KNOWLEDGE OF SPRAY EQUIPMENT CONTRIBUTES TO APPLICATOR EFFICIENCY

By John Kerr, Assistant Editor

Knowing how spray equipment functions not only makes someone a better applicator, but can save valuable time during work or back at the shop. A basic understanding of the spray system can provide, at the least, an intelligent and time-saving report of a malfunction, should one occur.

Since Green Industry operations often expand into new arenas, a sprayer used on lawns may also have to spray trees. "It makes no sense to have a system for each application," says Ed Gray, sales engineering manager of Spraying Systems Co. Also, many new and improved pesticides have recently become available and costs have risen sharply. Consequently many users have had to replace or modify their sprayers or spraying methods to meet changing requirements or to improve efficiency.

Once you've decided on what chemical to spray, you need to know how to spray it. "The chemical does the work; it just has to be applied at the proper rate and time, according to the manufacturer's specifications," says Gray. "If you have the right equipment, you're halfway there."

The right equipment on a spray system, according to the Weed Science laboratory manual written by Dr. William Meggitt and Jack Dekker of Michigan State University, consists of five basic components. These are the tank, nozzles, agitator, pump, and regulating devices. Much of the authors' research follows.

All possible uses for a spray system should be considered before purchasing a unit.

Tanks

Tanks for large scale spray systems are non-pressurized. These can be large (generally the bigger the greater the soil compaction problems) without being prohibitively expensive. In this system, a pump produces liquid pressure at the nozzle. Pressure exists in the system only from the pump to the nozzles. There is usually a suction from the tank to the pump. Non-pressurized tanks should be mounted so that the bottom of the tank is above the pump.

Tanks should be made of, or coated with, a corrosion-resistant material, such as stainless steel, aluminum, plastic, fiber glass, and steel with or without coatings. Chemicals may be corrosive to certain materials and care should be taken to avoid using incompatible equipment.

Keep tanks clean and free of rust, scale, dirt, and other contaminants. Solid particles from a tank can quickly wear out a pump and nozzle tips. Dirt may collect in the nozzle and restrict the flow of chemical resulting in improper rates of application. Debris from the tank can clog strainers and restrict flow of spray through the system.

Flush the tank with clean water after spraying is completed. A tank with a drain hole near one end permits tilting the tank to allow for complete drainage. An opening in the top large enough for internal inspection, cleaning, and service is desirable.

A volume sight gauge on the tank aids in efficient spraying. On metal tanks a clear plastic tube mounted on the end, marked off in gallons, works well. On clear plastic or fiber glass tanks, place marks on the side of the tank to indicate gallons.

If you are applying a chemical that requires agitation, keep the agitator running at all times when the chemical is in the tank. It is recommended to agitate the mixture in the tank before spraying. If the equipment is shut off and the chemical settles out, it may be very difficult to get the chemical into suspension.

Nozzles

Sprayer design and modification starts with the selection of the proper nozzles for the type of spraying to be done. It is the nozzles that break the liquid into droplets of optimum size, form the spray pattern and propel the droplets in the proper direction. The nozzles also determine the rate of chemical distribution at a particular pressure, forward speed, and nozzle spacing. Only after the nozzles have been selected and their total volume and pressure requirements measured (or computed) can the other elements of the sprayer be chosen or properly adjusted.

People involved in several different operations, such as spraying herbicides or insecticides, usually need to change their nozzles and orifice tips. Basically the same nozzles work well for landscape and turf care that work for agricultural purposes. A boom can have one nozzle or 20 depending on how wide of a swath you want. To a sprayer's pump-tank package, you can attach a boom to spray the lawn, a boom or gun to spray one side of a right-of-way or ditch, and a heavy-duty spray gun to hit the tops of trees. "The bottom line is the proper application rate, which is controlled by the spray tips," says Ed Gray. "Tips and nozzles are a minor investment compared to the whole rig, but since they control the rate of application, they are very important in terms of calibration, performance, and choice."

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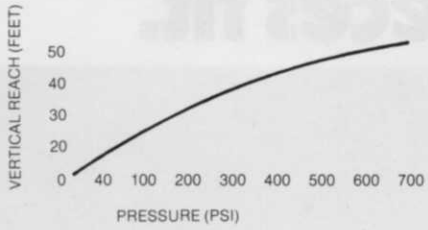

Height limitations of spray systems and nozzles should reduce wasteful and ineffective spraying over certain heights.

Table 1. Wear Comparison of Common Nozzles

Nozzle Material	Life Compared to Brass
Plastic or Nylon	Same
Aluminum	Same
Stainless Steel	3.5 times
Hardened Stainless	10 to 15 times
Tungsten Carbide	150 to 200 times

Table 2. Summary of Nozzle Types and Their Uses

Nozzle Type	Distribution of Droplets	Main Use
Flat Fan	Uniform when the boom is at the proper height. Best for broadcast spraying.	Herbicides or insecticides.
"Even" Spray	Not uniform for broadcast spraying. Good for band spraying.	Herbicides.
Full or Hollow Cone	Not uniform when used on a boom.	Insecticides.
Flooding Fan	Not uniform as flat fan nozzle.	Liquid Fertilizer and herbicides.
Boomless	Not uniform. Very poor in wind.	Herbicides in waste places.

Nozzle tips are made from several types of material. The most common types include brass, aluminum, nylon, stainless steel, and hardened stainless steel. Brass and aluminum tips are the cheapest, but the metal is softer and the tips wear faster. Nylon tips resist corrosion and abrasion, but some chemicals cause nylon to swell. Tips made from harder metals cost more, but wear longer. Tests have shown that 2,4-D may wear nozzles enough to increase the rate of chemical flow 8 percent in a period of 50 hours. A 10 percent increase may not be readily noticeable, but if 150 acres is sprayed with a chemical that costs $5 more per acre, a 10 percent increase in spray volume will cost $75 more.

Each nozzle on a spray rig should apply the same amount of chemical. Collect the discharge from each nozzle and compare the output. If the discharge from one nozzle varies more than 10 percent above or below the average of all the nozzles, replace it.

Do not mix nozzles of different materials, different discharge angles, or gallon capacity on the same sprayer. Any one of these will produce uneven spray patterns.

If spray nozzles become clogged from foreign matter or from contact with soil, care must be used in cleaning. It is best to disassemble the nozzle and blow out the dirt with compressed air. A soft bristled brush such as a toothbrush can also be used. Never use a nail or wire to clean the nozzle because they can easily damage it.

Nozzle spray patterns vary to accommodate a particular broadcast application. Table 2 summarizes the various nozzle types and their uses.

With a flat fan nozzle, the spray droplets arrange in a fan shape as they leave the spray nozzle. Less material applies along the edges of the spray pattern, so the patterns of adjoining nozzles must be overlapped to give a uniform spray across the length of the boom. Normal operating pressure is 30 to 40 psi which may cause drift. Lower pressures will reduce this. It can be used for most herbicides and some insecticides where penetration through the leaves is not required.

The "even" spray nozzle produces a fan-type pattern, but uniformly distributes the spray across a width. This pattern is ideal for band spraying where there is no overlap from other nozzles. Operating pressures of 40 psi will reduce the possibility of spray drift. Width of the band is dependent upon the nozzle placement above the ground.

A hollow cone nozzle produces a spray pattern with most of the liquid concentrated at the outer edge of a conical pattern. This nozzle is used mainly for applying insecticides, fungicides, and certain postemergent herbicides where complete coverage of the leaf surface is very important. Use the hollow cone pattern for low volume applications where a fine spray pattern is needed for thorough coverage. Use the solid cone spray pattern for high volume application where dense foliage requires a coarse spray for good penetration around plant leaves.

The flooding fan nozzle produces a wide, flat spray pattern that you can direct outward, down, or up. Use it for any application requiring wide coverage at low pressures with large droplets. The flooding nozzle works well for applying herbicides and mixtures of herbicides and fertilizers and it will operate at lower pressures than flat fan nozzles with less drifting.

A boomless nozzle consists of a cluster of nozzles capable of spraying widths of 30 to 60 feet. It suits spraying of roadsides, ditch banks, and right-of-ways. The spray is more susceptible to drift than nozzles mounted on a boom, and the distribution across the swath is not as uniform.

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A line strainer, or suction hose and strainer, is necessary to prevent rust, scale, and other foreign particles from damaging the pump and clogging the nozzles. For most emulsifiable chemicals used, a screen of 100 mesh should go in the line strainer and nozzles. If wettable powders are used, so should screens of 40 or 50 mesh to allow unrestricted flow.

The chemical package label of a pesticide usually recommends the proper pressure for spraying. Low pressures of 30 to 40 psi are usually sufficient for spraying herbicides or spreading fertilizer, but high pressures up to 400 psi may be needed for spraying insecticides or fungicides.

Since nozzles are designed for a certain pressure range, they must be used as such to get the proper application rate. Higher pressures increase the delivery rate, reduce the droplet size, and distort the spray pattern, which results in spray drift and uneven coverage. Lower pressures reduce the spray delivery rate and the spray material may not form a full spray pattern. A minimum pressure of at least 20 psi is usually necessary to produce a good spray pattern with most nozzles.

Agitator

Another item that must be considered before selecting the power package for a sprayer is the need for agitation. Liquid concentrates, soluble powders, and emulsifiable liquids require little agitation. But to keep wettable powders in suspension so that the chemicals will not settle out, causing the application rate to vary, requires intense agitation. This comes by means of a separate agitator, either a jet type or mechanical.

A jet agitator operates by a return pressure line hooked into the system directly behind the pump and should be positioned in the tank to provide agitation throughout. For a simple orifice jet agitator, a flow of 6 gpm per 100-gallon tank capacity is usually adequate. There are several types of suction venturi attachments available that help stir the liquid with less flow. With these, the agitator flow from the pump can be reduced to 2 or 3 gpm per 100-gallon tank capacity.

A mechanical agitator with a shaft and paddles will do an excellent job of maintaining a uniform mixture, but is usually more costly to install than a jet agitator.

Pump

Those who use their sprayers for several different kinds of spraying—herbicides for different weed control problems, insecticides, or fertilizers—face the need to change nozzles or noz-

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zle placement, to provide more agitation, increase ground speed, or apply chemicals at higher rates. Often these changes result in a need for a different or larger pump.

A sprayer pump must have sufficient capacity to operate the agitators as well as to supply the nozzle requirements. In fact it is recommended that the pump capacity be 20 percent greater than the sum of these requirements for the largest volume sprayed. This will allow for sufficient capacity if the pump wears and loses some strength.

If you plan to buy or build a sprayer, it's a good idea to anticipate what applications you may be using it for to determine the proper pump. Often, a pump works fine for two different jobs. For example, Myron Koistinin, applications engineer for Hypro, a Div. of Lear Siegler, Inc., says: "For lawns and trees, you can have a small spray boom that you can pull with a garden-type tractor and in addition have a hose reel that's set up on the trailer frame and a handgun to spot spray trees." Yet, he adds, if you use a field sprayer which requires relatively low pressure, it may not interchange for the high pressure needs of a tree sprayer.

The pump parts should resist the corrosive and abrasive effects of chemicals so that if wear or damage does occur it can be serviced easily. Other things to consider are pump cost, pressure requirements, ease of priming, and power source available.

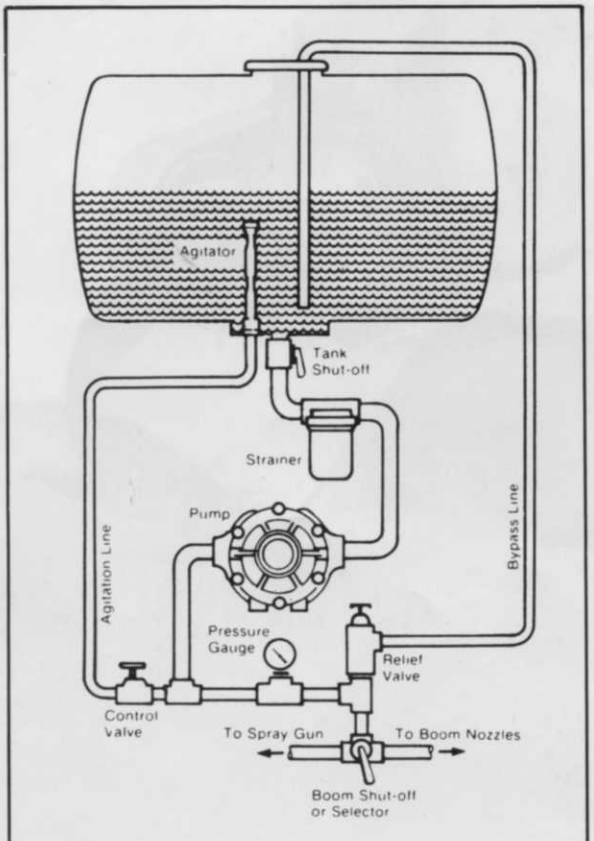

Figure 1. Roller pump system.

Most of the pumps used on weed and pest control sprayers are of three general types:

1. Roller or rotary pumps with rolling vanes
2. Centrifugal pumps
3. Piston pumps

Roller pumps have enjoyed wide popularity due to their low initial cost, compact size, easy repairability, and efficient operation at tractor PTO speeds. Moreover, their volume and pressure ranges are adequate for most spraying jobs.

A slotted rotor in the pump revolves in an eccentric case and the rollers move in and out radically to seal the spaces between the rotor and the wall of the case. As the rollers pass the outlet port, these spaces contract again directing the fluid out. Pump capacity is determined by the length and diameter of the inside case, its eccentricity, and the speed of rotation. The pressures produced by roller pumps will range to 300 psi and capacity at low pressures will range up to 300 gpm.

Roller pumps come with cast-iron or corrosion-resistant housings and nylon, Teflon, or rubber rollers Nylon rollers have proved to be the most resistant to chemicals and are recommended for multi-purpose sprayers. Sand or scale in the chemical being pumped is very abrasive to the rollers. Roller pumps should have factory-lubricated ball bearings, stainless steel shafts, and replaceable shaft seals. If bearings contain a grease fitting, do not overgrease them to cause damage or bearing failure.

Figure 1 shows the recommended hookup for roller pumps. The control valve is placed in the agitation line so the bypass flow is controlled, which will regulate the spraying pressure.

To adjust the system, close the control valve and open the boom shut-off valve. Start the sprayer, making sure flow is uniform from all spray nozzles, and adjust the relief valve until the pressure gauge reads about 10 to 15 psi above the desired spraying pressure. Slowly open the control valve until the spraying pressure is reduced to the desired point. If the pressure will not come down to the desired point, replace the agitator nozzle with one having a larger orifice. If insufficient agitation results when spraying pressure is correct and relief valve is closed, use a smaller valve for the same pressure.

Roller pumps are usually installed directly on the tractor PTO shaft. Anchor the pump to the tractor with a chain. This will allow the pump to move and reduce wear on the bearings if any misalignment exists.

Centrifugal pumps have become increasingly popular in recent years. They handle wettable powders and abrasive materials very well and their high capacity (70 to 130 gpm) provides plenty of volume for operation of hydraulic agitators in the tank.

They are capable of developing pressures up to 170 psi, but volume falls off rapidly about 30-40 psi. This steep performance curve is an advantage as it permits controlling pump output without a relief valve. However, high sensitivity to speed and inlet pressure variations makes for uneven pump output under some operating conditions.

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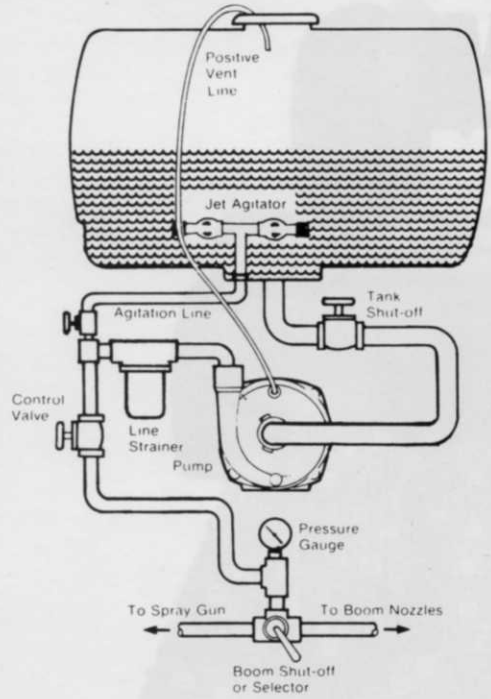

Figure 2. Centrifugal pump system.

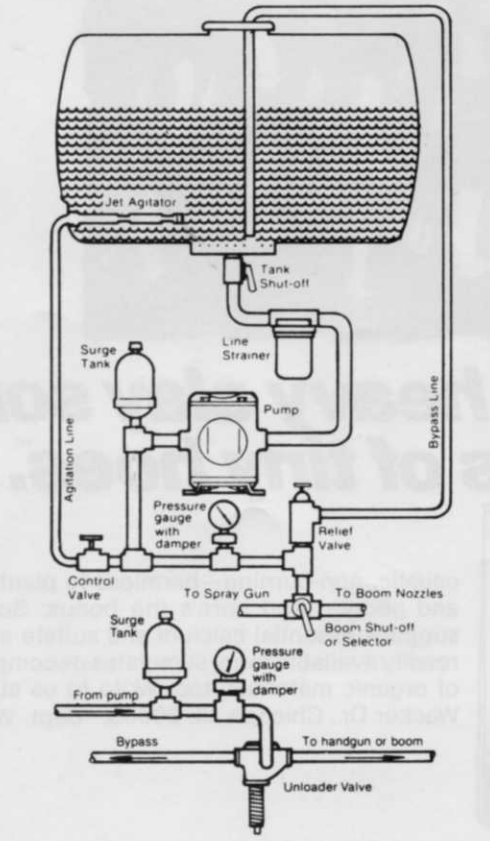

Figure 3. Piston pump system.

The need to operate at high speeds (3,000 to 4,500 rpm) requires some sort of speed-up mechanism to convert the speed of the PTO shaft to pump operating speed. The simplest of these and least expensive is an assembly of belts and pulleys.

Some pumps are built with a planetary gear system, in which the gears are completely enclosed and mounted directly on the PTO shaft. A direct connected hydraulic motor that operates off the tractor hydraulic system and will maintain a more uniform speed and output also drives centrifugal pumps. This frees the tractor PTO shaft for other uses. On some larger sprayers, particularly those used for applying herbicides on public lands, the pumps are driven by direct coupled gasoline engines.

Centrifugal pumps should be located below the supply tank to aid in priming the pump and maintaining a prime. Figure 2 shows the changes from roller pumps.

A small plastic vent tube leads from the top drain opening in the pump housing back to the tank. This positive vent allows the pump to prime itself by bleeding off trapped air when the pump is not operating. The small stream of liquid that flows back to the tank when the pump is operating is usually of little concern. No relief valve is used, since the pump is not a positive displacement type.

The final modification is the use of two control valves in the pump discharge line, one in the agitation line and one to the spray boom. This permits controlling agitation flow independent of nozzle flow.

To adjust for spraying, open the boom shut-off valve. Start the sprayer running and open the control valve to desired spraying pressure. Then open the agitation line valve until sufficient agitation is observed. If spraying pressure drops, readjust the control valve to restore desired pressure. Make sure flow from all nozzles is uniform.

A piston pump is a positive displacement pump, which means that its output is proportional to speed and virtually independent of pressure. It works well for wettable powders and other abrasive liquids. Either rubber or leather piston cups permits adapting the pump to water or petroleum based liquids and a wide range of chemicals. Lubrication of the pump is usually not a problem.

Piston pumps, although more expensive than other types, are dependable, highly adaptable, and have long life.

Larger sized models have capacities to 25 gpm and develop pressures to 600 psi. They usually require a surge tank at the pump outlet to reduce line pulsation.

Figure 3 shows the connection diagram for a piston pump. It is similar to a roller pump, except that a surge tank has been installed at the pump outlet. A damper in the pressure gauge stem reduces the effect of pulsation. When pressures above 200 psi are used, the relief valve should be replaced by an unloader valve. This will reduce the pressure on the pump when the boom is shut off.

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To adjust for spraying, open the control valve and close the boom valve. Then adjust the relief valve to open at a pressure 10 to 15 psi above spraying pressure. Open the boom control valve and make sure flow is uniform from all nozzles. Then adjust the control valve until the gauge reads desired spraying pressure.

Other less common pumps include the gear, flexible impeller, sliding vane impeller, diaphragm, and internal idle gear. Gear pumps work best at low pressures spraying pesticides that do not contain abrasive materials. The flexible impeller will handle mildly abrasive materials as well as a number of other chemicals which will not scratch the housing or cause the impeller to deteriorate.

Selecting the right pump is very important. "The type, volume, and physical nature of a pump determines whether you can add to a spraying system," says Bob Oberg, engineer at Broyhill. "Municipalities and many private operators at golf courses and lawn care companies will buy a good quality pump to begin with because it gives them a wider range of abilities." Oberg says his company sells a lot of large piston pumps where operators can use them for low pressure boom spraying and high pressure hand gun spraying. "Many turf spray operators will have a pumping system which can adapt to a variety of jobs more than agricultural sprayers, and are easily able to add a boom or handgun if they didn't already have one."

It should be noted that for spraying tall trees, it is more effective to increase the nozzle size than pump pressure. The greater the nozzle capacity and the narrower its spray pattern, the higher it will reach. Spraying Systems' Ed Gray says that at 40 psi, his company's sprayer can shoot 38 feet. You would have to increase the pressure to 800 psi to shoot 65 feet. Unless you treat many tall trees, it would not be economical to buy a high capacity pump. An interchangeable orifice tip is the most practical way to extend your spray reach, according to Gray.

Regulatory devices

A pressure regulator with by-pass line is needed to control the pressure, and thereby the delivery rate, of the liquid in a spray system. Since the actual discharge rate of any system is determined by the pressure at the nozzles, a pressure gauge should be mounted as near to the boom as possible.

A pressure gauge should have a total range twice the maximum expected reading. It is important that the gauge reads accurately and dependably. When calibrating, it is recommended to measure the discharge rate at a specific pressure on the gauge. If corrosive chemicals or a piston pump are used on a sprayer, install a gauge protector to prevent damage.

Screens in the main line, and before each nozzle, are needed to prevent foreign matter from entering the spray system and blocking the flow or changing the spray pattern. Screens should not be finer than 50 mesh if wettable powders are used. Boom controls are also needed to regulate which boom sections are operating at any given time.

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A relief valve is designed as a safety device to release liquid from a pressure system or line when the pressure exceeds a set level. By setting it to open at a desired spraying pressure, it is continuously bypassing any excess chemical back to the tank. It must be large enough to handle the entire pump capacity when the boom is shut off.

On spraying systems which operate at pressures over 200 psi, an unloader valve should be used in place of a relief valve. This unloads the pressure from the pump when the boom is shut off.

Boom control valves will direct the flow of chemical to a portion of the boom, the entire boom, or shut off the flow completely. Two types of flow controls are available: a manual control, which is mounted in the spraying hoses so it is accessible by the operator, and an electronic control. Nozzles mounted on sprayers should contain check valves which open at about 5 to 7 psi. These help prevent nozzle drip around edges.

Among other factors to consider for a spray system, along with the basic anatomy and the skill to adapt it to various purposes, are adjusting spraying volume, calculating the amount of pesticide needed, and mixing the chemical in the tank. Meggitt and Dekker offer the following tips:

Adjusting spraying volume

There are three basic methods for adjusting the volume of liquid sprayed:

1. Change the nozzle tips: This is the best method for making major changes (greater than approx. 25 percent) in the delivery rate of the sprayer. A smaller orifice in the nozzle tip means less spray delivered, and a larger orifice increases the delivery rate. Always select the nozzles for the job you want done.

2. Change the pressure: This is the least desirable method because pressure change will alter the nozzle pattern and droplet size. Reducing the pressure too much greatly reduces the spray angle and increases droplet size so plant coverage may be inadequate. Increasing the pressure increases production of small droplets and may contribute to an unacceptable drift problem. Also, a relatively large change in pressure is required for smaller changes in volume.

3. Change the speed of travel: This method is practical for smaller changes (less than about 25 percent) in delivery rate. The rate of delivery is inversely proportional to the speed; i.e., slower speed means more spray delivered, and a faster speed means less spray delivered per unit area. Slower speeds usually do not adversely affect a pesticide's performance, but too much speed increase may cause too wide a droplet distribution for acceptable chemical performance.

In some cases, it may be desirable to change all three variables. For example, you may wish to increase the spraying speed without changing the number of droplets or droplet size. Therefore, you could increase the nozzle size to partially compensate for the required increase in volume, and then increase pressure to reduce the droplet size from the larger nozzle and to increase the volume to the final target rate.

A sprayer cannot safely be calibrated from calculations, because of variations in speedometers, pressure gauges, hose sizes, nozzle wear, etc. The calculations will be near the desired rates, but a final calibration test is essential.

Calculation of the amount of pesticide needed

Many different approaches work to calculate the amount of pesticide needed. Which formula is not important as long the correct rate is obtained. The following are formulas for dry and liquid formulations that suit many problems:

1. Dry formulations: (wettable powders, granules, soluble powders, dusts, baits) Remember that commerical pesticides rarely are 100 percent pure active ingredient. Therefore, more weight of commercial pesticide is needed than active ingredient.

$$\text{pesticide weight/unit area} = \frac{\text{weight active ingredient/unit area desired}}{\text{percent active ingredient in product (expressed as a decimal)}}$$

2. Liquid formulations: (emulsifiable concentrates, flowable solutions) A ratio frequently is used to calculate amount of liquid formulation needed with one side of the ratio being the concentration of active ingredient per unit volume (pint, quart, gallon).

$$\frac{\text{weight of active ingredient}}{\text{volume containing the weight of active ingredient}} = \frac{\text{weight active ingredient/unit area desired}}{\text{volume of product/unit area}}$$

Guidelines for tank mixing

These guidelines are not a substitute for following label directions, but generally are the best procedure when more specific guidelines are not provided.

1. The sprayer tank must be clean. Oil, grease, old chemical residues, and other organic substances can be a primary cause of incompatibility.

2. Fill the tank at least one-half full to two-thirds full with water or the liquid fertilizer. Turn on the agitator immediately.

3. Premixing the pesticide with water or liquid fertilizer can substantially reduce compatibility problems. Premixing can be made in buckets.

4. The compatibility agent sometimes can be added to the premix or last to avoid foaming. Follow instructions provided with it.

5. Add the pesticide slowly to the sprayer tank. A wetting basket of cloth or 20 to 25 mesh screen over the tank filling port will assure slow addition to the tank, along with screening out lumps and foreign material.

6. Add the different pesticide formulations in the following sequence:

A. Soluble powders—must be completely dissolved in the tank before adding other pesticides. Pre-dissolving in water or in liquid fertilizer is desirable.

B. Wettable powders—make a slurry in water or the liquid fertilizer and add slowly to the sprayer tank.

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This will avoid the possibilities of invert emulsions.

D. Emulsifiable concentrates—generally can be added slowly and directly to the sprayer tank. If compatibility or an invert emulsion occurs, premix in water or liquid fertilizer and add slowly to the sprayer tank.

E. Soluble liquids—usually can be added slowly and directly to the sprayer tank, or premixing in water or liquid fertilizer may be required.

7. Finish adding the remaining water or liquid fertilizer. Maintain good agitation at all times, although too vigorous agitation may cause foaming or incompatibility problems. If agitation should stop for any reason, be sure that the contents are fully agitated again before starting to spray.

8. If an incompatible mixture forms in the sprayer tank, add a compatibility agent to attempt dispersal.

9. Use the spray mixture as quickly as possible. Clean the sprayer thoroughly when finished. Most pesticides are formulated with organic solvents that may damage organic sprayer components such as hoses and gaskets. Some pesticides are corrosive and may damage the pump, tank, or other metal parts if allowed to remain too long in a tank. The label will contain special instructions if a certain sprayer part is especially susceptible to damage from the pesticide formulation.

These guidelines along with a working knowledge of a sprayer's anatomy should help an applicator analyze his own equipment needs and diagnose problems, to a certain extent, when they affect his equipment. Manufacturers are also very willing to help with choosing and adapting the proper spraying equipment for your needs. As Hypro's ad manager, Al Henjum, says, you may very likely change applications and not always know what equipment changes are also necessary. "The key," he says, "is to have the whole system in balance." **WTT**

We'd like to thank manufacturers of spraying equipment for their cooperation in this article. A special thanks goes to William Meggitt and Jack Dekker of Michigan State University whose manual is an excellent and comprehensive text on the subject of spraying equipment. If you'd like a copy of their lab manual for Weed Science contact Michigan State University Press, E. Lansing, MI 48824.