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Plumbing Systems of Agricultural Sprayers

Properly adjusting and maintaining the plumbing systems of agricultural sprayers can improve the efficiency and uniformity of chemical applications.

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The plumbing systems of agricultural sprayers are usually considered foolproof. Sprayer problems may occur however, when plumbing and/or modifications are improperly done or maintenance is ignored. Retrofitting, addition of electrical control systems, and replacement of pumps or nozzles require knowledge of the plumbing system and how changes will affect sprayer performance. Routine maintenance of the plumbing systems is essential.

Pumps

A major component of the plumbing system is the pump. The characteristics of the pump usually will define the plumbing systems. Most pumps are categorized as positive displacement or nonpositive displacement.

The positive displacement pump moves a specific volume of liquid with each stroke or revolution. The pump output is proportional to speed and virtually independent of pressure. Examples of positive displacement pumps include piston, roller and diaphragm.

The output of nonpositive pumps varies directly with pump speed and is sensitive to pressure. Typically, the output will decrease dramatically with increasing pressure. An example of a nonpositive pump is a centrifugal pump which has in impeller with curved vanes that rotates at high speeds. The liquid is drawn into the center of the impellers. Then the liquid is dispersed by centrifugal force around the edge of the pump casing and through the outlet.

Characteristics of several pump types are outlined in *Table I*. Of these types, the roller, centrifugal, and piston pumps are the most widely used on agricultural spraying equipment.

Table I. Pumps for agricultural sprayers

Pump Type	Pressure Ranges (psi)	Operating Speeds (RPM)	Flow Rates (gpm)	Displacement Type
Centrifugal	5-80	2000-4500	0-120	nonpositive
Diaphragm	50-850	200-1200	1-60	semipositive
Piston	400-1000	600-1800	5-60	positive
Roller	50-300	300-1000	1-45	positive
Turbine	5-60	600-1200	10-80	nonpositive

An important factor in pump selection is discharge capacity. The pump should have sufficient capacity to supply all the nozzles and other accessories, provide agitation and offset pump wear (20 percent greater capacity). Use the following to determine pump capacity:

$$\text{Pump Capacity (gpm)} = \left\{ \begin{array}{l} \text{Boom Requirements (gpm)} + \\ \text{Agitation Requirements (gpm)} + \\ \text{Self-Cleaning Strainers (gpm)} + \\ \text{Other Accessories (gpm)} + 1 \text{ (gpm)} \end{array} \right\} \times 1.2$$

Where:

Boom Requirements (gpm) =	Number of nozzles x flow discharge per nozzle (gpm),
Agitation Requirements (gpm) =	Use guidelines given in section "Agitation",
Self-Cleaning Strainer (gpm) =	Extra flow needed to clean strainer, see section on "Strainers",
1 (gpm) =	Extra flow to assure proper operation of the by-pass valve, and
1.2 =	20 percent extra capacity for pump wear.

If the output from a pump fails to meet the sprayer nozzle and agitation requirements, overhaul or replace the pump.

Plumbing System for Nonpositive Displacement Pumps

The centrifugal pump is widely used to apply pesticides. One reason for its popularity is its simple flow control system. The pump is recommended for solutions that require additional mixing (ie. wettable powders) and agitation. Since this is a nonpositive displacement pump, the output can be completely shut off without using a pressure relief valve. Discharge is controlled by a throttling valve or electrical regulating valve. If used for agitation, the spray solution for jet agitation should be routed before the flow control valves.

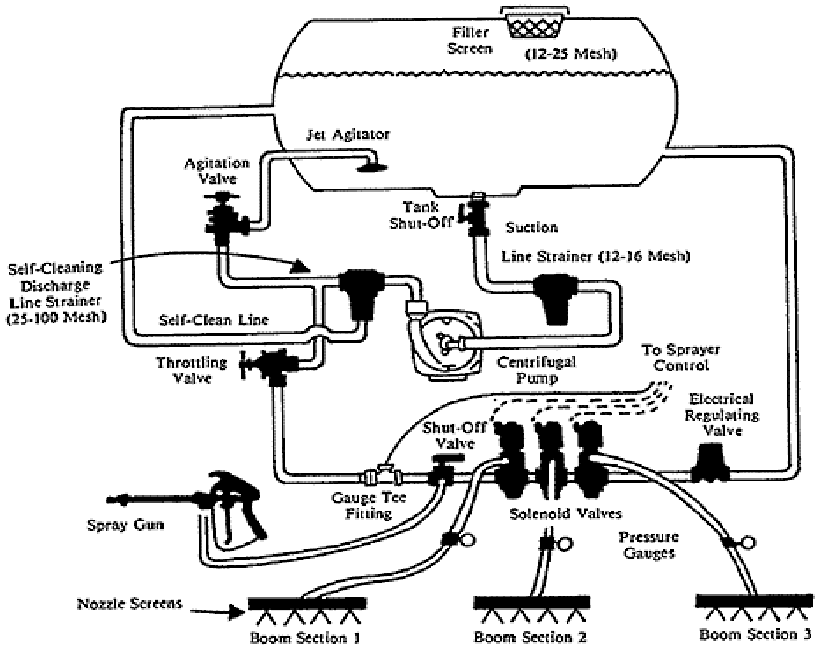

Figure 1. Plumbing diagram for a centrifugal pump (nonpositive displacement pump).

If a combination of manual and electrical control valves are used, proper sequencing of valves is important. Incorrect valve placement can lead to pressure surges and premature failure of the electric regulator or pressure gauges. Proper arrangement as shown in *Figure 1* will allow the manual throttling valve to regulate major pressure changes while the electric regulating valve can be used to fine tune nozzle pressure from the operator's platform. To operate a spraying system with a centrifugal pump:

1. Prime pump with all valves fully open.
2. Close the throttling valve while opening the boom solenoid valves.
3. With the pump running, adjust the throttling valve until the pressure gauge indicates the desired pressure.
4. Check for uniform discharge from the nozzles.

Plumbing System for Positive Displacement Pumps

The positive displacement pump requires a mechanism to release pressure and prevent damage when all outlets are closed. A spring actuated pressure relief valve insures a safety route to a by-pass line (*Figure 2*). Use the pressure relief valve (or regulator) to make large pressure adjustments. It adjusts the flow between the nozzles and the by-pass line back to the tank. An electric regulating valve can be used to fine tune the required nozzle pressure.

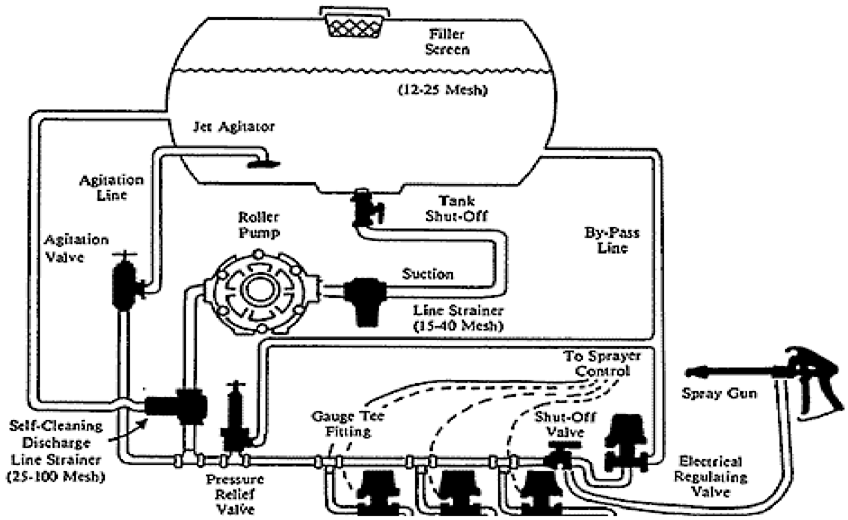

Figure 2. Plumbing diagram for a roller pump (positive displacement pump).

When positive displacement pumps are used, pressure relief valves designed to handle the system's maximum pressure are needed. As with nonpositive displacement pumps, the sequencing of the valves is very important.

To operate a spraying system with a roller pump:

1. Fully open the agitation valve, pressure relief valve and boom electric ball valves (or spray gun).
2. Start the sprayer. Make sure the nozzles have uniform discharge rates. Adjust the pressure relief valve until the pressure shows about 10 to 15 psi above the desired spraying pressure.
3. Use the electrical regulating valve to fine tune the pressure.
4. Shut off the boom valves. If the pressure increases over 10 psi, the pressure relief valve should be replaced with a larger capacity valve or the by-pass line may be too small for the excess flow.
5. Check for uniform discharge from the nozzle.

Hose and Lines

All hoses and fittings should be of sufficient quality and strength to handle liquids under maximum pressure. Select hoses and lines according to composition, construction and size.

Hoses should be flexible, durable and resistant to sunlight, oil, chemicals, and general abuse such as twisting and vibration. The outer hose coatings should be chemically resistant because they may contact the spray solutions. Sunlight resistance increases durability. Two chemically resistant materials are ethylene vinyl acetate (EVA) and ethylene propylene dione monomer (EPDM).

Suction hoses should be airtight, noncollapsible, as short as possible, and as large as the intake port. A collapsed suction hose can restrict flow and "starve" a pump, damaging the pump and seals. When spray pressure cannot be maintained, check the suction line for restrictions.

Lines between the pressure gauge and nozzles should be as direct as possible with minimum fittings, throttle valves and restrictions. These lines should be plumbed to the center of each spray boom (*Figure 2*). Spray lines and hoses must be properly sized, depending on the inside diameter of the hose and the flow capacity (gpm) of the line. Sufficient flow velocity is required so suspended particles will not settle in the lines. If lines are too small, pressure will drop and the nozzle flow rate will be insufficient.

A flow velocity below 5 to 6 feet per second is recommended. *Table II* gives suggested hose sizes for various flow rates.

Table II. The recommended hose sizes for various flow rates		
Highest Flow Capacity (gpm)	**Hose Size Inside Diameter (inch)**	
	Suction Hose	**Discharge Hose**
0 -1	1/2	1/4
1- 3	1/2	3/8
3- 6	3/4	1/2
6- 12	3/4	5/8
12- 25	1	3/4
25- 50	1-1/4	1
50-100	1-1/2	1-1/4

Many sprayers are constructed with "wet" booms and are fitted with nozzle assemblies that protrude one-third to one-half of the diameter of the boom. These nozzle assemblies take the spray solution out of the middle of the boom. The wet boom allows materials like sand and rust to be flushed out the bottom of the spray boom. Equip a wet boom with plugs or hose-end caps on the boom ends so they can be easily flushed. Polyvinyl chloride (PVC) schedule 90 can be used for a wet boom if it's supported adequately. Some pesticides will damage PVC so review the compatibility tables. Stainless steel is the best material and can be fixed with hose-end caps to facilitate flushing and drainage.

Agitation

The amount of flow required for sufficient agitation depends on the chemical formulation. For example, wettable powders require more agitation than emulsifiable concentrates to keep them in suspension. Applications that require vigorous agitation may need mechanical agitation such as propellers or paddles on a rotating shaft. For most spraying situations, hydraulic agitation is sufficient.

Hydraulic agitation requires a portion of the flow from the pump to be diverted back to the tank. The amount of flow for agitation will depend on chemical formulation, tank size and shape. Usually use 5 to 10 percent of the tank's capacity for agitation flow. For example, a 300-gallon tank should have a 15-30 gpm flow into the tank. After selecting the agitation flow rate, select the correct orifice size (*Table III*).

Table III. Tank Agitation Capacity		
Orifice Size (inch)	**Inlet Flow* (gpm)**	**Outlet Flow* (gpm)**
1/8	2.9	9.5
5/32	4.1	13.2
3/16	5.3	15.4
1/4	6.5	19.5
JET-Spring-loaded Orifice	0-15	2.5 times inlet

*Rates given at 30 psi.

Siphon caps can be used on jet agitators to reduce flow requirements by half. Siphon caps increase the flow by venturi action which increases the mixing potential.

A feature shown in *Figures 1* and *2* is a separate line and agitation valve for agitation. Often, sprayers are plumbed with the agitation coming from the by-pass line. This arrangement does not give the operator control over the amount of flow for agitation. For example, when a large flow is needed by the nozzles, there may be insufficient flow from the by-pass line for adequate agitation. When the nozzles are shut off, all flow is diverted into the by-pass line which causes foaming in the tank.

Strainers

Line and nozzle strainers are a very important component of the sprayer's plumbing system. Properly sized and placed strainers will prevent plugged or partially plugged nozzles and the uniformity problems associated with them. The mesh size of a strainer refers to the openings in a screen per linear inch.

For most positive displacement pumps, a suction line strainer between the tank and pump is required. This strainer should have a 30-50 mesh screen. A large suction line strainer (12-16 mesh) to keep rocks, labels, booklets, etc., out and to protect the pump should be used with a centrifugal pump. The strainer mesh must be larger so the inlet of a centrifugal pump is not restricted. If restricted, a centrifugal pump will create a vacuum within itself, thus starving the pump. A smaller strainer of 50 mesh should be on the pressure side of the centrifugal pump to protect nozzles and the agitation systems.

A self-cleaning line sprayer is an added benefit. It has a high velocity flow over the screen to provide continuous washing. The additional flow required for this washing action is 6 to 8 gpm per strainer. Additional plumbing and a throttling valve are needed to control wash water flow.

Screening should be progressively finer from the tank to the nozzles (*Table IV*) The largest mesh screens are in the filler opening and suction line. Screens need to be keyed to the nozzle orifice size. Screen area should be large enough to prevent pump starvation or excessive pressure losses. Use at least 2 square inches of screen area for each gallon per minute of flow in the suction line. Strainers, between pump and nozzles, should have at least 1 square inch of screen area for each gallon per minute of flow.

Table IV. Progressive screen mesh in a sprayer

Location	Mesh
Filler opening	12-25
Suction line (Roller Pump)	15-40
Suction line (Centrifugal Pump)	12-16
Discharge line	25-100*
Nozzle	50-100*

Nozzle strainers are important because they are the last place to prevent plugged nozzles. Nozzle strainers come in various sizes and materials. The mesh size of a nozzle strainer is dictated by the nozzle orifice size as suggested by the manufacturer's manual. Avoid nozzle orifice sizes that require more than a 50 mesh size (ie. 80 or 100 mesh). Since well water is usually used as a carrier source, the water may contain a small amount of sand and foreign material. A mesh of 80 or greater will easily plug and require frequent cleaning. Also, some pesticide materials may plug small nozzle openings and screens.

Clean strainers frequently. A shut-off valve between the tank and suction line will allow cleaning of the strainers without draining the tank. Always replace damaged or deteriorated strainers.

Maintenance and Care

Protect the sprayer from deterioration during storage. If the sprayer does not have rubber components (gaskets, diaphragms, hoses, etc.), use motor oil in the final flushing to help protect from corrosion. Another alternative is to use automotive antifreeze with a rust inhibitor. This protects against corrosion and reduces freezing if all the water was not drained. Seal openings to prevent dirt, debris or insects from entering and store the sprayer. Order all parts which need replacing well in advance of the next spray season.

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