment applies granules over a field using:

- A wide hopper with closely spaced gravity flow openings (e.g., Gandy-type spreader)
- A single flow opening with a mechanical spreader (e.g., a Vicon wig-wag spreader, or spinner spreader)
- A pneumatic delivery system (Using this type of system, granules are blown from the metering system through a boom to outlets. A powerful fan produces a stream of high-speed air to carry the granules.)

Banding application equipment applies granules in narrow bands that often line up with crop rows. Untreated areas are left between the rows. Banding helps reduce pesticide use, as only a small area is targeted. Banding application equipment can use either:

- Simple spreaders to distribute granules across a desired band width on the soil, or
- Small drop tubes or soil openers (These place granules in well-defined bands under the soil near the seed.)

In Review

There are many types of pesticide application equipment. Hand-operated sprayers, motorized sprayers, and granular application equipment are the most common. Know the type of pest to be controlled and the pesticide formulation that you plan to use. This will help you to better select the proper application equipment. The pesticide label and equipment manufacturer will sometimes provide information on the best match between pesticide formulations and application equipment. Application equipment has a number of components to manage pesticide delivery. The proper choice of equipment is important for safe, economical pesticide use and effective pest control.

Cleaning Application Equipment

Cleaning and taking care of application equipment will help make sure future pesticide applications are effective. It can also extend the life of the equipment.

Poorly cleaned equipment can cause residues to accumulate in the tank (or hopper), hoses, and nozzles. Residues often harden with time. This makes the equipment harder to clean. A large accumulation of residue can cause the equipment to break down.

Leftover residues can also mix with new product when you use equipment the next time. This can alter the effect of the second pesticide and damage crops.

Always clean application devices before using them for the first time. New sprayers can contain dirt, oil, or chips of metal.

It can be hard to clean large spray booms and other equipment after each use. When it is being used often, smaller application equipment should be cleaned daily.

Always clean equipment before using a different pesticide, and before off-season storage.

Measuring containers should be cleaned after each use. Residues left behind can contaminate the next spray mix.

Read the product label for cleaning instructions. Some products provide specific instructions for cleaning application equipment.

Good Practice Guidelines

A product label does not always provide instructions for equipment cleaning. However, there are a number of general rules to follow for cleaning sprayers or granular application equipment.

Wear proper protective clothing when cleaning application equipment.

Remove excess pesticide and/or wash water in a place and manner that will not harm the environment.

Cleaning Sprayers

Detailed sprayer cleaning is required when changing the pesticide being used or getting equipment ready for storage.

Wash the outside of the tank with soap (or mild detergent) and water.

Remove nozzle tips and screens. Clean them in a strong detergent and water. Use a soft brush. Partly fill the spray tank with clean water. Flush this through the booms for at least ten minutes before draining. Boom sections should be flushed one at a time. This provides the high-pressure flow needed for thorough cleaning.

Repeat this rinse cycle if residue can still be seen.

Fill the tank nearly full with clean water. Add a cleaning agent such as household detergent (250 milliliters to 100 liters of water) or ammonia (1 L to 100 L of water). The pesticide product label may call for a certain cleaning agent. Circulate this product through the system. Agitate for at least 15 minutes. Spray out and drain completely.

Repeat the wash cycle.

Rinse twice with clean water and drain.

Make sure that cleaning solutions are completely rinsed from the tank. Detergent residues can mix with the next pesticide and change the effect of the product.

When cleaning equipment, wear chemical-resistant gloves, boots, hat, apron, and goggles. This prevents contact with pesticides.

Winter Storage

Residues can freeze if they are left in equipment that is stored at temperatures below 0^{o}C. This can crack and damage tanks, hoses, and pumps. Equipment should be drained and rinsed with alcohol if it is to be stored where it might freeze.

Pumps and hoses should also be flushed with antifreeze. Nozzles should be removed, cleaned, and stored in a warm, dry place. This avoids damage from freezing.

Cleaning Granular Application Equipment

Granular application equipment should be cleaned after each use. Hoppers, metering mechanisms, and distribution systems require thorough cleaning to work properly.

When cleaning granular application equipment:

- Remove all pesticide from the device. This might require taking off some parts of the equipment.
- Clean the inside of the hopper.
- Clean and oil the flow-control slides or valves.
- Wipe off excess oil if there is risk of it coming into contact with pesticide during the next use.

Winter Storage

At the end of the season, extra cleaning should be done. This will help ensure the equipment works properly next year:

- Protect plastic parts from direct sunlight during storage. This will extend their life.
- Use sandpaper or a wire brush to clean rusted parts. Paint the cleaned parts.
- Coat the inside of the hopper and metering system with oil. This prevents rust and corrosion.
- Oil or grease the bearings.

Protecting Human Health and the Environment

Cleaning pesticide application equipment can pose a hazard to human health and the environment. Pesticide applicators can use the following guidelines to keep personal and environmental risk to a minimum:

- Never blow out nozzle tips using your mouth. Use a toothbrush or soft material to clean nozzle tips.
- Never use a piece of wire, nail, or metal object to clean nozzle tips. These can damage the opening, distort the spray pattern, and increase nozzle output.
- Wear protective clothing and equipment when cleaning sprayers and measuring containers.
- Clean up puddles of rinse or wash water. These can be hazards to children, pets, farm animals, or wildlife.
- Do not injure plants with wash or rinse water.
- Clean the sprayer away from waterways, ditches, wells, or other water sources.
- Do not contaminate natural waterways with wash or rinse water.

In Review

Clean and take care of pesticide application equipment to ensure it continues to work properly. Poorly cleaned equipment can apply the wrong amount of pesticide to the target area. This can result in crop damage or poor pest control. Proper cleaning will protect the applicator and the environment from contamination.

Equipment should be cleaned:

- **At the end of each workday**
- **When changing products or crops**
- **At the end of the season when equipment is being stored**

Many types of application equipment have specific cleaning instructions. Check with the manufacturer for details.

Maintaining Application Equipment

Taking care of pesticide application equipment can save you time and money. Good maintenance reduces hazards and the cost of accidents and breakdowns.

Maintaining equipment also protects the environment and the applicator.

Equipment care starts at the time of purchase. Select equipment that fits the required application. Equipment wears out quickly when it is not suited to the job or if it is overworked. Some equipment parts require more frequent attention than others.

Pumps

Pumps are designed to provide even pressure during product application.

Pressure changes in the pump can result from plugged lines or screens, or from valve or piston wear. Pressure changes can also mean that the pump is too small for the volume of product required.

If you see a pressure change during application:

- Check and clear plugged lines or screens.
- Repair or replace pistons.
- Increase pump capacity.

Screens

Screens filter product before it enters the nozzles. Screens should always be kept clear of residue and debris. They should also be sized properly for the nozzles used. This ensures that nozzles can handle the size of the product delivered.

Constant plugging of nozzles and poor spray patterns can indicate that the wrong screen size is being used.

If you notice poor spray patterns, you should:

- Check screen size to ensure that it suits the nozzles.
- Clean debris from the nozzles.

Agitators

Agitators are designed to mix the product. They can be hydraulic or mechanical. Mechanical agitators require more care than hydraulic agitators. Mechanical agitators have moving parts (e.g., shaft, bearings, paddles) that wear. Hydraulic agitators tend not to have moving parts.

If product is not mixing properly:

- Check agitators for wear.
- Replace worn components.
- Confirm that the problem has been solved.

Plumbing

Plumbing in a sprayer includes the hoses and fittings that bring product to the nozzles. Damaged plumbing can leak or spill product. Sprayer plumbing should be checked regularly.

If a leak is noticed:

- Check hoses and fittings for cracks, leaks, or wear.
- Replace hoses or fittings that show excess wear or holes.

Nozzles

Nozzles deliver product to the target. Nozzles should be calibrated at least once a year. The applicator should watch for uneven spray patterns during use. To maintain an even spray pattern:

- Check the pesticide label for information on proper nozzle types and sizes.
- Regularly check and clean nozzles.
- Replace worn or damaged nozzles.
- Ensure that the nozzle type used will properly spread the pesticide.

Other Preventative Maintenance

Preventative maintenance is sometimes needed throughout the year. If equipment is used for a long period of time, it will need to be maintained more often. If left unused for a long time, it may require more detailed care before its next use.

To keep application equipment working well:

- Overhaul the pump annually.
- Check the tires for proper inflation. Air pressure will affect the size of the tire. This will alter application rate. Over-inflated tires increase bouncing. This causes uneven product application.
- Paint corroded equipment parts. Do not paint inside the tank or hopper.
- Store the equipment under cover.
- Drain and rinse the tanks and/or hoppers when not in use.
- Use gaskets and washers made of materials such as Teflon. Pesticide residues do not break these down.
- Add environmentally safe antifreeze to the pump in the off-season. Flush antifreeze through the sprayer lines and booms.

In Review

Taking care of application equipment will help to ensure its proper function. It will also help to maintain even pesticide application rates. Good maintenance prolongs equipment life. It also protects the applicator and the environment.

Check the manufacturer's specifications and guidelines for more details on equipment care.

A pesticide application should control pests with little risk to human health and the environment.

Application Technology and the Environment

Application can be affected by:

- Choice of equipment
- Product choice
- Time and place of application

These factors are under the applicator's control.

Factors such as temperature, wind speed and direction, and site conditions are beyond the control of the applicator. However, they must be taken into account when making pesticide application decisions. You should understand the role that each factor plays in pest control.

Application Equipment and Pesticide Drift

Wind or air movement will cause pesticide drift. Drift from a target site can reduce the effectiveness of an application. It can also harm nearby plants and animals. There are two types of pesticide drift:

Spray drift (particle drift) is the movement of spray droplets away from the target area. This occurs when the wind is strong enough to pick up and carry droplets. Small spray droplets are more likely to drift than larger, heavier droplets. Granules and powders can also drift to some degree.

Vapour drift is the movement of pesticide vapours. Some pesticides change to a vapour after spending time in the air or on a plant. This vapour can be carried to other areas and harm susceptible plants. Vapour drift depends on the state of the pesticide rather than the application method used.

Application Equipment and Droplet Size

To reduce spray drift, you must know how spray droplets behave. The most important factor affecting drift is the initial size of the droplet. Large droplets are heavier and less likely to drift than smaller droplets. "The bigger they are, the harder they fall." Equipment manufacturers commonly take this into account when designing low-drift nozzles.

Atomize

To form droplets by forcing liquid under pressure through a small opening, like a nozzle.

The most common nozzle is the flat fan. Hydraulic pressure is used to "atomize" spray into a wide range of droplet sizes. This range of droplet sizes provides a consistent result over a number of spray conditions. Small droplets provide better coverage on plants. However, they are more likely to evaporate or drift because they fall quite slowly once they leave the nozzle.

Applicators may prefer large droplets. Because these don't evaporate so quickly, the product can stay longer on the target. Large droplets do, however, pose problems. They have more momentum when leaving the sprayer and are more likely to bounce off the target. This means less coverage. **See Table 8-2 below**

For each application, you must consider the range of droplet sizes that will be best for a given situation. Insecticides and fungicides tend to require smaller droplets for good coverage on leaf surfaces. A medium or coarse droplet size is often used for foliar herbicide application.

Droplet size (Diameter in microns	***Time it takes for the droplet to fall three meters in still air***
1 (fog)	28 hours
10 (fog)	17 minutes
100 (fog)	11 seconds
200 (fine spray)	4 seconds
400 (coarse spray)	2 seconds
1,000 (coarse spray)	1 second

Table 8-2: Effect of droplet size on drift potential.[1]

[1] (Source: Ross, Merrill A and Carole, A Lembi 1985. Applied Weed Science. Burges Publishing Company, Minneapolis, MN)

Measuring Droplet Size

Droplet sizes are often measured in microns (micrometers). One micron equals 0.001mm (one-thousandth of a millimeter). One dime is about 1,270 microns thick. Droplets smaller than 100 microns are most likely to drift.

Factors Affecting Droplet Size

Managing droplet size is a simple way to reduce drift. Pesticide applicators can change the nozzle type or the spray pressure to manage droplet size.

Nozzle Type

The nozzle type plays the greatest role in determining droplet size. Applicators should select a nozzle type based on the:

- Pesticide used
- Type of pest
- Location of the pest
- Type and size of the target plant
- Weather at the time of application

Nozzles that work with higher outputs (greater volumes) apply a coarser spray. These often produce less drift. Higher outputs will mean that the tank will have to be refilled more often. However, the increased volume of water or carrier will improve coverage and increase pesticide effectiveness.

Manufacturers often include tables that define nozzles by flow rate at a given pressure. Colour-coding of newer nozzles follows a standard system. This allows an applicator to quickly identify the nozzle output (flow rate) by the colour of the nozzle. Older colour-coded nozzles might not match the new standard coding system.

Common Nozzle Types

The TeeJet® nozzle, made by Spraying Systems Co, is a common brand. Each nozzle has a number that describes its characteristics. Features include spray angle, output, and the materials used to make the nozzle.

The **TeeJet® 11002VS** is a flat fan nozzle often used to apply herbicides.
"110" describes the spray pattern angle at an operating pressure of 40 pounds per square inch (psi). 65° and 80° angles are also available.

“02” describes the output in U.S. gallons per minute at 40 psi (02 = 0.2 gal/min.).

“VS” describes the nozzle material (V = the colour code, S = stainless steel).

TeeJet® flat fan nozzles also have a letter system that appears before the nozzle number. The letters further describe nozzle features (*see* table below).

All nozzles operate within a range of pressures. Some have a wide range (Turbo Jet); others have a narrow range (Drift Guard).

Wider range nozzles provide the applicator with more choice of droplet sizes. This helps when coverage and drift are a concern.

Prefixes	***Description***	***Features***
XR	Extended Range	Provides a good spray pattern between 15 and 60 psi
DG	Drift Guard	Uses a pre-orifice design to create a coarse spray at standard pressures of (30 to 60 psi)
AI	Air Induction	Uses a venturi to draw in and mix air with spray liquid Coarse droplets are formed.
TJ	Twin Jet	Contains two orifices. One points slightly back and the other slightly forward. This provides a finer spray at a given nozzle rate
TT	Twin Jet	A swirl chamber and turbo-flood jet design are used to create a wide angle coarse spray under a pressure range of 15 to 90 psi.

Spray Pressure

Changes in spray pressure will affect droplet size. Pressure affects the way droplets are formed when they leave the nozzle. Lower pressures create larger droplets. Higher pressures create smaller droplets.

Some applicators believe that they get better spray penetration into the crop canopy when pressure is increased and the initial speed of the droplets is faster. **This is not the case.** Droplets will move faster at first, but this increased speed does not last.

Always operate a nozzle at the lowest pressure possible for the job. This will help to cut down on pesticide drift.

Environmental Factors Affecting Pesticide Drift

Applicators should plan around a number of environmental conditions at the application site. These include

- Temperature and humidity
- Wind speed
- Wind direction
- Air turbulence
- Temperature inversion

The best way to prevent drift is to make sure the sprayer:

- Has the proper settings
- Is fitted with the proper nozzles
- Is adjusted to the environmental conditions

Temperature and Humidity

Temperature and humidity affect pesticide evaporation. High temperatures and low humidity increase the rate of pesticide evaporation. Small droplets can fully evaporate and leave pesticide particles in the air. Particles can then be carried up to several kilometers away from the treatment site (vapour drift).

Wind Speed

Wind speed affects pesticide drift. High wind speeds increase the risk of pesticide drift. Drifting pesticide can settle on pastures, wildlife habitat, or waterways. This can then injure livestock, wildlife, beneficials (e.g., pollinators), fish or other aquatic life.

Pesticides that drift to residential property can harm people or pets. These can also damage lawns, trees, ornamental landscaping, and gardens.

Applicators can be held liable for any injury, property damage, or monetary loss resulting from pesticide drift on non-target areas. Always apply pesticides within recommended wind speeds to reduce drift. This limits the risk of damage to sensitive plants or animals. It also limits inhalation and contact risk to applicators and bystanders.

Many pesticide labels state the maximum wind speed for legal application. Provincial laws may also provide maximum wind speeds for product application. **Always follow the lower of these two wind speeds.**

Wind Direction

Wind direction is a major factor in off-target drift. Pesticides should not be applied if the wind is blowing toward:

- Susceptible crops
- Environmentally sensitive areas
- Residential or recreational properties

Apply a pesticide only when the wind is stable and blowing away from sensitive areas.

Air Turbulence

Air turbulence is caused when there is a large difference between the temperature of the air at ground level and the temperature of the air layer above. Air turbulence can also cause pesticide drift.

Upward air currents begin when air just above the soil is warmer than the air higher up. The larger the difference between these air temperatures, the stronger the air currents.

Air currents can carry spray droplets and pesticide particles far from the treatment area. Do not apply pesticides during turbulent air conditions.

Temperature Inversion

A temperature inversion occurs when the air near the soil surface is cooler than the air above it. Temperature inversions often happen at night when the earth cools. Warm air blocks the upward air movement that would otherwise disperse airborne chemicals. Wind will promote air mixing and reduce inversion conditions.

Low-level winds during a temperature inversion can cause small spray drops to remain in the air. These can then move out of a treatment area as a concentrated cloud. Do not apply a pesticide during inversion conditions. Wait until morning. If the temperature at ground level rises, the inversion should end.

Product Volatility

Each pesticide will have its own volatility. A volatile product will quickly change into a vapour or gas. Volatile products pose a higher risk of off-target drift.

The temperature during application plays a major role in product volatility. You can help to reduce evaporation by spraying only when temperatures are low.

Low volatility formulations reduce off-target drift. For instance, *2, 4-D* is sold in amine or ester formulations. Ester formulations are volatile. Only amine formulations should be applied near sensitive areas.

Practices to Reduce Pesticide Drift

There are a number of other ways to prevent spray drift.

Adjuvants

Use of adjuvants will impact droplet size. Adjuvants can also change physical properties, such as viscosity and the surface tension of the spray mix.

Each adjuvant affects droplet size in a certain way. This can depend on the formulation of the pesticide. Some adjuvants increase droplet size. Others have the opposite effect and may not produce expected results. Some adjuvants can have no effect on droplet size. Do not use adjuvants unless they are registered for use with a given pesticide product.

Buffer Zones

Buffer zones protect non-target areas from pesticide drift. Buffer zones are an untreated boundary around a treated area. Never apply a pesticide on the edge of a water body or other sensitive area. Leave a strip of untreated natural vegetation to protect the environment. Some product labels provide buffer zone statements, or directions for use near sensitive areas.

Individual Nozzle Hoods

Individual nozzle hoods shield spray droplets from wind for the first part of their journey from the sprayer. Some shroud the top portion of the spray stream. Other hoods cover the whole boom.

A near-perfect seal will have to be maintained at the front and back of the shields. This prevents air movement beneath the shields. Some boom hoods do not allow you to see sprayer nozzles during application. A monitoring system should be used to ensure proper application.

Timing of Application

Timing of application can affect pesticide drift. Product application during early morning or early evening can reduce the risk of pesticide drift. Wind speed is often lower and humidity higher at these times of day.

Avoid pesticide application during the middle of the day. This lowers the contact danger to wildlife such as birds, mammals, and pollinators that visit crops during this time.

Precipitation

Precipitation can also affect a pesticide. Spray applications should not be made just before rain. If rain falls right after application, the pesticide is likely to wash off. Pest control can then be lost.

Severe rain can cause runoff. This can wash pesticide onto non-target or sensitive areas. Nearby property, crops, or wildlife can then be harmed.

Specialized Application Equipment

Specialized application equipment includes wipers or wick-weeders that can be used to apply herbicide. No droplets are formed. There is no risk of spray drift.
For these applications to work, weeds should be higher than the crop. Weeds should also be the only plants wiped with the herbicide. Two passes, in opposite directions, are often needed to apply the herbicide.

Always read and follow pesticide label directions. Information will sometimes include directions to reduce drift. It can also provide steps to follow when using a product near environmentally sensitive areas.

In Review

Product drift is always a concern. There are a number of steps an applicator can take to reduce off-target drift.

Application equipment should be well maintained and calibrated. Choosing proper nozzles will reduce product drift. Attention to these factors will:

- **Ensure proper product application rates**
- **Provide better pest control**
- **Help protect the environment**

Environmental factors are always a concern. Key concerns to plan for include wind speed, wind direction, temperature, humidity, air turbulence, inversion, and volatility. These will impact how and when you apply product, and the effectiveness of the application.

Summary

Pesticide application equipment can be very simple or very complex. The type of equipment you choose to apply pesticides at any one time should be based on the:

Size and type of area to be treated
Crop to be treated
Type of pest you want to control
Pesticide formulation
Label recommended application method

Application equipment can be designed to apply either liquid or solid pesticide formulations. Either type of equipment is made up of a number of components. Knowing these components and how they work will help you make the most of your equipment. Cleaning and maintenance also helps the equipment work properly. The product will then be delivered as planned.

Calibration is used to determine output based on the:

Area to be covered
Speed of delivery
Rate of product required

Equipment will have to be calibrated to deliver product to the target at the recommended rate. If product is delivered at a different rate than recommended, it will not be as effective.

Product drift or runoff is always a concern when applying pesticides. There are a number of steps the applicator can take to reduce drift and runoff. These include choosing proper nozzles and taking wind, temperature, precipitation, and timing into account. Maintain buffer zones to protect sensitive environmental areas.

SECTION B: CALIBRATING APPLICATION EQUIPMENT

Learning Objectives

Completing this chapter will help you to:

- **Calibrate pesticide application equipment**.
- **Understand that calibration ensures that the correct amount of pesticide is applied.**
- **Know how to calculate the correct amount of pesticide required.**

Calibrating Application Equipment

Pesticide manufacturers conduct extensive research to identify the rate at which pesticides should be applied to be both effective and safe. Only properly calibrated equipment will deliver product at the desired rate.

The Importance of Proper Calibration

Pests can only be controlled when the pesticide is applied on target at the right rate. Calibration of application equipment will help:

- Ensure that pesticide will be applied uniformly
- Ensure that nozzle pressure forms droplet sizes that limit spray drift
- Result in the proper equipment output
- Meet label requirements
- Determine the amount of product and carrier to add to the spray tank

The wrong amount of pesticide can be applied if equipment is not calibrated. This can happen even if the amount of product required to treat an area has been properly calculated.

The application of too much pesticide can:

- Contaminate food crops
- Damage the environment
- Increase risk to human health

The application of too little pesticide can:

- Fail to control the pest
- Promote pest resistance
- Waste time and money
- Waste product

When equipment wears out or fails to perform, pesticide delivery rates will change. Faulty equipment parts can be identified during calibration.

Application equipment should be calibrated:

- Before it is used for the first time
- At the start of the season
- When travel speed, nozzle spacing, or nozzles are changed
- When equipment output changes
- When equipment is changed in any other way

Pre-calibration Sprayer Check

Application equipment needs to be in good repair before it is calibrated. A pre-calibration check includes the following:

- Repair and replace faulty hoses.
- Clean all screens and nozzles with a soft brush.
- Ensure that all nozzles on the boom are the same type and size. Nozzle spacing should be the same across the whole boom.
- Set the pressure gauge at the pressure that will be used. Run water through the system. Make sure that water flows through all nozzles.
- Check individual nozzle output. Make sure that each nozzle on the boom delivers the same volume of water (within 10 percent) over a given time. Make sure that spray patterns for each nozzle are even and consistent.
- Make sure the boom is level along its entire length. Set it at the desired height above the target (soil or plant). Check the nozzle manufacturer's specifications for proper nozzle height.
- Run the sprayer slowly over a dry, level surface. Check the spray pattern of clean water on the soil or surface. The pattern should be uniform.

Sprayer Output

Before using any pesticide, find out how much product needs to be delivered to the target. Each pesticide has its own application rate.

Liquid Formulations

Pesticide labels often give sprayer output as the amount of spray to be applied per unit of area. Some labels state exactly what the sprayer output should be. For example, this can be expressed as:

> **600 liters (L) of spray per hectare, or Apply in 200 to 600 L of water per hectare.**

Granular Formulations

Labels state application output as weight per unit of area. For example:

> ***Output should be 100 kilograms (kg) of product per hectare.***

Calculating Output

The label will not always dictate the exact output. It may tell you to:

> ***Apply until runoff, or Apply product to thoroughly wet foliage.***

In these cases, you will have to calculate the needed output to get the desired results. To do this, you will need to determine the amount of product that will need to be mixed and applied. Then, you will have to decide on the output for delivery.

Take the following into account when using liquid formulations:

Coverage required – Spraying to product runoff requires much more spray solution than spraying to wet the surface.

Surface to be treated – Dense foliage or porous surfaces can require more spray solution. There will have to be enough product to pass through and reach the pest.

Droplet size – A high sprayer output tends to mean that a coarser spray can be used. Coarser sprays use larger droplet sizes.

Mixing requirements – A high sprayer output means more water and more tanks of spray solution will be used. Frequent stops will be required to refill the tank(s).

Calibrating Sprayers

You can calibrate the sprayer once the pre-calibration check has been finished and output has been determined. There is more than one way to calibrate a sprayer.

One method of calibration is given below. This method assumes sprayer output in liters per hectare (L/ha).

To complete this equation, the applicator must know:

- The time it takes the tractor to travel 50 meters (measured in seconds)
- The average nozzle output (in milliliters)
- The nozzle spacing (in meters)

Step #1 – Measure the time

- Donald a 50-meter distance in a field.
- Select the tractor gear, RPM (throttle), and the speed that you will drive when spraying.
- Drive the 50-meter distance three times. Time each pass. Make sure the tractor is moving at the desired spraying speed for the whole distance.
- Calculate the average time of the three passes (measured in seconds).

Step #2 – Measure the average nozzle output

To determine the amount of product that will be delivered through each nozzle:

- Park the sprayer with the PTO engaged and the throttle set to the same RPM as in the test run.
- Adjust the pressure regulator to the desired working pressure with full flow to the boom.
- Collect the output from each nozzle for the average length of time needed to travel the 50 meters in the test run. Measuring output from each nozzle takes time, but it allows you to find those that need to be cleaned or replaced.
- Add the totals for each nozzle. Divide by the total number of nozzles.

For example, if you have 20 nozzles and a total of 10 liters of water, the nozzle output equals 0.5 liters per nozzle (10 liters divided by 20 nozzles = 0.5 liters per nozzle).

If the output from a nozzle is over or under the average by five percent, clean or replace the nozzle and screen.

For example, if the average nozzle output is 0.5 liters, a five percent change would be plus or minus (+/-) 25 ml or more per nozzle. A difference of less than 25 ml is acceptable in this example.

For nozzles that test outside the +/- five percent range, you should measure nozzle output again after the change is made.

Step #3 – Measure nozzle spacing

By this time, you know the average output per nozzle over the 50-meter test run. Now you need to know the spacing of the nozzles. This will help you to calculate how much product will be applied with each pass of the sprayer.

- Measure the distance (in meters) between two nozzles on the spray boom. The following formula will provide the output in liters per hectare (L/ha):

Sprayer output (L/ha) = average nozzle output (ml) / nozzle spacing (m) x 0.2*

$$\text{Sprayer output (L/ha)} = \frac{\text{average nozzle output (ml)}}{\text{nozzle spacing (m)}} \times 0.2^{*}$$

*** 0.2 is a constant factor to change units to L/ha.**

Use the following guide if you need to convert liters per hectare to another unit:

To determine:			
Liters per acre:	**liters per hectare**	**x**	**0.4**
Imperial gallons per acre:	**liters per hectare**	**x**	**0.09**
US gallons per acre:	**liters per hectare**	**x**	**0.11**

Example #1 – Calculating sprayer output in liters per hectare

1 **Time to travel 50 m:** (1,800 rpm in 6^{th} gear)

run 1 – 25.06 sec
run 2 – 25.39 sec
run 3 – 24.79 sec

Total = 75.24 / 3 runs

Average = 25.08 sec
Travel time = 25 sec

2

Nozzle #	milliliters (ml)
1	325 ml
2	320 ml
3	330 ml
4	325 ml
5	315 ml
6	315 ml
7	330 ml
Total	2,260 ml / 7 nozzles

Adjusting the Sprayer Output

Calibration can sometimes show that your equipment is not delivering the right output. Adjust the sprayer and test it again.

Sprayer output can be adjusted in one of three ways:

Change the pressure – Lower pump pressures deliver less spray than higher pump pressures. Any change in pressure will change the size of the spray droplets and the nozzle pattern. Keep changes in pressure small to maintain droplet size and nozzle pattern.

Change the nozzle size – Changing the nozzle size is the best way to make a greater change in sprayer output.

Change the travel speed – Driving more slowly will deliver more spray per unit of area. Changing the travel speed is an easy way to make small changes to sprayer output.

Use the following formula to determine the speed required to output the correct amount of product:

$$\textbf{Required speed} = \frac{\textbf{present speed (km/hr) x present sprayer output (L/ha)}}{\textbf{desired sprayer output (L/ha)}}$$

If you adjust pump pressure or change nozzle size, you should measure the nozzle output again. If you change travel speed, you do not have to re-measure nozzle output. Make sure that pump pressure does not change after a change to throttle RPM.

Calibrating Granular Application Equipment

Granular application equipment can use gravity feed, whirling discs (spinners), or air-blast methods to apply granules. Product output in kilograms per hectare (kg/ha) depends on the travel speed of the equipment, and the output of granules per minute (kg/min.). Equipment output per minute will depend on:

- The size of the adjustable hopper openings
- Size, weight, and shape of granules
- The roughness of the field

Granular application equipment will need to be calibrated for each batch of product used and for changing field conditions.

Consult the equipment manual for initial settings. Use the output settings called for, based on the type of granules to be used. Use the advised speed unless the surface is soft, muddy, or uneven. Use a lower speed in these cases.

Use the following steps to calibrate most types of granular spreaders:

Step #1 - Check the width of the application and application pattern

- Fill the hopper with granules.
- Drive a short, measured distance at the desired speed.
- Measure the width of the application area. Check that granules are evenly spread along the area.
- If the granule pattern is uneven, you may need to adjust the speed of the spinner. Or you may have to change the place on the spinner where the granules land. Follow the manufacturer's guidelines to do this.

Step #2 – Find the applicator output by measuring the actual amount applied to a measured test area

- Fill the hopper to half full with granules.
- Donald out a distance of 200 m or more.
- Collect the material discharged from the spreader in a bag or box as the tractor travels 200 m.
- Weigh the contents of the container. Calculate the applicator output per hectare using the following:

$$\textbf{Output} = \frac{\text{amount applied to test area (kg)} \times 10{,}000\ \text{m}^2\text{/ha}}{\text{distance travelled (m)} \times \text{width of application (m)}}\ \text{(kg/ha)}$$

Step #3 - Adjust the applicator output

If you calibrate the equipment and discover it is not delivering the required rate, adjust the output. To change the applicator output:

- Adjust the granule output setting on the spreader. Repeat calibration.
- Adjust the travel speed.
- Use the following formula to calculate the speed required to obtain a desired output:

$$\textbf{Required speed (km/hr)} = \frac{\text{present speed (km/hr)} \times \text{present applicator output kg/ha)}}{\text{desired applicator output (kg/ha)}}$$

Use these same steps to calibrate pneumatic spreaders. In this case, measure output in grams, not liters.

Pneumatic spreaders are highly specialized. The manufacturer will provide detailed calibration instructions. Consult these instructions for more information.

Calculating Pesticide Rate

The pesticide rate is the amount of product applied per unit of area or per plant. In Canada, the pesticide rate is displayed on the label as either liters per hectare (L/ha) or kilograms per hectare (kg/ha).

Proper calibration of application equipment by itself does not guarantee the correct amount of pesticide will be applied to a given area. Calibration only ensures uniform output at the target speed. To make sure the pesticide is delivered exactly as required, you will also have to prepare the correct amount of pesticide to treat a given area.

Directions for mixing pesticide are given on the product label. Labels also provide application rates. A few simple calculations will help you to plan for, buy, and mix the right amount of pesticide for each job.

A pesticide label is a legal document. Applicators must use the product only for the pests and crops (livestock) listed. The given application rate must be used.

What happens when too much or too little pesticide is applied? Too much pesticide can damage crops or harm other plants or animals. Extra pesticide can stay on the target as residue or run off into the soil. Too little pesticide may not control the pest problem. It can also lead to pest resistance. In this case, both time and money are wasted.

Use the following steps to calculate the amount of pesticide and water to add to the spray tank. You will need to know the output of the application equipment.

Determining how much product you need – Before you purchase pesticide product, you will need to know:

- The size of the area to be treated
- The application rate
- The number of applications to be made to the area

This will help you to determine the amount of pesticide needed.

Step #1 – Area to be treated

To determine the area of square or rectangular fields, measure the width and length of the area to be treated. Multiply these measures to determine the area in hectares or acres, as below:

For hectares = $\frac{\text{length (m) x width (m)}}{10{,}000\ m^2/\text{ha}}$

For acres = $\frac{\text{length (feet) x width (feet)}}{43{,}560\ ft^2/\text{acre}}$

Step #2 – Number of applications

Decide how many applications of each product you expect to make during the season. Do not buy more product than you plan to use in one season. This will reduce the amount of pesticide product on site. It will also limit the storage space required.

Check the product label to find the pesticide application rate recommended for the given pest and crop.

Example # 1 – Determining how much product you need

Imagine that you need to apply the same insecticide for control of aphids to two fields this season. The first field is 700 m by 225 m in area. The second field is 325 m by 530 m in area.

The label application rate is 2 L/ha. The label states the maximum application is two applications per season. You expect to need two applications this season.

1 Area: Field # 1 = $\frac{\text{700 m x 225 m = 15.75 ha}}{10{,}000\ m^2/\text{ha}}$

+

Field # 2 = $\frac{\text{325 m x 530 m = 17.23ha}}{10{,}000\ m^2/\text{ha}}$

Total area 32.98 ha

2 Application rate = 2 L/ha

3 Number of applications in one season = two applications

4 Quantity of product required =

2L/ha x 32.98 ha x 2 applications = 131.92 L

The total amount of pesticide required is 131.92 L (132 L). Purchase an amount closest to this.

Step #3 – Determining the area covered by one full tank of product

You now know the amount of pesticide you need. Next, you must calculate the area one full tank will cover. You will need to know the calculated sprayer/spreader output to do this.

To determine the area covered by one full tank, divide the tank capacity by the sprayer or spreader output. Output is found by calibrating your sprayer or spreader.

Area covered by one full tank of product:

<u>tank size</u> (L) = number of hectares one tank will cover sprayer output (L/ha)

<u>tank size</u> (gal) = number of acres one tank will cover sprayer output (gal/ha)

Be sure you know whether your sprayer is measured in US gallons or Imperial gallons.

1 US gallon = 3.79 liters
1 Imperial gallon = 4.55 liters

Example #1 – Determining the area one full tank will cover

A farmer has a 1,000 kg hopper. He wants to know how many hectares can be covered when spreading a granular herbicide at the label-recommended rate of 175 kg/ha.

$$\text{Number of hectares (ha)} = \frac{\text{1,000 kg (full tank)}}{\text{175 kg/ha (rate)}} = 5.7 \text{ ha}$$

One full tank will deliver product at the recommended rate to 5.7 hectares.

How much product to add to a full tank – You now know the area covered by a full tank. Next, you can calculate how much pesticide mix needs to be prepared.

Multiply the area covered by one tank of pesticide by the application rate that you will be using.

How much concentrated product to add to a full tank:

Area covered by one tank (ha) x application rate (L/ha or kg/ha) = amount of concentrated product to add to the tank

Area covered by one tank (acres) x application rate (L/acre or kg/acre) = amount of concentrated product to add to the tank

Example #2 – Determining how much concentrated product to add to a full tank

A full spray tank covers five hectares. A fungicide needs to be applied at the label-recommended rate of 0.6 kg/ha. How much fungicide needs to be added to the tank?

Fungicide to add = 5 ha x 0.6 kg/ha = 3 kg

Three kilograms of product should be added to the tank.

How much product to add to a partial tank – You may need to calculate a partial tank to finish an application.

Use the following formulae to find the amounts of water and product needed for a partial tank:

Pesticide needed for a part tank:

Area to be sprayed (ha) x pesticide application rate (L/ha or kg/ha)

Area to be sprayed (acre) x pesticide application rate (L/acre or kg/acre)

Water needed for a part tank:

Area left to spray (ha) x sprayer output (L/ha)

Area left to spray (acre) x sprayer output (gal/acre)

Example #3 – Determining all necessary spray application information

A farmer's field is 550 m by 600 m. He plans to apply one herbicide using the label rate of 1.7 kg/ha. The label calls for a water volume of 200 to 300 L/ha.

The farmer has just re-calibrated the sprayer to an output of 250 L/ha. The sprayer tank holds 1,500 liters when full. The farmer must now calculate:

- **The size of the treatment area**
- **How much herbicide is needed**
- **The area covered by one full tank**
- **How many full tanks need to be applied**
- **How much herbicide and water is needed to complete the field (if a part tank is needed)**

Example #3 – *continued*

The farmer uses the following formulae:

1. **Treatment area = length (m) x width (m)**
   = 550 m x 600 m = 30,000 m^2
   and $\frac{30,000\ m^2}{10,000\ m^2/ha}$ = 33 hectares

2. **Herbicide needed = area to treat x application rate**
   = 33 ha x 1.7 kg/ha = 56.1 kg

3. **Area covered by one tank = $\frac{\text{tank size (L)}}{\text{sprayer output (L/ha)}}$ = $\frac{1,500\ L}{250\ L/ha}$**
   = 6 ha

4. **Amount of pesticide to add to one tank = area covered by one tank x pesticide rate = 6 ha x 1.7 kg/ha = 10.2 kg**

5. **Number of full tanks to mix = $\frac{\text{total area}}{\text{area covered by one tank}}$**
   = $\frac{33\ ha}{6\ ha}$ = 5.5 (round to 5 full tanks)

6. **Area left to cover = total area - (total area covered by full tanks x number of full tanks) = 33 ha – (6 ha x 5 full tanks) = 33 ha – 30 ha = 3 ha**

7. **Amount of herbicide to add to part tank = area left to cover x pesticide application rate = 3 ha x 1.7 L/ha = 5.1 L**

8. **Amount of water to add to part tank = area left to cover x sprayer output = 3 ha x 250 L/ha = 750 L**

The farmer will need to buy 56.1 kg of herbicide to cover 33 hectares with one application. He will need to mix five sprayer tanks with 1,500 L water and 10.2 kg of herbicide. One partial tank with 750 L water and 5.1 kg of herbicide will also be needed to cover the entire field.

Example #4 – Determining all necessary granular application information

A 2.5-hectare field of blueberries requires a granular herbicide application using a spinner spreader with a 200-kilogram hopper. The spinner spreader was calibrated to output at a rate of 10 kg/ha.

1. **Total amount of herbicide needed = total area x herbicide rate**
   = 2.5 ha x 10 kg/ha = 25 kg

Example #4 – *continued*

2 Area covered by one full hopper = hopper size (kg) / spreader output (kg/ha)

= 200 kg / 10 kg/ha = 20 ha

The total area to cover is less than the area of one full hopper. A partial hopper must be calculated.

3 Amount of pesticide needed to cover treatment area of 2.5 ha

= area to cover X herbicide rate

= 2.5 ha X 10 kg/ha = 25 kg

This blueberry field will require 25 kg of herbicide in the hopper to treat at a rate of 10 kg/ha.

In Review

Calibration involves the checking and adjusting of delivery rates of pesticide application equipment. Equipment that is properly calibrated and used will deliver the correct amount of pesticide in an even pattern.

There are a number of calibration procedures you should be familiar with. You will have to use an accurate calibration method to suit the type of application equipment.

The manufacturer, or equipment professionals who offer calibration services, can provide more detailed information on calibration, sprayer pressures, choosing nozzles, and equipment output.

Case Study: Upgrading a pesticide Sprayer

Donald recently inherited the family farm from his father. He produces forages, small grains, and corn. Donald has been thinking about taking out a loan to upgrade equipment on the farm. He has identified the ten-year-old pesticide sprayer as the first piece to replace. It is important to upgrade the sprayer because pesticides are very costly and they can harm the environment when applied incorrectly. Before buying a new sprayer, however, Donald called a local equipment specialist. He wanted to get an estimate of the cost to bring his old sprayer up to standard.

When the specialist arrived, he was sure Donald's sprayer could operate much better after some basic maintenance. He first removed all of the nozzles and screens. These were cleaned using a strong detergent. Over time, nozzles and screens will become clogged with pesticide residue. This will affect both output and spray pattern. Nozzles and screens should be removed and cleaned at least once a year. Cleaning should be done more often when pesticide formulations that do not dissolve well (e.g., wettable powders) are used.

Donald had often left excess pesticide mixture in his sprayer. Over time, chemical residue had built up in the spray lines and the tank. This residue can be slowly released into future tank mixes. Even small amounts of residue can reduce the effectiveness of the pesticide being applied. It can also damage crops or the environment. To remove this chemical residue, the equipment specialist rinsed the tank and lines with water and detergent. This was followed by a clean water rinse. All rinse water was run through the system and sprayed out where it would not harm humans or the environment.

Now that the sprayer was clean, the nozzles and screens were put back together to check the spray pattern. The sprayer was partly filled with clean water. The desired pressure was selected, and the spray patterns were visually assessed. Nozzles will wear out over time and produce poor spray patterns. This can cause non-uniform droplets to reach the target. Any nozzle having a poor pattern was replaced.

Once the poor nozzles were replaced, the sprayer system was tested at multiple pressure settings. Donald tested the sprayer between the pressure ranges that he would most often use. He did this to see if the pump was in good order. During this pressure test, Donald also checked all lines and fittings for leaks.

Next, the sprayer was calibrated to find the output from each nozzle. If a nozzle output was found to be +/- ten percent of the average total output, it was replaced. Nozzles that do not provide the right pesticide output will result in a poor application rate. This will waste money. It can also reduce pest control and harm the crop or the environment.
Proper calibration is needed to find the total output of a sprayer. This will allow the correct amounts of pesticide and water to be added for a given treatment area. After cleaning, calibration, and nozzle replacement, Donald's sprayer delivered an even, constant output across the width of the boom.

Donald was concerned about off-target drift. He was also concerned with using the correct amount of pesticide per hectare. The specialist suggested that Donald purchase a set of "new technology" nozzles that use lower pressure and create larger droplets. These nozzles reduce pesticide drift.

The specialist also suggested the purchase of an electronic sprayer controller, designed to keep the application rate constant. As the tractor moves through the field and changes ground speeds, the electronic controller will open or close the control valve. This provides a constant product application rate.

Donald was pleased with the results of his work. With the calibration of his sprayer, and the purchase of the sprayer controller and low-drift nozzles, he now has fewer worries about the function of his “ten-year-old sprayer”. He also has a sprayer that works very well, and he didn’t have to invest a lot of money. He knows that if he takes better care of the sprayer, it will last him for a few more years.

Self-study Questions

Answers are located in Appendix A of this manual.

1 You wish to apply a pesticide at a rate of 45 L/acre. The forward travel speed is 8 km/h and the nozzle spacing is 50 cm. What nozzle capacity (L/minute) do you require?

a) 7.40 L/min
b) 0.74 L/min
c) 1 L/min
d) 0.074 L/min

2 Practices that will help to reduce pesticide drift include:

a) avoiding early morning and early evening application
b) using buffer zones
c) spraying just before rain
d) using individualized nozzle hoods
e) B and D only

3 During a calibration test, you used a tractor with a 15-meter boom, and travelled 100 meters. How many hectares were covered in this test? How many acres were covered? (Use the following conversions)

1 hectare = 10,000 square meters
1 hectare = 2.47 acres

a) 2.47 acres / 1.5 hectares
b) 0.37 acres / 0.15 hectares
c) 3.70 acres / 1.5 hectares
d) 100 acres / 2.47 hectares

4 Which of the following droplet sizes will stay suspended in air for the longest period of time?

a) 1 micron
b) 10 microns
c) 100 microns
d) 1000 microns

5 Vapour drift can negatively affect off-target plants and animals. Which of the following practices will help to minimize vapour drift?

a) apply a less volatile pesticide
b) apply with a wiper or wick-weeder
c) apply a pesticide with an adjuvant added
d) apply a pesticide during weather conditions that limit evaporation (overcast, low humidity)
e) A and D only
f) A and C only