Spray Equipment and Calibration

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Many pesticides used to control weeds, insects, and disease in field crops, ornamentals, turf, fruits, vegetables, and rights-of-way are applied with hydraulic sprayers. Tractor-mounted, pull-type, pickup-mounted and self-propelled sprayers are available from numerous manufacturers to do all types of spraying. Spray pressures range from near 0 to over 300 pounds per square inch (PSI), and application rates can vary from less than 1 to over 100 gallons per acre (GPA). All sprayers have several basic components: pump, tank, agitation system, flow-control assembly, pressure gauge, and distribution system (Figure 1).

Figure 1. Typical agricultural spray system. (20KB b&w illustration)

Properly applied pesticides should be expected to return a profit. Improper or inaccurate application is usually very expensive and will result in wasted chemical, marginal pest control, excessive carryover, or crop damage.

Agriculture is under intense economic and environmental pressure today. The high cost of pesticides and the need to protect the environment are incentives for applicators to do their very best in handling and applying pesticides.

Studies have shown that many application errors are due to improper calibration of the sprayer. A North Dakota study found that 60 percent of the applicators were over or under applying pesticides by more than 10 percent of their intended rate. Several were in error by 30 percent or more. A study in another state found that four out of five sprayers had calibration errors and one out of three had mixing errors.

Applicators of pesticides need to know proper application methods, chemical effects on equipment, equipment calibration, and correct cleaning methods. Equipment should be recalibrated periodically to compensate for wear in pumps, nozzles, and metering systems. Dry flowables may wear nozzle tips and may cause an increase in application rates after spraying as little as 50 acres.

Improperly used agricultural pesticides are dangerous. It is extremely important to observe safety precautions, wear protective clothing when working with pesticides, and follow directions for each specific chemical. Consult the operator's manual for detailed information on a particular sprayer.

Pump and Flow Controls

Asprayer is often used to apply different materials, such as pre-emergent and postemergence herbicides, insecticides, and fungicides. A change of nozzles may be required, which can affect spray volume and system pressure. The type and size of pump required is determined by the pesticide used, recommended pressure and nozzle delivery rate. A pump must have sufficient capacity to operate a hydraulic agitation system, as well as supply the necessary volume to the nozzles. A pump should have a capacity of at least 25 percent greater than the largest volume required by the nozzles. This will allow for agitation and loss of capacity due to pump wear.

Pumps should be resistant to corrosion from pesticides. The materials used in pump housings and seals should be resistant to chemicals used, including organic solvents. Other things to consider are initial pump cost, pressure and volume requirements, ease of priming and power source available.

Pumps used on agricultural sprayers are normally of four general types:

- Centrifugal pumps
- Roller or rotary pumps with rolling vanes
- Piston pumps
- Diaphragm pumps

Centrifugal Pumps and Controls

Centrifugal pumps are the most popular type for low-pressure high-volume sprayers. They are durable, simply constructed, and can readily handle wettable powders and abrasive materials. Because of the high capacity of centrifugal pumps (130 gallons per minute [GPM] or more), hydraulic agitators can and should be used to agitate spray solutions even in large tanks.

Pressures up to 80 PSI are developed by centrifugal pumps, but discharge volumes drop off rapidly above 30 to 40 PSI. This "steep performance curve" is an advantage as it permits controlling pump output without a relief valve. Centrifugal pump performance is very sensitive to speed (Figure 2), and inlet pressure variations may produce uneven pump output under some operating conditions.

Figure 2. Centrifugal and roller pump performance. (10KB b&w graph)

Centrifugal pumps should operate at speeds of about 3,000 to 4,500 revolutions per minute (RPM). When driven with the tractor PTO, a speed-up mechanism is necessary. A simple and inexpensive method of increasing speed is with a belt and pulley assembly. Another method is to use a planetary gear system. The gears are completely enclosed and mounted directly on the PTO shaft. Centrifugal pumps can be driven by a direct-connected hydraulic motor and flow control operating off the tractor hydraulic system. This allows the PTO to be used for other purposes, and a hydraulic motor may maintain a more uniform pump speed and output with small variations in engine speed. Pumps may also be driven by a direct-coupled gasoline engine, which will maintain a constant pressure and pump output independent of vehicle engine speed.

Centrifugal pumps should be located below the supply tank to aid in priming and maintaining a prime. Also, no pressure relief valve is needed with centrifugal pumps. The proper way to connect components on a sprayer using a centrifugal pump is shown in Figure 3. A strainer located in the discharge line protects nozzles from plugging and avoids restricting the pump input. Two control valves are used in the pump discharge line, one in the agitation line and the other to the spray boom. This permits controlling agitation flow independent of nozzle flow. The flow from centrifugal pumps can be completely shut off without damage to the pump. Spray pressure can be controlled by a throttling valve, eliminating the pressure relief valve with a separate bypass line. A separate throttling valve is usually used to control agitation flow and spray pressure. Electrically controlled throttling valves are popular for remote pressure control and are installed in an optional bypass line as shown in Figure 3.

Figure 3. Spray system with centrifugal pump. (22KB b&w illustration)

A boom shut-off valve allows the sprayer boom to be shut off while the pump and agitation system continue to operate. Electric solenoid valves eliminate the need for chemical-carrying hoses to be run through the cab of the vehicle. A switch box which controls the electric valve is mounted in the vehicle cab. This provides a safe operator area if a hose should break.

To adjust for spraying with a centrifugal pump (Figure 3), open the boom shut-off valve, start the sprayer and open the throttling control valve until pressure comes up to 10 PSI over the desired spraying pressure. Then adjust the agitation control valve until good agitation is observed in the tank. If the boom pressure has dropped slightly as a result of the agitation, readjust the main control valve to bring the pressure up to 10 PSI above spraying pressure. Then open the bypass valve to bring the boom pressure down to the desired spray pressure. This valve can be opened or closed as needed to compensate for system pressure changes so a constant boom pressure can be maintained. Be sure to check for uniform flow from all nozzles.

Roller Pumps and Controls

Roller pumps consist of a rotor with resilient rollers that rotate within an eccentric housing. Roller pumps are popular because of their low initial cost, compact size and efficient operation at tractor PTO speeds. They are positive displacement pumps and self-priming. Larger pumps are capable of moving 50 GPM and can develop pressures up to 300 PSI. Roller pumps tend to show excessive wear when pumping abrasive materials, which is a limitation with this pump.

Material options for roller pumps include cast-iron or corrosion resistant NI-resist housings; nylon, polypropylene, teflon or Buna-N-rubber rollers and Viton, Buna-N or leather seals. Nylon rollers are used for all-around spraying; they are suitable for fertilizers and weed and insect control chemicals, including suspensions. Buna-N rollers are used for pumping abrasive suspensions and water.

Polypropylene rollers have proved to be excellent for water handling applications and have approved wear characteristics. Teflon rollers have also demonstrated multi-use chemical handling ability. Roller pumps should have factory-lubricated sealed ball bearings, stainless steel shafts, and replaceable shaft seals.

The recommended hookup for roller pumps is shown in Figure 4. A control valve is placed in the agitation line so the bypass flow is controlled to regulate spraying pressure. Systems using roller pumps contain a pressure relief valve (Figure 5). These valves have a spring-loaded ball, disc or diaphragm that opens with increasing pressure so excess flow is bypassed back to the tank, preventing damage to sprayer components when the boom is shut off.

Figure 4. Spray system with a roller pump. (21KB b&w illustration)

Figure 5. Pressure relief valve. (13KB b&w illustration)

The agitation control valve must be closed and the boom shut-off valve must be opened to adjust the system (Figure 4). Start the sprayer, making sure flow is uniform from all spray nozzles, and adjust the pressure relief valve until the pressure gauge reads about 10 to 15 PSI above the desired spraying pressure. Slowly open the throttling control valve until the spraying pressure is reduced to the desired point. Replace the agitator nozzle with one having a larger orifice if the pressure will not come down to the desired point.

Use a smaller agitation nozzle if insufficient agitation results when spraying pressure is correct and the pressure relief valve is closed. This will increase agitation and permit a wider open control valve for the same pressure.

Piston Pumps and Controls

Piston pumps are positive displacement pumps, where output is proportional to speed and independent of pressure. Piston pumps work well for wettable powders and other abrasive liquids. They are available with either rubber or leather piston cups, which permit the pump to be used for water or petroleum based liquids and a wide range of chemicals. Lubrication of the pump is usually not a problem due to the use of sealed bearings.

The use of piston pumps for farm crop spraying is limited partly by their relatively high cost. Piston pumps have a long life, which makes them economical for continuous use. Larger piston pumps have a capacity of 25 to 35 GPM and are used at pressures up to 600 PSI. This high pressure is useful for high pressure cleaning, livestock spraying or crop insect and fungicide spraying. A piston pump requires a surge tank at the pump outlet to reduce the characteristic line pulsation.

The connection diagram for a piston pump is shown in Figure 6. It is similar to a roller pump except that a surge tank has been installed at the pump outlet. A damper is used in the pressure gauge stem to reduce the effect of pulsa-tion. The pressure relief valve should be replaced by an unloader valve (Figure 7) when pressures above 200 PSI are used. This reduces the pressure from the pump when the boom is shut off so less power is required. If an agitator is used in the system, agitation flow may be influenced when the valve is unloading.

Open the throttling control valve and close the boom valve to adjust for spraying (Figure 6). 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 throttling control valve until the gauge indicates the desired spraying pressure.

Figure 6. Spray system with piston or diaphragm pump. (19KB b&w illustration)

Figure 7. Unloader valve. (11KB b&w illustration)

Diaphragm Pumps and Controls

Diaphragm pumps are popular in the agricultural market because they can handle abrasive and corrosive chemicals at high pressures. They operate efficiently at tractor PTO speeds of 540 rpm and permit a wide selection of flow rates. They are capable of producing high pressures (to 850 PSI) as well as high volume (60 GPM), but the price of diaphragm pumps is relatively high. High pressures and volumes are needed when applying some pesticides such as fungicides. Diaphragm pumps are excellent for this job. The spray system hookup for diaphragm pumps is the same as for piston pumps (Figure 6). Be sure the controls and all hoses are large enough to handle the high flow, and all hoses, nozzles and fittings must be capable of handling high pressure.

Spray System Pressure

The type of pesticide and nozzle being used usually determine the pressure needed for spraying. This pressure is usually listed on the chemical package. Low pressures of 15 to 40 PSI may be sufficient for spraying most herbicides or fertilizer, but high pressures up to 400 PSI or more may be needed for spraying insecticides or fungicides.

Spray nozzles are designed to be operated within a certain pressure range. Higher than recommended pressures increase the delivery rate, reduce the droplet size, and may distort the spray pattern. This can result in excess spray drift and uneven coverage. Low pressures reduce the spray delivery rate, and the spray material may not form a full width spray pattern unless the nozzles are designed to operate at lower pressures.

Always follow the pressure recommendations of nozzle manufacturers as explained in product catalogs.

Avoid using nozzles too small for the job. To double the spray rate from nozzles, the pressure has to be increased by a factor of four times. This may exert excessive strain on sprayer components, increase wear on the nozzles and produce drift-susceptible droplets.

A pressure gauge should have a total range twice the maximum expected reading. The gauge should indicate spray pressure accurately. Measuring the discharge rate at a specific pressure on the gauge is recommended during calibration. Install a gauge protector or damper to prevent damage.

Sprayer Tanks

The tank should be made of a corrosion-resistant material. Suitable materials used in sprayer tanks include stainless steel, polyethylene plastic and fiberglass. Pesticides may be corrosive to certain materials. Care should be taken to avoid using incompatible materials. Aluminum, galvanized or steel tanks should not be used. Some chemicals react with these materials, which may result in reduced effectiveness of the pesticide, or rust or corrosion inside the tank.

Keep tanks clean and free of rust, scale, dirt, and other contaminants which can damage the pump and nozzles. Also, contamination may collect in the nozzle and restrict the flow of chemical, resulting in improper spray patterns and rates of application. Debris 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 at the bottom near one end helps allow complete drainage. A tank with a small sump in the bottom is another excellent alternative. An opening in the top large enough for internal inspection, cleaning, and service is a necessity.

The capacity of the tank must be known to add the correct amount of pesticide. Most new tanks have capacity marks on the side. If your tank is not translucent, it should have a sight gauge to indicate the fluid level. The sight gauge should have a shut-off valve at the bottom to allow closing in case of damage. On plastic and fiberglass tanks, marks can be placed on the side of the tank. Your sprayer should be sitting on level ground when reading the gallons remaining in the tank. Incorrect volume readings cause improper amounts of pesticide to be added, which can result in poor pest control, crop injury, or increased pesticide cost.

Tank Agitators

An agitator in the tank is needed to mix the spray material uniformly and keep chemicals in suspension (Figures 8 and 9).

> **Figure 8. Jet agitators.** (7KB b&w illustration)
>
> **Figure 9. Sparge tube.** (9KB b&w illustration)

The need for agitation depends on the type of pesticide applied. Liquid concentrations, soluble powders, and emulsifiable liquids require little agitation. Intense agitation is required to keep wettable powders in suspension so a separate agitator, either a hydraulic or mechanical type, is required. The hydraulic jet type is operated by a pressure line hooked into the spray system directly behind the pump. The hydraulic jet agitator should be positioned in the tank to provide agitation throughout the tank. A flow of 5 to 6 GPM for each 100 gallons tank capacity is usually adequate for an orifice jet agitator. Several types of venturi-suction agitators are available that help stir the liquid with less flow. With these, the agitation flow from the pump can be reduced to 2 or 3 GPM per 100 gallon tank capacity.

Do not install a jet agitator on the pressure regulator bypass line, as low pressure and intermittent liquid flow will usually produce poor results. They will agitate the spray solution only when the spray boom is shut off.

A mechanical agitator with a shaft and paddles will do an excellent job of maintaining a uniform mixture but is usually more costly than a jet agitator. Mechanical agitators must be operated by a separate drive, hydraulic motor or 12 volt electric motor. They should be run between 100 and 200 RPM. Higher speeds may cause foaming of the spray solution. Adjustable agitators are desirable to minimize the foaming that can occur with vigorous agitation of certain pesticides as the volume in the tank decreases. Agitation should be started with the tank partly filled and before pesticides are added to the tank. With wettable powders and flowables, continue to agitate while filling the tank and during travel to the field. Don't allow pesticides to settle as the spray mix must be kept uniform to avoid concentration error. This is especially important with wettable powders because they don't dissolve, they are usually much heavier than water, and they are extremely difficult to get them in suspension after they have settled out in the tank and hoses.

NEXT | CONTENTS