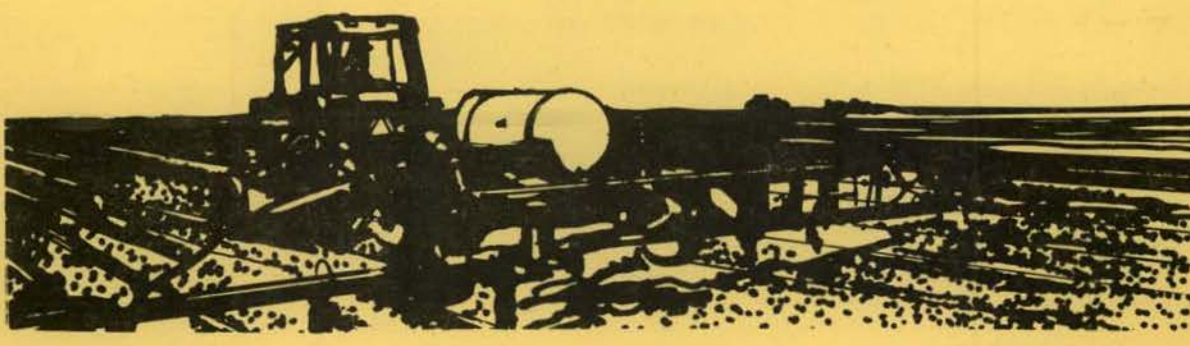
Bulletin No. 658

Spray Equipment and Calibration



Cooperative Extension Service
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This publication has been adapted by Tom Karsky, University of Idaho Extension Farm Safety Specialist, from North Dakota State University Cooperative Extension Service Bulletin AE73.

Introduction

Most pesticides are applied with hydraulic sprayers. Pesticides are used to control weeds, insects and diseases in a wide variety of areas including: field crops, ornamentals, turf, fruits, vegetables and rights-of-way. 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 (Fig. 1).

Properly applied pesticides are expected to return a profit. Improper application can result in wasted chemical, marginal pest control, excessive carryover or crop damage. Inaccurate application is usually very expensive.

Users of pesticides should 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. Wettable powders may wear nozzle tips, causing an increase in application rates after spraying as little as 50 acres.

Improperly used agricultural pesticides are dangerous. Operators must 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

A sprayer is used to apply many different materials, such as postemergence herbicides, preemergence herbicides, insecticides and fungicides. A change of nozzles may be required which can affect spray volume and/or 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 necessary volume to the nozzles. A pump should have a capacity at least 20 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 damage 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:

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

Centrifugal Pumps and Controls

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

Pressures up to 70 PSI are developed by centrifugal pumps, but discharge volume drops off rapidly above 30 to 40 PSI. This "steep performance curve" is an advantage since it permits controlling pump output without a relief valve. Centrifugal pump performance is very sensitive to speed (Fig. 2), and inlet pressure variations may produce uneven pump output under some operating conditions.

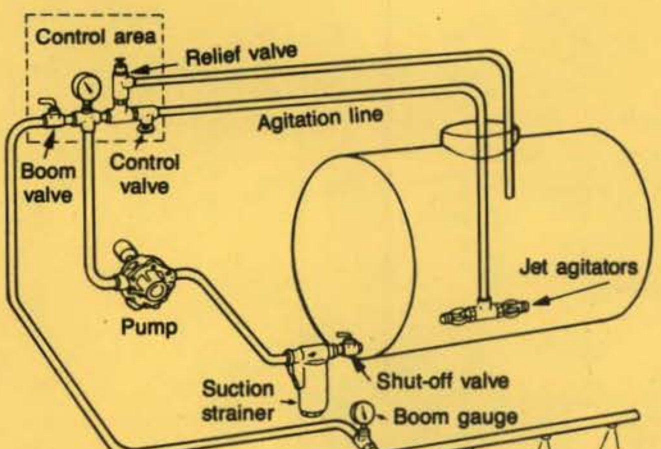

Fig. 1. Typical agricultural spray system.

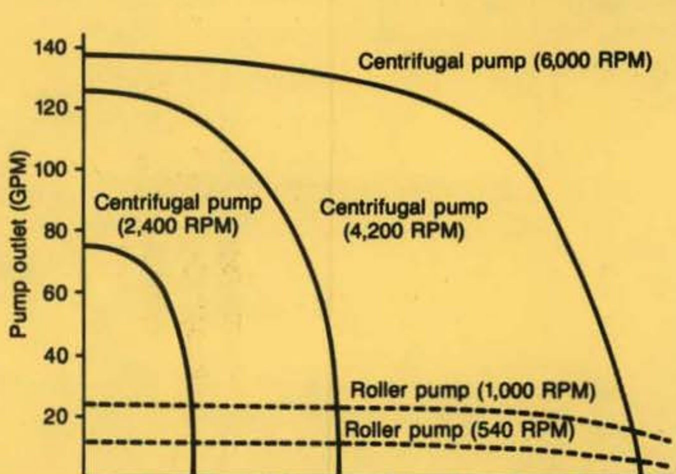

Fig. 2. Centrifugal pump performance curves.

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, inexpensive speed increaser is a belt and pulley assembly. Some pumps 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. 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 tractor engine speed.

Centrifugal pumps should be located below the supply tank to aid in priming and maintaining a prime. The proper way to connect components on a sprayer using a centrifugal pump is shown in Fig. 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. Nor is a pressure relief valve required. Spray pressure can be controlled by a simple gate valve, eliminating the pressure relief valve with a separate bypass line. A special throttling valve to control the spray pressure and agitation flow is normally used. Electrically controlled throttling valves are popular for remote pressure control.

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. Manual and electric boom shut-off valves are shown in Fig. 4.

To adjust for spraying with a centrifugal pump (Fig. 3), open the boom shut-off valve, start the sprayer and open the throttling valve to the desired spraying pressure. Then adjust the control valve for proper agitation. If spraying pressure drops, readjust the control valve to restore desired pressure. Check to be sure flow is uniform from all nozzles.

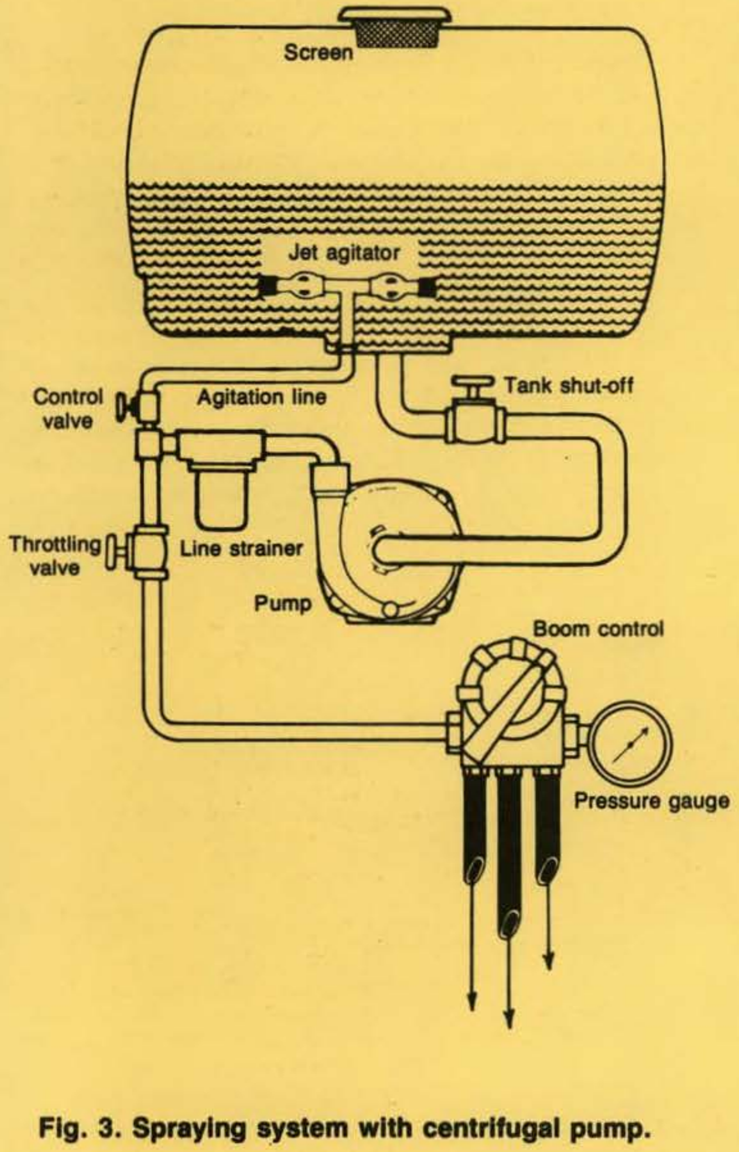

Fig. 3. Spraying system with centrifugal pump.

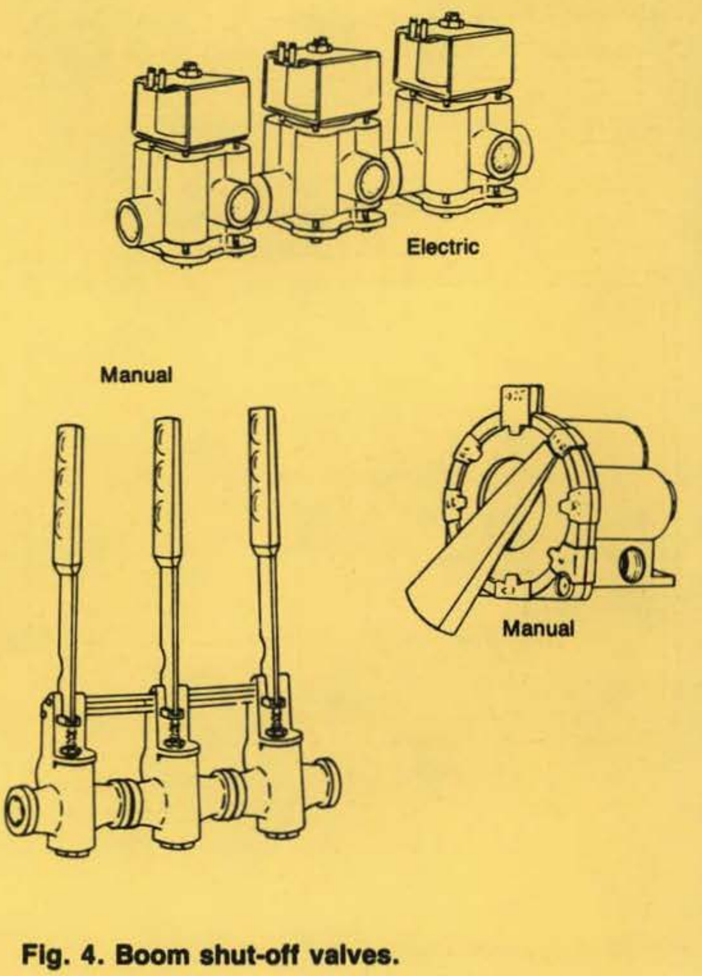

Fig. 4. Boom shut-off valves.

Roller Pumps and Controls

Roller pumps are popular due to low initial cost, compact size and efficient operation at tractor PTO speed. They are positive displacement pumps and self-priming.

Roller pumps have a slotted rotor that revolves in an eccentric case. Rollers in the slots seal the spaces between the rotor and the wall of the case. As the rollers pass the pump inlet, the spaces around the rollers enlarge and are filled with liquid drawn through the suction hose. When the rollers approach the pump outlet, the spaces become smaller, and the fluid is forced through the outlet. Pump output is determined by the length and diameter of the rollers and case, eccentricity and the speed of rotation. Roller pumps can develop pressures up to 300 PSI and capacities to 50 GPM.

Material options for roller pumps include cast-iron or corrosion-resistant housings and nylon, Teflon or rubber rollers. Viton, rubber or leather seals are also used. Nylon or Teflon rollers are resistant to most farm chemicals and are recommended for multi-purpose sprayers. Abrasive materials will cause extreme wear and failure of roller pumps. 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 Fig. 5. 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 (Fig. 6). 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.

The agitation control valve must be closed and the boom shut-off valve must be opened to adjust the system (Fig. 5). Start the sprayer, make 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 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.

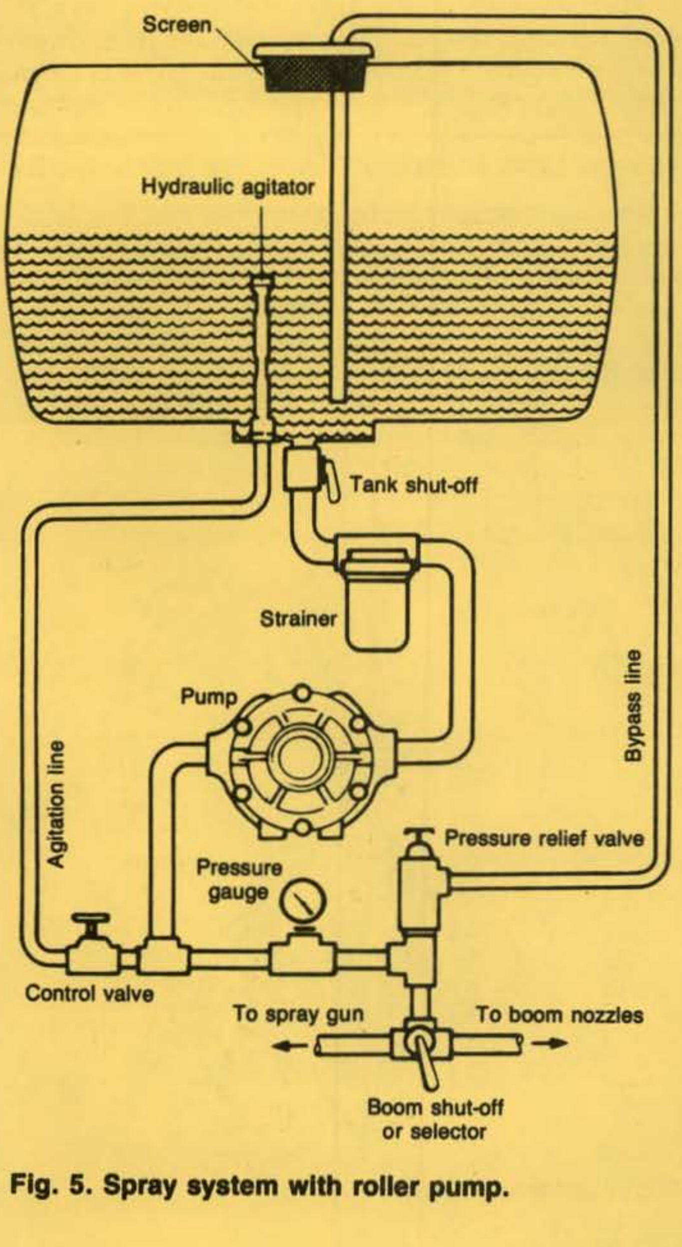

Fig. 5. Spray system with roller pump.

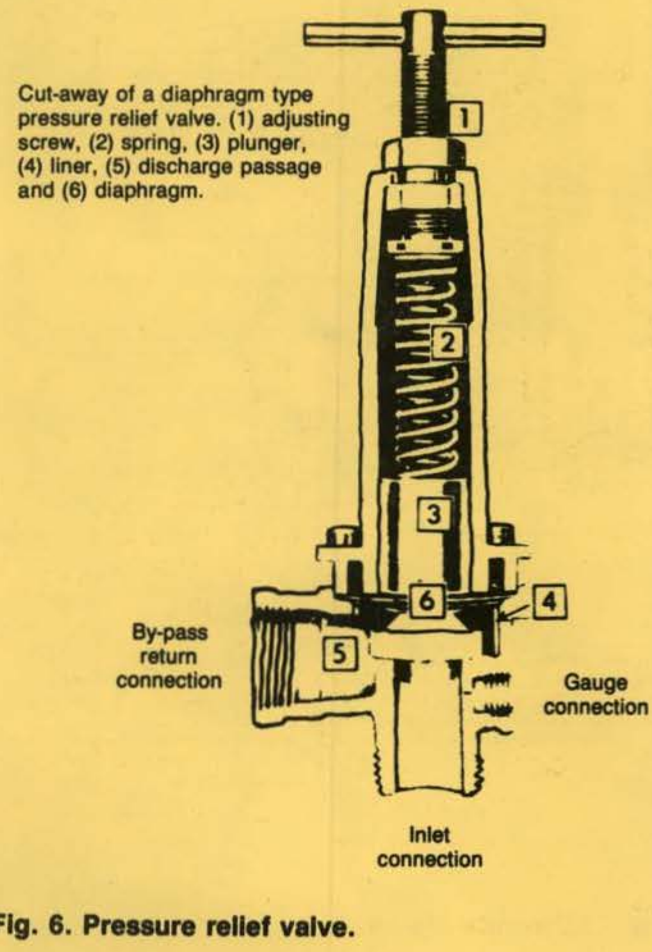

Fig. 6. Pressure relief valve.

Piston Pumps and Controls

Piston pumps are positive displacement pumps whose 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 relatively high cost, but a piston pump may be the best buy for the commercial applicator. The piston pump has a long life which makes it economical for continuous use. Larger piston pumps have a capacity up to 25 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 (Fig. 7) 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 pulsation. The pressure relief valve should be replaced by an unloader valve (Fig. 8) 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 insufficient when the valve is unloading.

Open the control valve and close the boom valve to adjust for spraying. 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 indicates the desired spraying pressure.

Diaphragm Pumps

Diaphragm pumps are positive displacement and excellent general purpose sprayer pumps. They are capable of producing high pressures (to 850 PSI) as well as high volume (60 GPM). 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 piston pumps (Fig. 7). Be sure that the controls and all hoses are large enough to handle the high flow and that all hozes, nozzles and fittings are capable of handling high pressures.

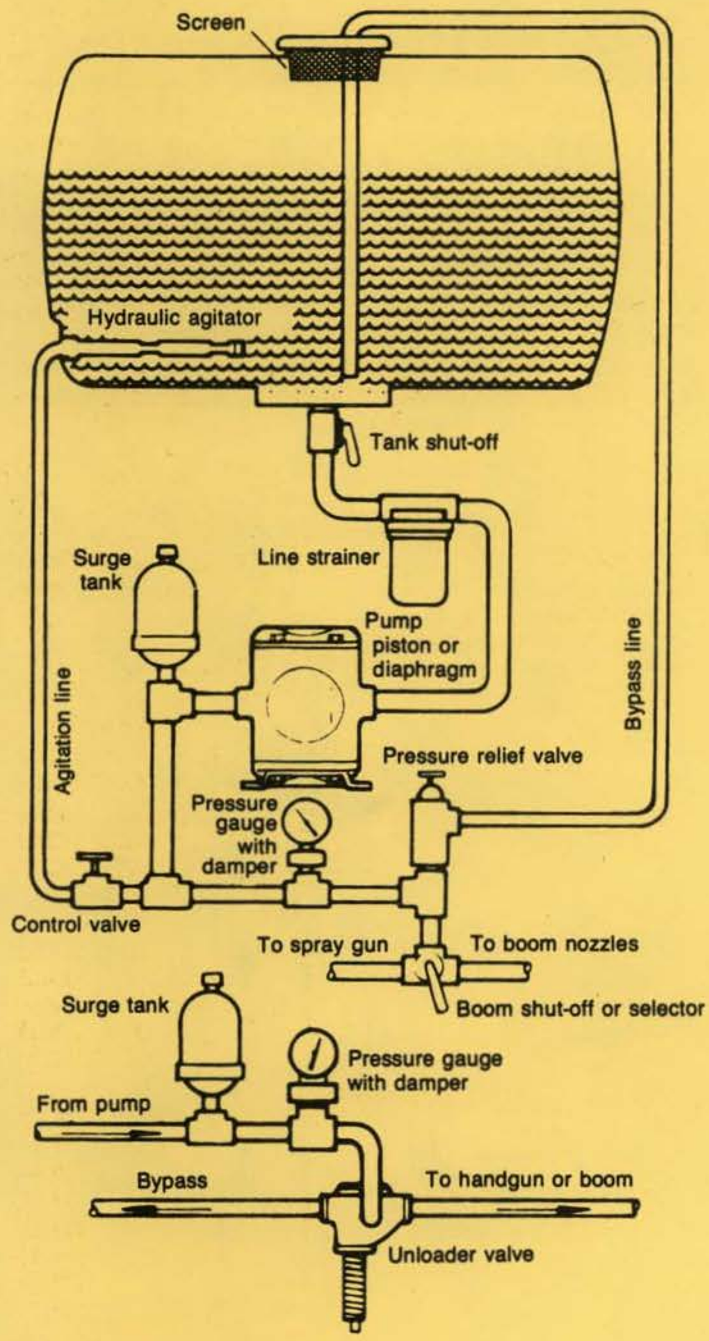

Fig. 7. Spraying system with piston or diaphram pump.

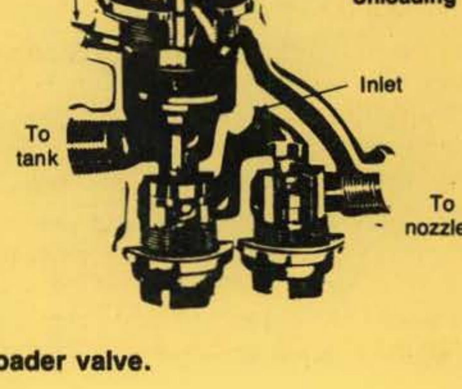

Fig. 8. Unloader valve.

Spray System Pressure

The types of pesticide and nozzle being used usually determine the pressure needed for spraying. The label on the chemical package usually recommends the sprayer pressure. Low pressures of 30 to 40 PSI may be sufficient for spraying most herbicides, or fertilizer, but high pressures of 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. Pressures higher than recommended 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. Always follow the pressure recommendations of nozzle manufacturers as explained in their product catalogs.

Avoid using nozzles too small for the job. To double the spray rate from nozzzles, the pressure has to be increased 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 two times 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 spray tank should be made of a corrosion-resistant material such as stainless steel, polyethylene plastic and fiberglass. Pesticides may be corrosive to certain materials. Avoid using incompatible equipment. Aluminum, galvanized or steel tanks should not be used. Some chemicals react with these materials, resulting in reduced activity of the chemical and corrosion inside the tank.

Keep tanks clean and free of rust, scale, dirt and other contaminants which can damage the pumps and nozzles. Contaminants may also collect in the nozzle and restrict the flow of chemicals, resulting in improper 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 permits tilting the tank to allow for complete drainage. An opening in the top large enough for internal inspection, cleaning and service is desirable.

The capacity of the tank must be known to add the correct amount of pesticide. Many new tanks have capacity marks on the side. If your spray tank does not have gallon marks, Table 1 can be used to make a measuring scale for horizontal, round sprayer tanks. A clear plastic tube mount-

Table 1. Round tank gauge chart

	Gallons per foot of horizontal length of tank							
Inches deep	38" dia	40" dia	42" dia	44" dia	46" dia	48" dia	50" dia	60" dia
1	.42	.43	.44	.45	.46	.47	.48	.53
2	1.18	1.22	1.25	1.28	1.31	1.33	1.36	1.50
3	2.16	2.22	2.28	2.33	2.39	2.44	2.49	2.74
4	3.30	3.39	3.48	3.57	3.65	3.74	3.82	4.20
5	4.57	4.70	4.83	4.95	5.07	5.19	5.30	5.84
6	5.96	6.13	6.30	6.46	6.62	6.77	6.93	7.64
7	7.45	7.66	7.88	8.08	8.28	8.48	8.67	9.57
8	9.02	9.29	9.55	9.80	10.05	10.29	10.52	11.63
9	10.66	10.98	11.30	11.60	11.90	12.19	12.47	13.80
10	12.37	12.75	13.12	13.48	13.83	14.18	14.51	16.08
11	14.14	14.58	15.01	15.43	15.84	16.24	16.63	18.45
12	15.95	16.46	16.96	17.44	17.91	18.36	18.81	20.09
13	17.81	18.39	18.95	19.50	20.03	20.55	21.06	23.43
14	19.70	20.35	20.99	21.61	22.21	22.79	23.37	26.03
15	21.62	22.36	23.07	23.76	24.43	25.09	25.72	28.70
16	23.57	24.38	25.18	25.95	26.69	27.42	28.13	31.43
17	25.53	26.44	27.31	28.16	28.99	29.79	30.57	34.21
18	27.51	28.51	29.47	30.41	31.31	32.19	33.05	37.04
19	29.50	30.59	31.65	32.67	33.66	34.63	35.56	39.92
20	31.49	32.68	33.84	34.95	36.03	37.08	38.10	42.84
21	33.47	34.77	36.03	37.25	38.42	39.56	40.67	45.80
22	35.43	36.85	38.22	39.55	40.82	42.09	43.25	48.80
23	37.38	38.92	40.41	41.85	43.22	44.55	45.85	51.82
24	39.30	40.98	42.59	44.15	45.62	47.07	48.45	54.87
25	41.19	43.00	44.75	46.43	48.02	49.59	51.07	57.95
26	43.05	45.01	46.88	48.69	50.41	52.09	53.69	61.04
27	44.86	46.97	48.99	50.94	52.78	54.58	56.29	64.15
28	46.63	48.90	51.07	53.15	55.13	57.06	58.89	67.27
29	48.34	50.78	53.11	55.34	57.45	59.51	61.47	70.40
30	49.97	52.61	55.10	57.49	59.75	61.95	64.04	73.54
31	51.55	54.38	57.05	59.60	62.01	64.35	66.58	76.68
32	53.04	56.07	58.94	61.66	64.23	66.72	69.09	79.81
33	54.43	57.70	60.76	63.67	66.41	69.05	71.57	82.93
34	55.69	59.23	62.51	65.62	68.53	71.35	74.01	86.04
35	56.83	60.66	64.18	67.50	70.60	73.59	76.42	89.13
36	57.81	61.97	65.76	69.30	72.61	75.78	78.77	92.21
37	58.57	63.14	67.23	71.02	74.54	77.90	81.08	95.26
38	59.00	64.14	68.58	72.64	76.39	79.96	83.33	98.28
39		64.93	69.78	74.15	78.16	81.95	85.51	101.28
40		65.36	70.81	75.53	79.82	83.85	87.63	104.24
41			71.62	76.77	81.37	85.66	89.67	107.16
42			72.06	77.82	82.79	87.37	91.62	110.04
43				78.65	84.05	88.95	93.47	112.87
44				79.10	85.13	90.40	95.21	115.65
45					85.98	91.70	96.84	118.38
46					86.44	92.81	98.32	121.05
47						93.67	99.65	123.65
48						94.14	100.78	126.18
49							101.66	128.63
50							102.14	131.00
51								133.28
52								135.45
53								137.51
54								139.44
55								141.24
56								142.88
57								144.34
58								145.58
59								146.55
60								147.08

ed on the end of metal tanks, marked off in gallons, makes an excellent sight gauge. 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 chemical material uniformly and keep chemicals in suspension (Figs. 9 and 10).

The need for agitation depends on the type of pesticide applied. Liquid concentrates, soluble powders and emulsifiable liquids require little agitation. Intense agitation is required to keep wettable powders in suspension. A separate agitator, either a hydraulic type or mechanical, is required. The jet type is operated by a return pressure line hooked into the system directly behind the pump. The jet agitator should be positioned in the tank to provide agitation throughout the tank. A flow of 6 GPM for each 100 gallons tank capacity is adequate for a simple orifice jet agitator. Several types of suction venturi attachments are 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 gallons 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. 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 should be operated between 100 and 200 RPM. Higher speeds may cause foaming of the spray solution.

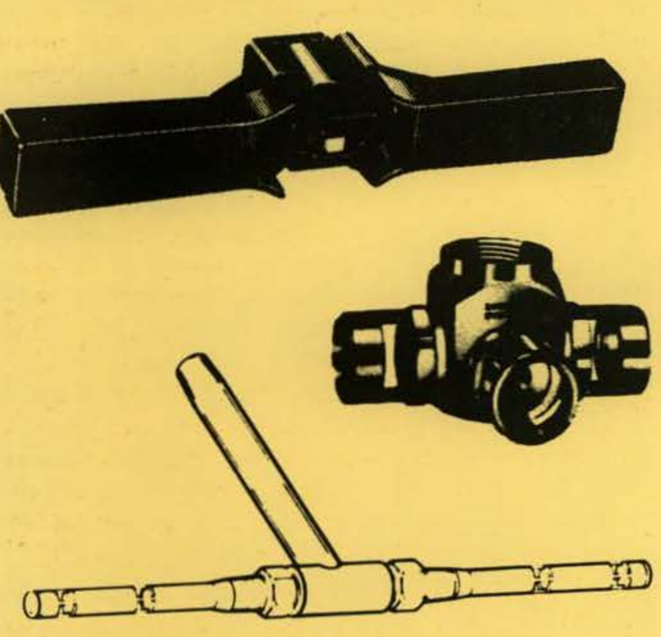

Fig. 9. Jet agitators.

Strainers

Three types of strainers are commonly used on agricultural sprayers: tank-filler strainers, line strainers and nozzle strainers. Strainer numbers (e.g. 20-mesh, 50-mesh or 100-mesh) indicate the number of openings per inch. Strainers with high numbers have smaller openings than strainers with low numbers.

Coarse basket strainers set in the tank-filler opening prevent debris from entering the tank as it is being filled. A 16- or 20-mesh tank-filler strainer will also restrain lumps of wettable powder until they are broken up, helping to give uniform mixing in the tank.

A suction-line strainer should be used between the tank and a roller pump to prevent rust, scale or other material from damaging the pump. A 40- or 50-mesh strainer is recommended. A suction-line strainer is not usually needed to protect a centrifugal pump except against large pieces of foreign material. The inlet of a centrifugal pump must not be restricted. A strainer on the inlet side should have an effective straining area several times larger than the area of the suction line, should be no smaller than 20-mesh and should be cleaned frequently. A line strainer (usually 50-mesh) should be located on the pressure side of the pump to protect the spray and agitation nozzles.

Small-capacity nozzles must have a strainer that will stop any particle that may plug the nozzle orifice. These strainers vary in size, depending upon the size of the nozzle tip used, but they are commonly 50- or 100-mesh. Nozzle manufacturer catalogs list the recommended strainer for each nozzle tip.

Distribution Systems

Select hoses and fittings to handle the chemicals at the selected operating pressure and quantity. Peak pressures are often encountered that are higher than average operating pressures. These peak pressures usually occur as the spray boom is shut off. Choose components on the basis of composition, construction and size.

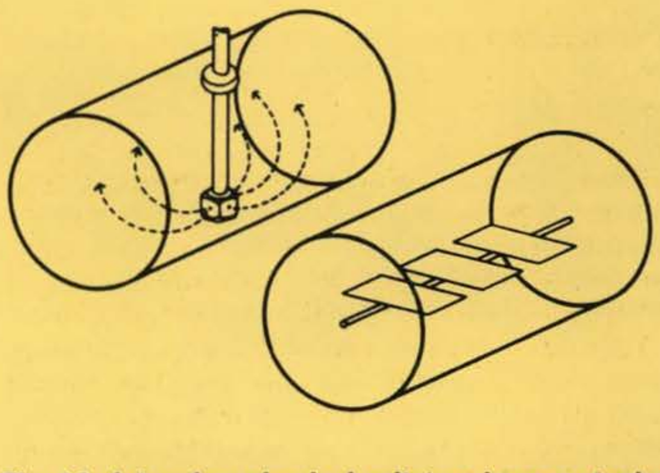

Fig. 10. Jet and mechanical agitators in spray tanks.

Hoses must be flexible, durable and resistant to sunlight, oil, chemicals and general abuse such as twisting and vibration. Two widely used materials that are chemically resistant 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 pump intake. A collapsed suction hose can restrict flow and "starve" a pump, causing decreased flow and damage to the pump. If you cannot maintain spray pressure, check the suction line to be sure that it is not restricting flow.

Other lines, especially those between the pressure gauge and the nozzles, should be as straight as possible, with a minimum of restrictions and fittings. The proper size of these lines varies with the size and capacity of the sprayer. A high but not excessive fluid velocity should be maintained throughout the system. If the lines are too large, the velocity will be so low that some pesticides, such as wettable powders, may settle out and clog the system. If the lines are too small, an excessive pressure drop will occur. A flow velocity of 5 to 6 feet per second is recommended. Suggested hose sizes for various pump flow rates are listed in Table 2. Some chemicals will react with plastic materials. Check sprayer and chemical manufacturers' literature for compatibility.

Boom stability is important in achieving uniform spray application. The boom should be relatively rigid in all directions. Swinging back and forth or up and down is undesirable. Gauge wheels mounted near the end of the boom will maintain uniform boom heights. The boom height should be adjustable from about 1 to 4 feet above the ground.

Table 2. Guide for determining hose size.

Pump output	Suction hose	Discharge hose
(gal/min)	(inside diameter in inches)	
Under 12 GPM	¾	⅝
12-25 GPM	1	¾
25-50 GPM	1¼	1
50-100 GPM	1½	1¼

Nozzles

Proper nozzles must be used for specific spraying jobs. Nozzles break the liquid into droplets of optimum size, form the spray pattern and propel the droplets in the proper direction. Nozzles determine the rate of pesticide distribution at a particular pressure, forward speed and nozzle spacing. Drift can be minimized by selecting nozzles that produce the largest droplet size while providing adequate coverage at the intended application rate and pressure.

Nozzles are made from several types of materials. The most common are brass, plastic or nylon, stainless steel, hardened stainless steel and ceramic. Brass and nylon nozzles are the least expensive but are soft and wear rapidly. Nylon nozzles resist corrosion, but some chemicals cause nylon to swell. Nozzles made from harder metals cost more but wear longer. Test results indicate that spraying 2,4-D with water carrier may wear brass nozzles and increase the rate of flow by 8 percent after 50 hours of use. A 10 percent increase in flow rate may not be readily noticeable; however, spraying 150 acres with a pesticide that costs $10 per acre at the increased rate would cost an extra $1 per acre or $150. More important, the extra chemical may also cause crop injury and decrease crop yield. The durability of various nozzle materials compared to brass is shown in Table 3.

Table 3. Wear comparison of common nozzles.

Nozzle material	Life compared to brass
Plastic or nylon	0.7 to 1 time
Stainless steel	3.5 times
Hardened stainless	10 to 15 times
Ceramic	90 to 100 times
Tungsten carbide	150 to 200 times

Each nozzle on a sprayer should apply the same amount of pesticide. Collect the discharge from each nozzle under operating conditions and compare the output. If the discharge from one nozzle varies more than 10 percent above or below the average of all nozzles, replace it. (See examples on pages 19, 20, 22 and 23.)

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

Be careful in cleaning clogged spray nozzles. Remove the nozzle from the nozzle body and use compressed air to blow it out. A soft bristled brush such as a toothbrush can also be used to clean the nozzle. The nozzle orifice is easily damaged if wire or a jackknife is used.

Select the correct type of nozzle spray pattern. Specific use, such as broadcast application of herbicides or spraying of insecticides on row crops, determines the type of nozzle needed. One nozzle cannot meet all spraying needs.

Flat-fan Spray Nozzles

Flat-fan nozzles are widely used for broadcast spraying of herbicides. They produce a tapered-edge, flat-fan spray pattern. Less material is applied along the edges of the spray pattern, so the patterns of adjoining nozzles must be overlapped to give uniform coverage over the length of the boom. For maximum uniformity, overlap should be about 50 percent of the nozzle spacing (Fig. 11). Normal operating pressure is 30 to 40 PSI. Lower pressures produce larger droplets, which reduce drift potential but also narrow the width of the spray pattern. Higher pressures produce small drops for maximum plant coverage, but smaller drops are more susceptible to drift. At higher pressures the spray pattern widens out.

Flat-fan nozzles are available in several spray discharge angles. The most commonly used nozzles are listed in Table 4. Proper boom height is measured from the target

Table 4. Recommended boom height for flat-fan nozzles that will give proper overlap.

Nozzle spray angle degrees	Height of boom above sprayed surface	
	20-inch nozzle spacing	30-inch nozzle spacing
65	21 to 33	32 to 34
73	20 to 22	27 to 29
80	17 to 19	24 to 26
110	10 to 12	14 to 18

to the nozzle. For postemergence pesticides, the target is the growing crop and not the soil surface. Boom height for two common nozzle spacings is listed in Table 4.

An LP or "low-pressure" flat-fan nozzle is available. This nozzle develops a normal flat-fan angle and distribution pattern at spray patterns from 10 to 20 PSI. Operating at this lower pressure results in larger drops and less drift than the larger flat-fan nozzle.

An X-R or "Extended Range" flat-fan nozzle is also available. A normal flat-fan angle and distribution pattern is developed over a wide range of pressures (15 to 60 PSI). This nozzle is ideal for sprayers equipped with sprayer controllers. Operating at high pressure results in small droplets and better coverage while low pressures produce large droplets and less drift.

Flooding Fan Nozzles

Flooding fan nozzles (Fig. 12) produce a wide-angle, flat-spray pattern and are used for applying herbicides and mixtures of herbicides and liquid fertilizers. The nozzle-spacing for applying herbicides should be 60 inches or less. These nozzles are most effective in reducing drift when they are operated within a pressure range of 10 to 25 PSI.

The width of the spray pattern of flooding fan nozzles is changed more by pressure changes than occurs with flat-fan nozzles. Also, the distribution pattern is not as uniform as that of the regular flat-fan nozzle. The best distribution is achieved when the nozzle is mounted at a height and angle to obtain at least 100 percent overlap (double coverage). When set for 100 percent overlap, a change in nozzle pressure distorts the spray pattern.

Flooding fan nozzles can be mounted so they spray straight down, straight back or at any angle in between (Fig. 13). Studies indicate the most uniform pattern is obtained when the spray is directed straight back. This will produce the greatest chance for drift of the small droplets. Directing the spray straight down will keep the drift potential to a minimum but produces the most irregular spray pattern. The best compromise position is to set the nozzle at a 45-degree angle with the sprayed surface. Also, be careful so the spray discharge does not hit the incorporation equipment.

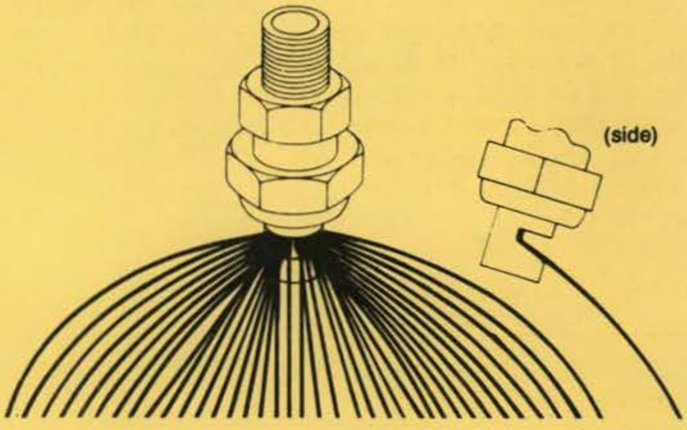

Fig. 12. Flooding fan nozzle discharge pattern.

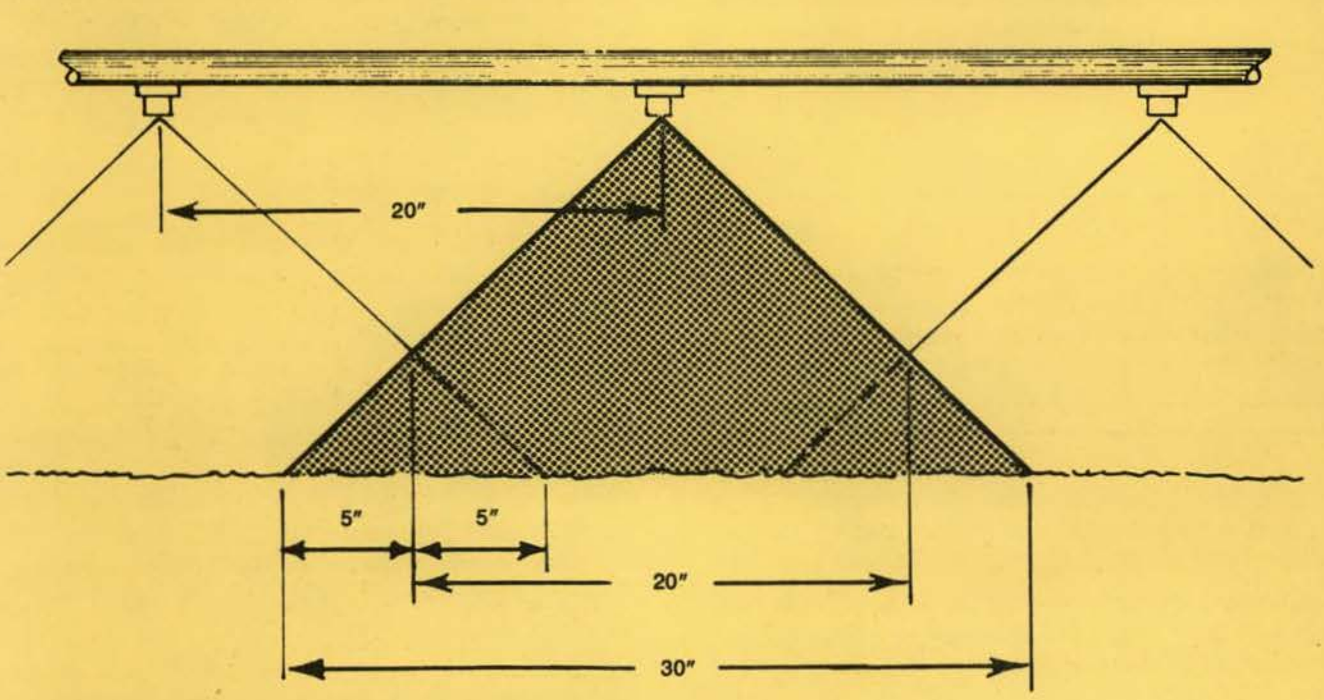

Fig. 11. Proper overlap with a flat-fan type nozzle with 20-inch nozzle spacing.

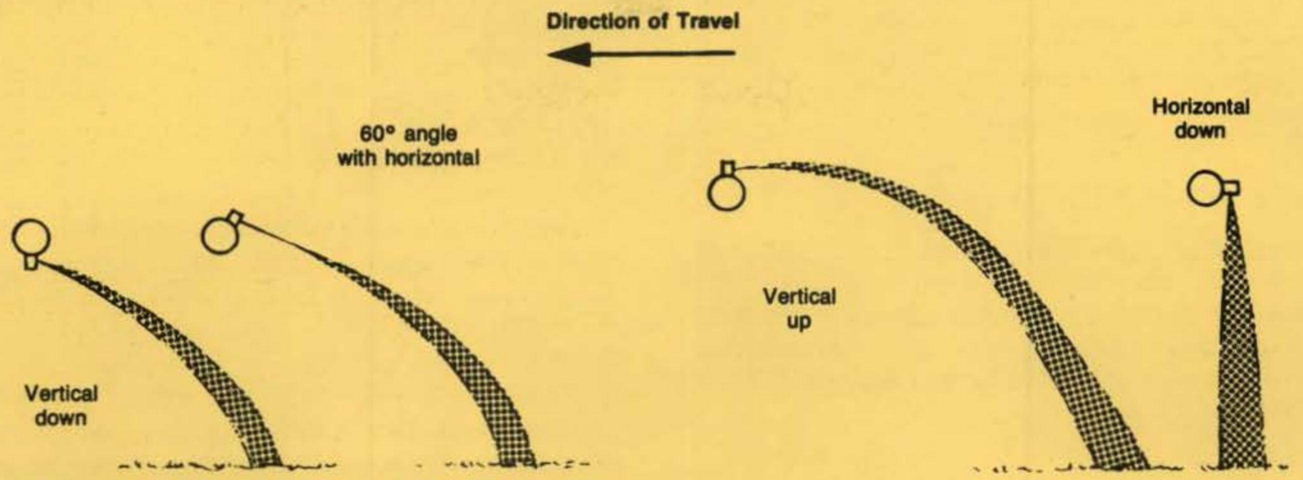

Fig. 13. Various positions for mounting flood fan nozzles.

"Even" Flat-fan Spray Nozzles

"Even" flat-fan nozzles apply uniform coverage across the entire width of the spray pattern (Fig. 14). They should be used for banding pesticides over the row and should be operated between 30 and 40 PSI. Do not use this nozzle for broadcast applications. The width of the band varies with nozzle height above target and spray pressure as shown in Table 5.

Table 5. Recommended spraying heights for "even" flat-fan spray nozzles operated at 40 PSI.

	Height above the target		
Desired band width	40-degree nozzles	80-degree nozzles	95-degree nozzless
(inches)			
8	11	5	4
10	14	6	5
12	17	7	6
14	19	8	7
16	22	10	8

Hollow Cone Nozzles

Hollow cone nozzles are generally used to apply insecticides or fungicides to field crops where complete coverage of the leaf surface is important. The hollow cone pattern is used for applications where a fine spray pattern is needed for thorough coverage. These nozzles usually operate in the pressure range of 40 to 100 PSI or more depending on the nozzle being used and the pesticide being applied. Spray drift is higher than from other nozzles due to the smaller droplets produced.

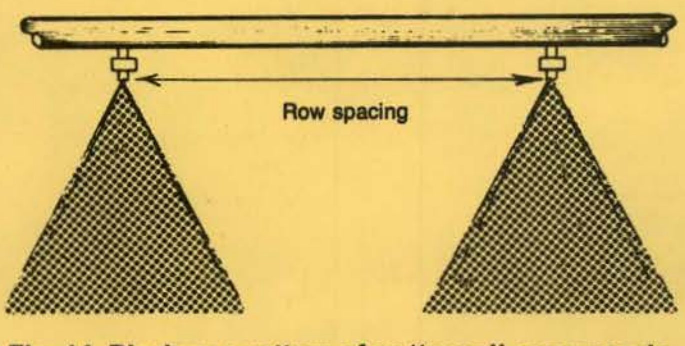

Fig. 14. Discharge pattern of an "even" spray nozzle.

A hollow cone nozzle produces a spray pattern with more liquid concentrated at the outer edge of the pattern (Fig. 15). Any nozzle producing a cone pattern including the whirl-chamber type, will not provide uniform distribution for broadcast applications unless the nozzles are tilted from the vertical.

Hollow cone nozzles used on high pressure sprayers for applying fungicides in broadcast applications can be aimed straight down when they are spaced 10 to 12 inches apart. The extremely fine drops produced at pressures above 40 PSI move enough to compensate for the non-uniformity of the pattern.

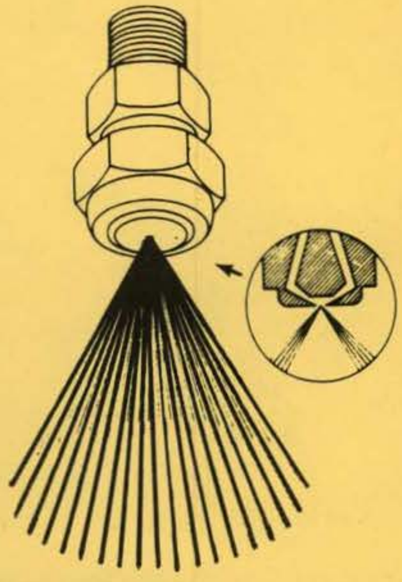

Fig. 15. Hollow cone spray pattern.

"Raindrop" nozzles have been designed to produce large drops in a hollow cone pattern at pressures of 20 to 60 PSI. They are designed to reduce spray drift. They are recommended for broadcast applications when tilted 45 degrees or more from vertical. Table 6 summarizes nozzle types and their uses.

Nozzle Adjustment Problems

For broadcast application, flat-fan nozzles should be properly spaced and adjusted on the sprayer. For good spray coverage, nozzle discharge angle, nozzle distance from the sprayed surface and the nozzle spacing on the boom must all be considered. Fig. 16 shows some of the common boom adjustment problems.

Other Spraying Equipment

Rotary Nozzle

The rotary nozzle uses centrifugal force instead of pressure to produce droplets. This process, known as controlled droplet application (CDA), forms droplets of relatively uniform size. Liquid enters at the center of the spinning disc and is propelled outward to the teeth on the edge. When the droplet is heavy enough, centrifugal force throws it from the spinning disc. Droplet size can be controlled by varing the rotational speed of the disc. This allows the same nozzle to be used for insecticides, herbicides and fungicides. Flow rate, controlled by pressure and a metering orifice in the nozzle line, also has some influence on droplet size.

Rotary nozzles with horizontal discs (Fig. 17) produce a hollow cone pattern. Some are mounted on extension arms perpendicular to the boom to eliminate obstructions that might interfere with the spray pattern. The nozzles are usually set at a slight angle to improve droplet penetration into the canopy and the overlap between spray patterns.

Experience has shown that a reduction in drift accompanies the uniform droplet size. However, the pattern is susceptible to distortion from wind. Canopy penetration is another problem with rotary nozzles. University of Illinois tests with 6 mph winds showed 91 percent of the spray from a 8002 flat-fan nozzle operating at 40 PSI was deposited in the swath, compared to only 70 percent from a rotary nozzle operating at 2,000 RPM.

Rotary nozzles with vertically positioned discs produce a fan-shaped pattern (Fig. 18). The droplets are directed down into the plant canopy giving better spray penetra-

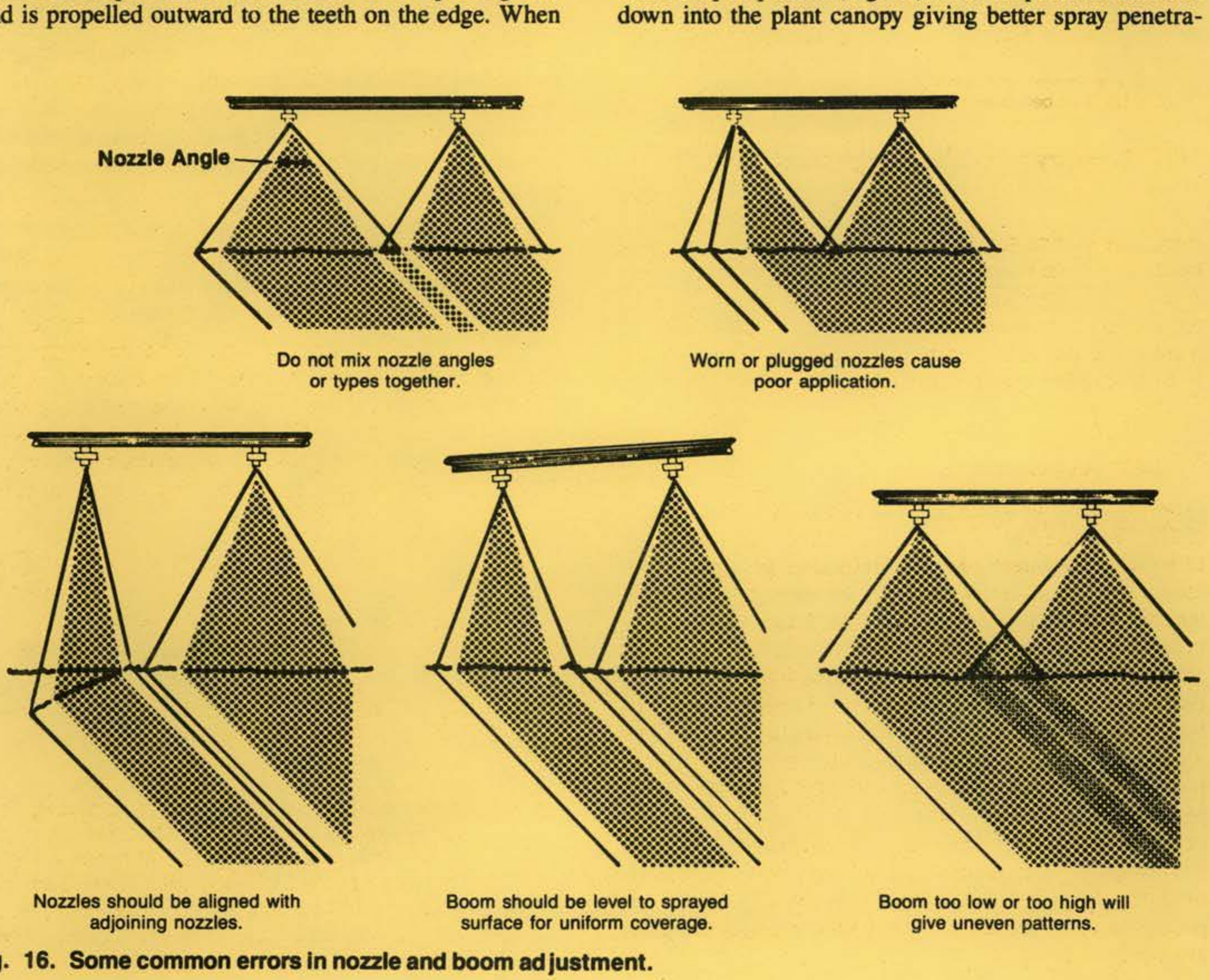

Fig. 16. Some common errors in nozzle and boom adjustment.

Table 6. 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. They are best for directed spraying.	Insecticides and fungicides
Flooding fan	Not as uniform as flat-fan nozzle	Liquid fertilizer and herbicides.

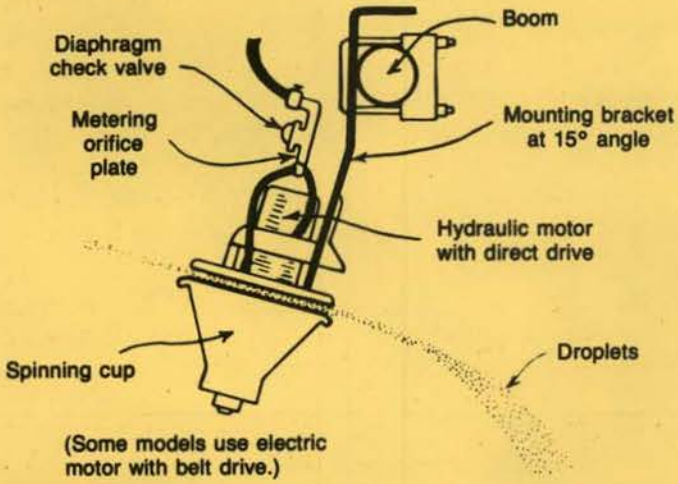

Fig. 17. Rotary nozzle with horizontal disc.

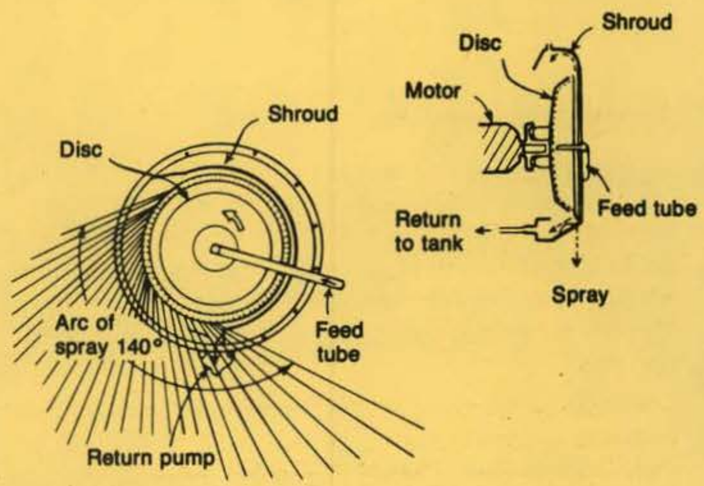

Fig. 18. Vertical disc rotary nozzle.

tion. The feeding tube delivers the spray to the center of the disc, and the shroud covering the upper segment of the disc collects droplets from that segment of the disc and recycles them to the pump. Droplets from the lower segment are delivered to the target. The disc is mounted directly to a variable speed electric motor.

Wiper Applicators

Several types of wiper applicators are available commercially. One consists of a long horizontal tube or pipe (3 to 4 inches diameter) that is filled with a systemic herbicide (Fig. 19). A series of short, overlapping ropes or a wetted pad on the tube is in contact with the herbicide and becomes saturated by wicking action. Another unit is the roller applicator that consists of a tube 8 to 12 inches in diameter turned by a hydraulic motor. The tube is covered by carpet that is being continuously wetted. These units are mounted on the front or rear of tractors on a three-point-hitch type unit that is hydraulically adjusted. The applicator can be set at a height so the pad applies herbicides to weeds taller than the crop but does not contact the crop. Best results are obtained with double coverage of wiper applicators. The second pass should be in the opposite direction to the first pass so two sides of the plant are covered.

Injector Sprayers

Injector sprayers continuously meter concentrated pesticide into the spray system as needed. They contain two or more tanks with one or two tanks for concentrated pesticide and a larger tank for carrier. Some units are designed so the volume of pesticide metered is determined by ground speed. Others are adjusted based on a constant travel speed. Any change in speed may cause over or under application. The advantage is that no mixed chemical is left over at the

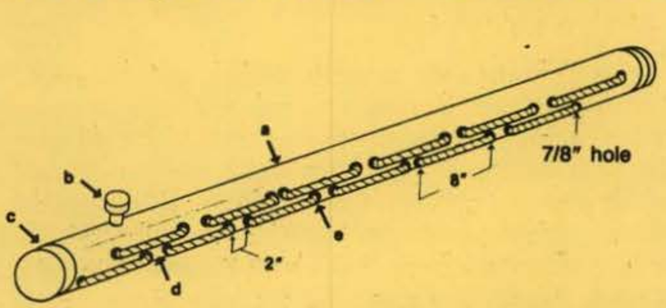

Fig. 19. Typical rope wick applicator showing the components assembled. Materials are (a) 3-inch PVC pipe; (b) capped fill spout — PVC; (c) end cap — PVC; (d) wick of ½-inch diameter soft braided nylon marine rope; (rubber bushing (for ½-inch rope) with compression cap.

end of the spraying season. Also, these units may be useful in spot spraying as a troublesome pest is encountered and another chemical may be added to the spray solution that will give better control than the one normally used. One problem with injection sprayers is the timely injection of the chemical into the system so it is discharged at the proper time. Lead time on injection may vary because of the size of the hoses on your sprayer, the amount of liquid being applied and the point of injection of the chemical into the system. Injection equipment requires precise measuring equipment in good condition. It is more difficult to measure small amounts of chemical on a continuous basis than to measure one larger quantity and mix it in the spray tank at one time.

Spray Monitors

Several types of monitors are currently available. They are available as either nozzle or system monitors. Nozzle monitors sense flow at individual nozzles. If flow through a nozzle stops because of plugging, a signal such as a flashing light or buzzer is indicated to the operator. These monitors are especially useful on nozzles not visible to the operator.

System monitors sense the operating condition of the complete sprayer including factors such as travel speed, pressure and flow. The inputs are fed into a microcomputer along with other inputs such as swath width and gallons of spray mix in the tank. The console displays the pressure and travel speed. The most important function of the monitor is to continuously compute and display the application rate (GPA). In addition, the monitor will compute and display other information such as field capacity (acres per hour), gallons applied, gallons remaining in the tank, acres covered and distance covered. The sensor must be installed and accurately calibrated before it will function. Many times monitors will result in better pest control, less probability of pollution and less pesticide application.

Spray Controllers

Spray controllers are monitors with the added capability of automatic rate control. This may be a built-in or add-on function. The controller receives the actual application rate from the monitor and compares it with the desired rate. If there is a difference, the controller will adjust the application rate automatically (usually by adjusting pressure) to reduce the error. If the error becomes large, the unit will signal the operator that the controller is unable to correct the problem. This may happen if speed varies too much for pressure compensation, a hose or connection breaks, a line strainer plugs or some other problem occurs. When pressure change is used to correct application rate, nozzle spray patterns may change. Be sure to limit the pressure change to small amounts to maintain uniform coverage.

Spray Markers

Another helpful accessory to aid uniform spray application is a foam or dye marker system to mark the edge of the spray swath (Fig. 20). This mark shows the operator where to drive on the next pass to reduce skips and overlaps and is a tremendous aid in non-row crops such as small grains. The mark may be continuous or intermittent. Typically 1 to 2 cups of foam are dropped every 25 feet. The foam or dye requires a separate tank and mix, a pump or compressor, a delivery tube to each end of the boom and a control to select the proper boom end. A new marker recently introduced is the paper type. This unit drops a piece of paper intermittently the length of the field.

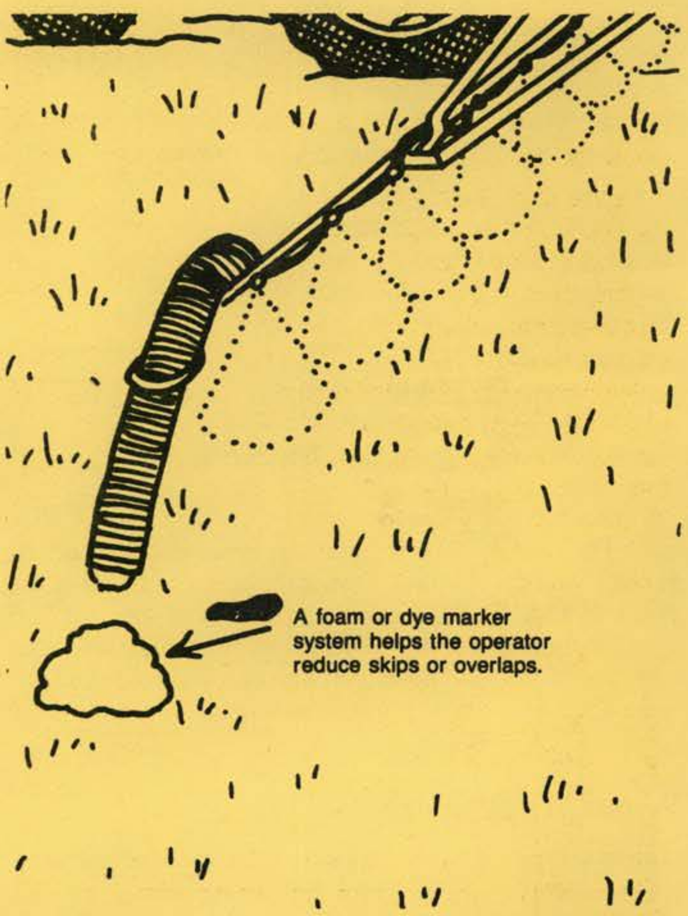

Fig. 20. Foam marker.

Shielded Spray Boom

Shielded spray booms or completely covered booms show potential for use on broadcast sprayers to increase spray deposition in the target swath. The main disadvantage of shielded booms is the increased weight that must be carried on the spray boom. A wheel on the end of the boom may be needed to carry the extra weight and maintain a stable spraying height.

Air Blast Sprayers

Air blast units spray chemical into a high speed air stream that carries the chemical to the crop and gives good penetration of the crop or weed canopy. Air blast sprayers will deposit more pesticide on the underside of crop or weed leaves than other sprayers and may improve pest control. These sprayers may have a high drift hazard because of the small drop produced and dissipation of the air blast when hitting the ground and the resulting upward movement of air and chemical carried in the air.

Spray Drift

Drift of pesticides away from the target is an important and costly problem facing applicators. In addition to the potential damage to non-target areas, drift tends to reduce the effectiveness of chemicals and costs money. Drift may occur by two different means.

Vapor drift ocurs when a chemical vaporizes after being applied to the target area. The vapors are then carried to another area where damage may occur. The amount of vaporization that occurs depends largely on the temperature and formulation of the pesticide being used. Volatile ester formulations of 2,4-D and MCPAs vaporize rapidly at temperatures as low as 40 degrees F, while "low volatile" esters resist vaporization up to 75 to 90 F. The amine formulations are essentially "non-volatile." When operators choose the correct herbicide formulation, the dangers of vapor drift are reduced substantially.

Physical droplet drift is the actual movement of spray particles away from the target area. Many factors affect physical drift, but one of the most important is droplet size. Small droplets fall through the air slowly, so they are carried farther by air movement. Fig. 21 shows the distance small droplets can be carried downwind when carried by a 3 miles-per-hour breeze.

Liquid sprayed through a nozzle divides into droplets that are spherical or nearly spherical in shape. The recognized measurement for indicating the size of these droplets is in microns.

A 1-micron drop has a diameter of 1/1,000 of a millimeter. Approximately 25,400 1-micron diameter spheres set side by side would equal one inch. The thickness of a dime is about 1,270 microns. Droplets smaller than 100 microns are highly "driftable." This size drops are so small that they cannot be seen unless in extremely high concentrations such as on a "foggy" morning.

All spray droplet atomizers available today produce a wide range of droplet sizes, some wider range than others. Controlled droplet applicators also produce droplets of various sizes with the range of sizes less than hydraulic nozzles. Table 7 shows a typical distribution of droplet sizes for a flat-fan nozzle when spraying water at two different pressures.

Most of the droplets produced are small. Table 7 indicates that more than half of all of the droplets were less than 63 microns in diameter. However, little of the total volume is contained in droplets less than 63-micron diameter. Most of the volume is contained in the larger

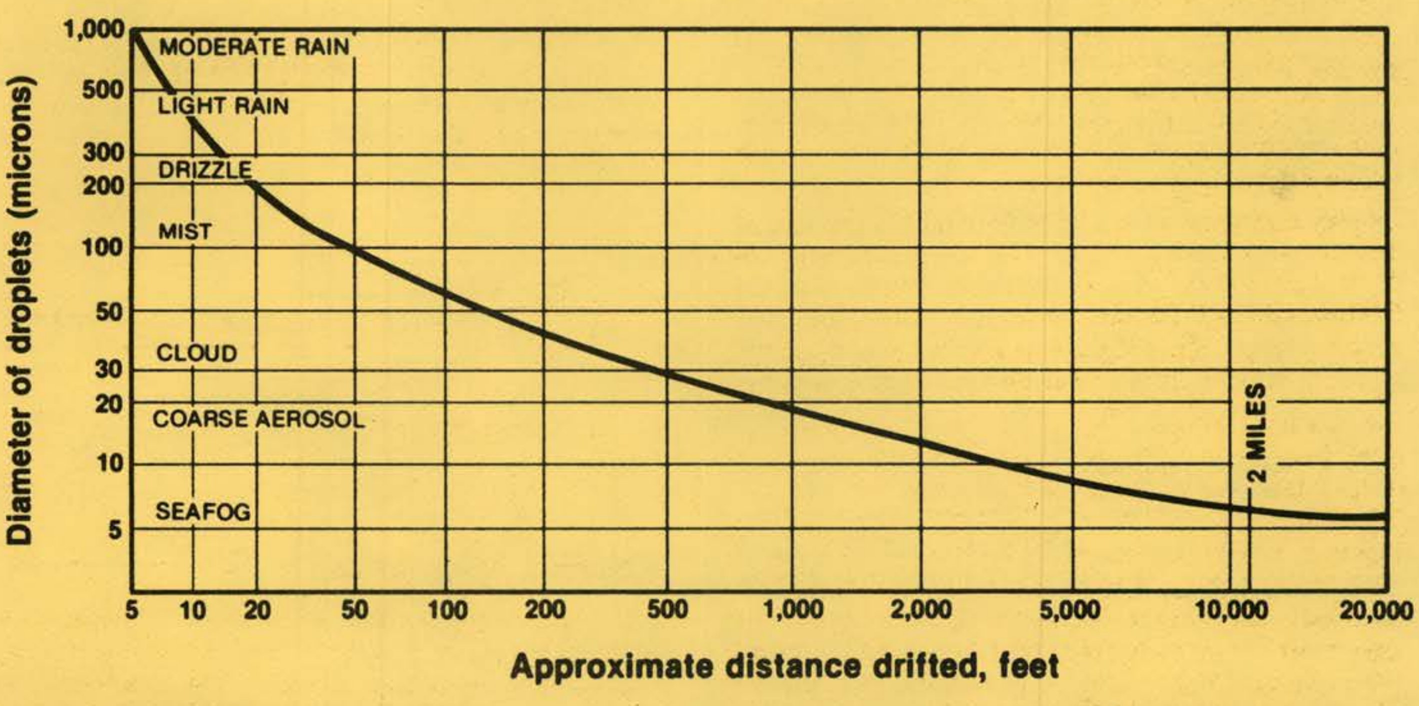

Fig. 21. Relationship of droplet size to spray drift (based on droplets falling 10 feet in a 3 MPH wind).

Example: A droplet with a 100-micron diameter would drift 50 feet, while a 7-micron diameter droplet could drift 2 miles.

Table 7. Droplet size range for a flat-fan nozzle at 20 PSI and 40 PSI.

Size range, microns	Percent of all droplets 20 PSI	Percent of all droplets 40 PSI	Percent of total volume 20 PSI	Percent of total volume 40 PSI
0-21	22.4	44.6	0.1	0.4
21-63	37.6	39.5	3.0	10.4
63-105	21.2	10.0	10.7	20.1
105-147	9.2	3.8	16.2	25.4
147-210	7.2	1.9	36.7	35.3
210-294	2.3	0.2	27.5	7.7
over 294	0.2	0.006	5.8	0.7

droplets, particularly those ranging in size from 63 to 210 microns. These principles hold true for both pressures, although increasing the pressure caused more of the spray to be contained in small droplets. Even though the volume of small droplets is low, downwind crops that are susceptible to injury from the pesticide can be seriously affected.

The number of droplets deposited per square inch of surface from the ordinary spray nozzle is normally far more than the minimum required to control a specific pest. In some situations, particularly when using fungicides and insecticides, high spray droplet density may be needed.

Table 8 shows how many drops would be deposited per square inch of surface if 1, 5 and 10 gallons of spray solution were applied in uniform size droplets of different diameters. When 10 gallons per acre of spray solution are applied in uniform 400-micron droplets, there are 180 droplets per square inch. A coverage of 180 droplets per square inch is probably more than adequate for most herbicide applications. Remember, nozzles produce a wide range of drop sizes; nozzles that produce one size droplet are not yet available.

The objective in applying chemicals is to achieve uniform spray distribution while retaining all the spray droplets within the intended spray area.

Spray liquid may have a velocity of 60 feet per second or more when leaving a nozzle. The speed is reduced because of air resistance and because the spray material breaks into small drops. After their initial speed slows, the drops continue to fall slowly at a constant velocity. Large drops maintain velocity for a longer time than small ones because evaporation reduces droplet size as soon as drops are formed in the air. Small drops evaporate very quickly, leaving minute quantities of the pesticide in the air as shown in Fig. 22. Larger droplets are more likely to be deposited on target, so the amount of chemical drifting out of the target area is reduced. Relative humidity affects the evaporation rate of droplets. Under dry, low-humidity conditions, evaporation occurs much faster than in high humidity atmospheric conditions.

Table 8. Number of droplets per square inch for three application rates.

Droplet size (micron)	Droplets per square inch 1 GPA	5 GPA	10 GPA
50	9,224	46,120	92,250
100	1,164	5,820	11,750
200	142	710	1,425
300	43	215	430
400	18	90	180
800	2.2	11	22

"Drift" is not always harmful. It depends on the pesticide being used, the target pest and the non-target organisms or objects that are downwind or adjacent to your target area. Keep in mind that if you have considerable drift downwind, you will be losing valuable pesticide. Drift from most herbicides should be kept to a minimum, and all drift-reducing techniques should be used if the chemical permits. When using an insecticide for mosquito control, "drift" may be desirable. In this situation, a small driftable droplet is needed to get into small areas to do an effective job.

Several factors affect droplet size and potential drift. They include:

1. Wind direction
2. Wind speed
3. Air stability
4. Spray pressure
5. Nozzle spray angle
6. Nozzle type
7. Relative humidity and temperature
8. Spray thickeners
9. Boom height

Wind direction: Pesticides should not be applied when the wind is blowing toward an adjoining susceptible crop or a crop in a vulnerable stage of growth. Wait until the wind blows away from the susceptible crop or, if weed problems are minor, don't spray at all.

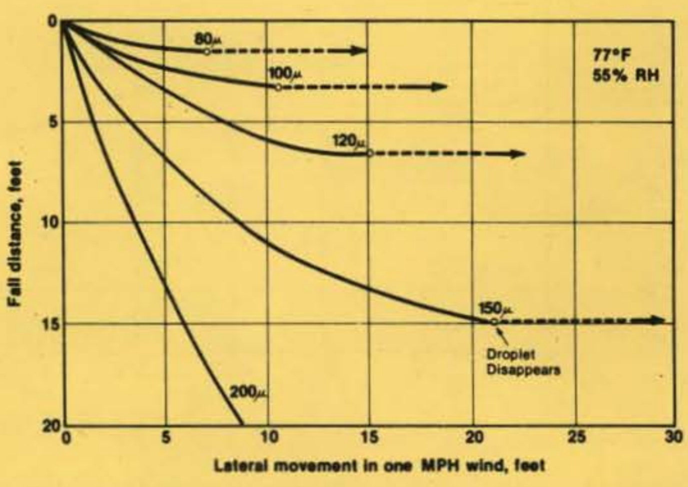

Fig. 22. Evaporation rate of water droplets (μ=droplet diameter in microns).

Wind speed: The amount of herbicide lost from the target area and the distance it moves both increase as wind velocity increases. However, severe drift injury can occur with low wind velocities, especially under temperature inversion situations.

Air stability: Air movement largely determines the distribution of spray droplets. Wind is generally recognized as an important factor, but vertical air movement is often overlooked. Temperature inversion is a condition where cool air near the soil surface is trapped under a layer of warm air. A high inversion occurs when ground air is 2 to 5 degrees cooler than the air above. Under inversion conditions, little vertical mixing of air occurs, even with a breeze. Spray drift can be severe under inversion conditions since small spray droplets may fall slowly or may stay suspended and move with a gentle breeze into adjoining areas.

Another case of spray drift is temperature "lapse" greater than 2.3 F decrease per 1,000 feet altitude. Under a normal "lapse" situation, cool air gently sinks, displacing lower warm air and causing vertical mixing of air. This may cause small droplets to be carried aloft and dispersed. When the "lapse" is stronger, more spray will be carried upward causing a greater chance for spray drift.

Research has shown that temperature inversion causes more spray drift than "lapse" conditions at a given wind speed.

Spray drift may occur even with relatively calm conditions under an inversion, especially with small droplets. Some of the most severe drift problems have occurred with low wind velocities, inversion conditions and small spray droplets. Spray drift under inversion conditions could be reduced by increasing droplet size, by using larger orifice nozzles or by using lower spray pressures.

Avoid applying herbicides near susceptible crops during temperature inversion conditions. Inversions can often be identified by observing smoke from a smoke bomb or fire. Smoke moving horizontally close to the ground would indicate a temperature inversion.

Spray pressure: Spray pressure influences the formation of droplets from the spray solution. The spray solution emerges from the nozzle in a thin sheet, and droplets form at the edge of the sheet. Higher pressures cause the sheet to be thinner, and this sheet breaks up into smaller droplets. Large orifice nozzles with higher delivery rates produce larger droplets than smaller orifice nozzles. Small droplets are carried farther downwind than larger drops formed at lower pressures. Table 9 shows the percentage of chemical deposited downwind at two measured distances. It also shows how far downwind 1 percent of the applied chemical will be carried.

Nozzle spray angle: Spray angle is the interior angle formed between the outer edges of the spray pattern from a single nozzle. Nozzles with wider spray angles will produce a thinner sheet of spray solution and smaller spray droplets than a nozzle with the same delivery rate but narrower spray angle. However, wide angle nozzles are placed closer to the target than narrow ones, and the benefits of lower nozzle placement outweigh the disadvantage of slightly smaller droplets.

Nozzle type: Droplet sizes produced by various nozzle types at different spray pressures and output are shown in Table 10. "Flat-fan," "flooding" and "hollow cone" nozzles produce similar sized droplets and a similar volume of small droplets. The flooding nozzle tends to produce slightly larger droplets than the flat-fan, while the flat-fan produces slightly larger droplets than the hollow cone.

Two types of Raindrop nozzles have been developed for drift control. The type "RA" is a whirl chamber nozzle with a secondary swirl chamber attached. The type "RD" is a disc-core nozzle with a secondary whirl chamber attached. Compared with the other nozzle types listed in Table 10, the Raindrop nozzles produce the largest droplets and also the lowest volume of small droplets. For many

Table 9. Comparisons of distances downwind for 1 percent of the application rate to be deposited.

Run no. and comparison	Pressure PSI	Wind speed	% deposited at 4 ft	% deposited at 8 ft	Downwind distance ft*
1. Regular flat-fan at 14" height	40	3.5	3.1	.6	7
Regular flat-fan at 27" height	40		5.9	1.5	13
2. Regular flat-fan at 25 PSI	25	9.9	10.3	3.1	15.5
Regular flat-fan at 40 PSI	40		9.1	3.6	17
3. Regular flat-fan at 18"	30	5.3	9.3	2.2	14
Low-pressure flat-fan at 18"	15		5.7	1.4	11
4. Regular flat-fan and 6 oz. Nalco-Trol thickener	30	8.2	3.3	.5	7
Regular flat-fan with no thickener	30		8.3	3.1	16.5
5. Flooding flat-fan at 13"	10	4.2	1.3	.6	5.5
Regular flat-fan at 18"	30		3.5	1.1	9
6. Raindrop nozzle at 18"	40	10.3	4.8	.6	7
Regular flat-fan at 18"	30		10.2	3.3	16

*Downwind distance for deposit to drop to 1 percent of application volume.

herbicide applications, a large droplet will give good results. If good plant coverage is desired, the Raindrop may not do an adequate job.

Relative humidity and temperature: Low relative humidity and high temperature conditions cause faster evaporation of spray droplets between the sprayer and the target. Evaporation reduces droplet sizes, which in turn increases the potential drift of spray droplets. Spraying during lower temperatures and higher humidity conditions will help reduce drift.

Boom height: Operating the spray boom as close to the sprayed surface is a good way to reduce drift. The closer the boom is to the ground, the wider the angle of spray discharge must be to give uniform coverage. Be sure nozzles are right for the application. Booms that bounce will cause uneven coverage and drift. Wheel-carried booms are a good way to stabilize boom height, which will reduce the drift hazard and produce a better spraying job.

Drift reduction benefits when nozzles are mounted as close to the ground as possible are shown in Table 9. Chemical deposited at both the 4- and 8-foot distances downwind is less for the lower positioned nozzles. Flood nozzles produce a wide spray pattern and can be operated at low pressures. The wide pattern allows them to be mounted close to the ground, keeping drift to a minimum.

Spray thickeners: Some spray adjuvants act as spray thickeners when added to the spray tank. These materials increase the number of larger droplets and decrease the number of fine drops. They tend to give water-based sprays a somewhat "stringy" quality. Thickeners reduce drift but do not make the spray drift-proof. The reduction in deposits downwind when a thickener is added to the spray tank is shown in Table 9.

Droplets formed from an oil tend to drift farther than droplets from a water carrier because oil droplets are usually smaller, lighter and remain airborne for a longer period. Oils form into smaller droplet sizes than water when the spray is produced with the same hydraulic nozzle and the same spray pressure.

Boom height: Studies have shown that the closer a nozzle is mounted to the sprayed surface, the lower the amount of spray drift (Table 9). But to provide a uniform spray pattern with proper overlap, nozzles must be mounted at the proper height above the target. Nozzle mount height depends on nozzle spacing on a boom. A 20-inch nozzle spacing allows nozzles to be mounted closer to the spray target than a 30-inch nozzle spacing. Boom bounce should be reduced as much as possible, and variation from the recommended height will change the spray pattern.

Drift Control

Because all nozzles produce a range of droplet sizes, the small, drift-prone particles cannot be completely eliminated. Drift can be reduced and kept within reasonable limits, however.

1. Use adequate amounts of carrier. This means larger nozzles, which in turn usually produce larger droplets. Although this will increase the number of refills, the added carrier improves coverage and usually increases the effectiveness of the chemicals. Lower spray volumes produce smaller droplets, resulting in greater drift hazard.

Table 10. Influence of nozzle type and spray pressure on droplet size.

Nozzle type	Delivery rates	Spray pressure	Spray angle	Volume median diameter*	Volume with less than 100 micron dia.
	(gal/min)	(lb/sq in)	(degrees)	(microns)	(%)
Flat-fan	0.12	15	65	239	
(LF-2)	0.17	30	76	194	
	0.20	40	80	178	17.5
Flooding	0.12	15	90	289	
(D-1)	0.17	30	115	210	
	0.20	40	125	185	15.5
Hollow cone	0.12	15		228	
(HC-12)	0.17	30		185	
	0.20	40	70	170	19.0
Whirl chamber	0.12	15		195	
(WRW-2)	0.17	30		158	
	0.20	40	120	145	23.0
Raindrop	0.12	15		539	
(RA-2)	0.17	30		381	
	0.20	40	120	330	1.0
Raindrop	0.11	15		506	
(RS-1)	0.16	30		358	
	0.18	40	90	310	0.8

Source: Delavan Manufacturing Company

*Volume median diameter (VMD) is a term used to describe the droplet size produced from a nozzle. VMD is defined as the diameter at which half the spray volume is in droplets of larger diameter and the other half of the volume is in smaller droplets.

2. Avoid high pressure. Higher pressures create finer droplets; 40 PSI should be considered the maximum for conventional broadcast spraying.
3. Use a drift-reducing nozzle where practical. It produces larger droplets and operates at lower pressures than the equivalent flat-fan nozzle.
4. Many drift-reducing spray additives that can be used with regular spray equipment are available today.
5. Use wide-range nozzles and keep the boom stable and as close to the crop as possible.

Calibrating Chemical Applicators

The amount of chemical solution applied per acre depends upon forward speed, system pressure, size of nozzle and spacing of nozzles on the boom. A change in any of these will change the rate of application.

Testing of ground sprayers in Idaho identified a number of problems that can have a major impact on application accuracy (Table 11).

Forward speed and pressure must be adjusted and kept in adjustment to set the sprayer for any given rate per acre. The nozzle size should be changed when necessary to make a large change in application rates. The sprayer must be adjusted correctly and all nozzles must discharge an equal amount of spray. If either of these items are incorrect, poor results will be obtained.

Calibration of the sprayer is extremely important so you know exactly how much pesticide you are applying uniformly to an area. Sprayers must be calibrated even when new or when nozzles are replaced. They should also be recalibrated after a few hours of use because new nozzles wear, and flow rate will increase rapidly. Calibrate your sprayer by measuring the amount of pesticide applied to

(text continues on page 22)

Table 11. Problems of farm-operated ground sprayers identified in Idaho tests.

% of sprayers with problems	Problem
70	Calibration error greater than ±10% from the owner's prediction.
35	Greater than ±10% variation in discharge from individual nozzles.
41	Inaccurate travel speed from what the owner predicted.
32	Improper boom height for the nozzle spacing and nozzle discharge angle.
20	Inaccurate pressure gauges. Many of the gauges indicate too low pressure.

Calibration Method No. 1

This method involves spraying over a measured distance starting with a full tank of water. Traveling over a longer distance will provide more accurate results.

½-mile distance

1. Start with a **full** tank of water.
2. Spray a distance in a field known to be 160 rods (½ mile) long. Be sure to do this in the field in which you will be spraying.
3. **Measure** the gallons of water required to refill the tank.
4. Use the following formula to figure gallons per acre (GPA) for a ½ mile distance only.*

$$GPA = \frac{\text{Number of gallons to refill the tank} \times 16.5}{\text{Actual width of boom coverage (ft)}}$$

Example: After spraying for a ½ mile distance, 10 gallons are required to refill the tank. The sprayer covers a 30-foot swath.

$$GPA = \frac{10\text{ (gal)} \times 16.5}{30\text{ (ft)}}$$

$$GPA = 5.5$$

Note: This formula works for a ½ mile distance only.

*The general formula that can be used to calibrate a sprayer over any distance is:

$$GPA = \frac{\text{Number of gallons to refill tank} \times 43{,}560\text{ sq ft/acre}}{\text{Actual width of boom coverage (ft)} \times \text{distance of travel (ft)}}$$

Table 12. Seconds to drive 300 feet converted to miles per hour (MPH).

MPH	Seconds to drive 300 feet	MPH	Seconds to drive 300 feet	MPH	Seconds to drive 300 feet
1.0	204	5.5	37	10.0	20
1.5	136	6.0	34	10.5	19
2.0	102	6.5	31	11.0	18
2.5	82	7.0	29	12.0	17
3.0	68	7.5	27	13.0	16
3.5	58	8.0	26	14.0	15
4.0	51	8.5	24	15.0	14
4.5	45	9.0	23	16.0	13
5.0	41	9.5	22		

Calibration Method No. 2

To use this method, you must measure the discharge from individual nozzles and travel speed. Measure the travel speed in the field you will be spraying. Inaccurate speedometers, varying tire size and tire slippage can cause large errors in speedometer readings. Several methods can be used to measure travel speed. Table 12 converts the time to drive 300 feet to speed in miles per hour.

When measuring travel speed, drive at a uniform speed and use the speed that will be used while spraying. Another accurate method of finding travel speed is to time the sprayer over a known distance of ¼ or ½ mile. To calculate MPH, use the following formula:

$$\text{MPH} = \frac{\text{Distance (ft)} \times 60}{\text{Time (seconds)} \times 88}$$

The next step in calibration is to collect the discharge from each nozzle for a 30-second time period at the recommended operating pressure. Use a measuring cup indicating ounces. Add all the nozzle output amounts together and divide by the number of nozzles. This gives the average discharge for all nozzles. Use this average on the graphs in Table 13. **Be sure to use the correct graph for your nozzle spacing.**

All nozzles on the sprayer should discharge nearly equal amounts. Variation from the average should be less than 10 percent. To find this, take 10 percent of the average amount collected, subtract from the average and also add it to the average. All individual nozzle discharge readings should fall between these limits. If only a few (one or two) do not, replace the bad nozzle(s). If several nozzles fall outside the 10 percent range, replace all the nozzles.

Example: Individual nozzle readings, ounces collected in 30 seconds.

Nozzle #1 - 14 ounces
Nozzle #2 - 18 ounces
Nozzle #3 - 17 ounces
Nozzle #4 - 15 ounces
Nozzle #5 - 16 ounces
Total of 5 nozzles = 80 ounces

$$\text{Average} = \frac{80}{5.0} = 16 \text{ ounces/nozzle}$$

10% of 16 is 1.6 ounces

$$16.0 + 1.6 = 17.6 \text{ ounces} \qquad 16.0 - 1.6 = 14.4 \text{ ounces}$$

The range of 14.4 ounces to 17.6 ounces allows for ± 10 percent variation for these five nozzles. Nozzles number 1 and 2 fall outside the ± 10 percent and should be replaced.

The final step in calibrating your sprayer is to plot the tractor speed and nozzle discharge values in Table 13. Select the chart with your nozzle spacing. Then draw a straight line connecting the speed and nozzle discharge values and intersecting the GPA column. If the nozzle spacing on your boom is different from those in the graphs, use the 40-inch nozzle chart. Then multiply the GPA coverage obtained from that chart by the correction factor in Table 14.

Example: Travel speed is 4 mph and you collect an average of 20 ounces from the nozzles in 30 seconds. If you have 40-inch spacing, you are delivering 11.6 GPA (see dotted line, Table 13). If the nozzles are on 30-inch spacing, multiply 11.6 by 1.33 (from Table 14) The output would be 15.4 GPA.

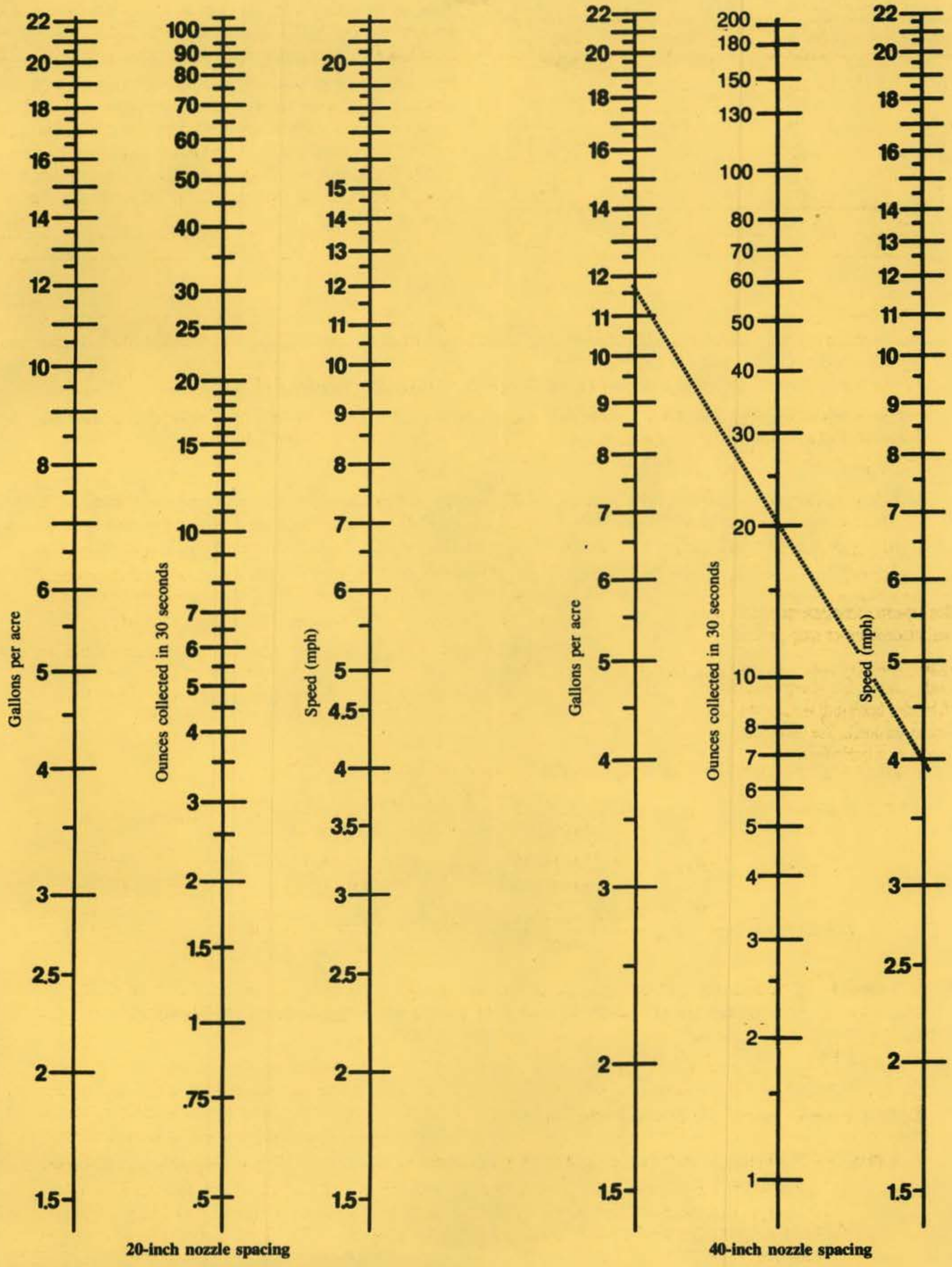

Table 13. Calibration charts for 20-inch and 40-inch nozzle spacing.

Table 14. Correction factors for nozzle spacings other than 40 inches.

Nozzle spacing	Correction factor	Nozzle spacing	Correction factor
12″	3.33	26″	1.54
14″	2.86	28″	1.43
16″	2.50	30″	1.33
18″	2.22	32″	1.25
20″	2.00	34″	1.18
22″	1.82	36″	1.11
24″	1.67	38″	1.05

a part of an acre. Then calculate how much would be applied to an entire acre. Be sure to check the flow rate of all nozzles on the sprayer so they are similar.

A good way to check your calibration is to determine how much pesticide was applied to a certain acreage. For example, if 50 acres were sprayed and 600 gallons of chemical mix were used, the application rate was 12 gallons per acre. This system is simple and has the advantage of measuring the amount of spray that was actually applied to an area. Keep in mind, this should not be your only calibration method.

Calibration Method No. 3: "The 47 Second Catch"

This method requires collecting water from the nozzle for 47 seconds. By doing so, you can reduce the amount of calculations needed for calibration.

1. Determine your speed as in Method 2.
2. Then collect the output from the nozzles for 47 seconds and average the nozzle output as in Method 2. This average, divided by 100, is the gallon per minute (GPM) output of the nozzles. This can also be used to compare your actual output with the GPM suggested in the manufacturer's catalog. If your nozzles have a higher GPM than the manufacturer, they are worn and should be replaced.

Example: Average nozzle readings collected in 47 seconds is 50 ounces.

$$\text{GPM} = \frac{\text{ounces collected in 47 sec}}{100}$$

$$\text{GPM} = .5$$

3. To determine the gallons per acre, use one of these formulas:

For 20″ spacing $$\text{GPA} = \frac{300 \times \text{GPM}}{\text{MPH}} \text{ or } \frac{3 \times \text{oz collected in 47 sec}}{\text{MPH}}$$

For 30″ spacing $$\text{GPA} = \frac{225 \times \text{GPM}}{\text{MPH}} \text{ or } \frac{2.25 \times \text{oz collected in 47 sec}}{\text{MPH}}$$

For 40″ spacing $$\text{GPA} = \frac{150 \times \text{GPM}}{\text{MPH}} \text{ or } \frac{1.5 \times \text{oz collected in 47 sec}}{\text{MPH}}$$

Example: If you have a 20″ spacing and collect an average of 50 ounces from each nozzle in 47 seconds and travel at 5 MPH then how many gallons per acre are you applying?

$$\text{GPA} = \frac{3 \times 50}{5} = 30 \text{ GPA}$$

4. To determine speed, you rearrange the formula.

Example: If you have a 40″ spacing and collect 60 ounces in 47 seconds and want to apply 20 GPA, how fast should you go?

$$\text{MPH} = \frac{1.5 \times 60 \text{ (oz)}}{20 \text{ (GPA)}} = 4.5 \text{ MPH}$$

Spray equipment in good condition will apply chemical properly if accurately calibrated and correctly operated. Manufacturers' owners manuals include tables to show rates of application for various nozzles, pressures and ground speeds. Use this information initially to set up the sprayer; then use one of the methods described on pages 19 through 23 to adjust the sprayer for accurate application.

Band and Directed Spraying

Band application is applying a chemical in parallel bands, leaving the area between bands free of chemicals.

Directed spraying is application of a chemical to a specific area such as a plant canopy, a row or at the base of the plants.

Several nozzle configurations are often used when foliage penetration or row crop height present a problem. Fig. 23 shows several commonly used nozzle configurations.

The two- and three-nozzle configurations give better bottom leaf coverage than a single nozzle. This can be important with many pesticides. Drop nozzles are useful for herbicide application in taller row crops to reduce the risk of crop injury. In smaller row crops a single nozzle "band" configuration using a nozzle with a uniform pattern, i.e. even flow flat-fan, should be adequate.

Band Applicator Calibration

The calibration methods used for broadcast spraying can also be used to calibrate band applicators. The only difference is the area being covered. The main idea to keep in mind is what is meant by an acre. Total acre refers to the entire acreage in the field. This would include the sprayed band and the area between the bands. A treated acre refers only to the treated area in the band. The spray that would be discharged on broadcast rate is concentrated in a narrow band by the ratio of spacing divided by the band width. For example, if you have a 40-inch row spacing and are spraying a 10-inch band, you are treating ¼ the area (10 inch band/40-inch width). In band spraying, the row spacing and the nozzle spacing are the same.

Unless otherwise specified, chemical application rates are given on a broadcast basis. For band applications, the rate per treated acre is the same as the broadcast rate, but the total amount of pesticide used on a field is less because only a portion of the field is treated.

Spray discharge charts furnished by manufacturers for band nozzles are usually listed as applying chemical on a broadcast basis. This amount applied will increase when directed into a narrow band.

In nozzle manufacturer charts, gallons per acre means volume applied to the area actually sprayed (treated acre). Depending on row spacing and band width, this area is

Calibration Method No. 4

This method involves collecting water from a nozzle as the sprayer travels a distance of 100 feet. This method is useful for sprayers with ground driven pumps. Since it is difficult to collect spray from all the nozzles, collect spray from several nozzles located along the boom to determine an average output.

1. Mark off distance of 100 feet. Collect the sample from the nozzle as the sprayer is traveling the staked distance.
2. Once you have collected the sample, use the following formula.

$$\text{GPA} = \frac{\text{oz/100 ft} \times 41}{\text{nozzle spacing (inches)}}$$

Example: You collected 20 ounces in 100 feet and your nozzle spacing is 40 inches. The gallons per acre you are applying are:

$$\text{GPA} = \frac{20 \times 41}{40} = 20.5 \text{ GPA}$$

3. To determine the ounces you need to collect in 100 feet to obtain your desired GPA, change the formula to:

$$\text{oz/100 feet} = \frac{\text{GPA} \times \text{spacing}}{41}$$

some fraction of the total field. The following is an example of the higher volume discharged in a treated acre when the broadcast rate is determined:

Example: 10-inch band width
30-inch row spacing
5 gallons per acre measured with broadcast calibration method.

$$\frac{\text{30-inch row spacing} \times \text{5 GPA}}{\text{10-inch band width}} = \text{15 GPA being applied in the row}$$

With 15 GPA being applied in the row (treated acre), mix the chemical in the spray tank based on this rate. Do not mix it on the 5 GPA (total acre) rate or you will be applying the chemical in the row at three times the desired rate. If you do not want to apply water in the row at 15 GPA, a smaller nozzle would be needed. Refer to the charts in the nozzle manufacturer's catalog.

Table 15 can be used to convert broadcast rates to band rates of chemicals. Multiply the GPA found on the broadcast basis by the factor in Table 15.

Directed Spraying Calibration

Calibrating a row crop sprayer with two or three nozzles per row can be done using calibration methods previously described but the following is simpler and may work best.

1. From Table 16 determine the distance of row needed to equal 1/128 acre for your row spacing. Stake this distance off in a field you will be spraying.

Table 15. Conversion factor to convert broadcast rate (rate per total acre) to band rate (rate per treated acre).

Band width	Row spacing (inches)			
	20	30	36	40
(inches)				
8	2.5	3.8	4.5	5.0
10	2.0	3.0	3.6	4.0
12	1.6	2.5	3.0	3.3
14	1.4	2.1	2.6	2.9

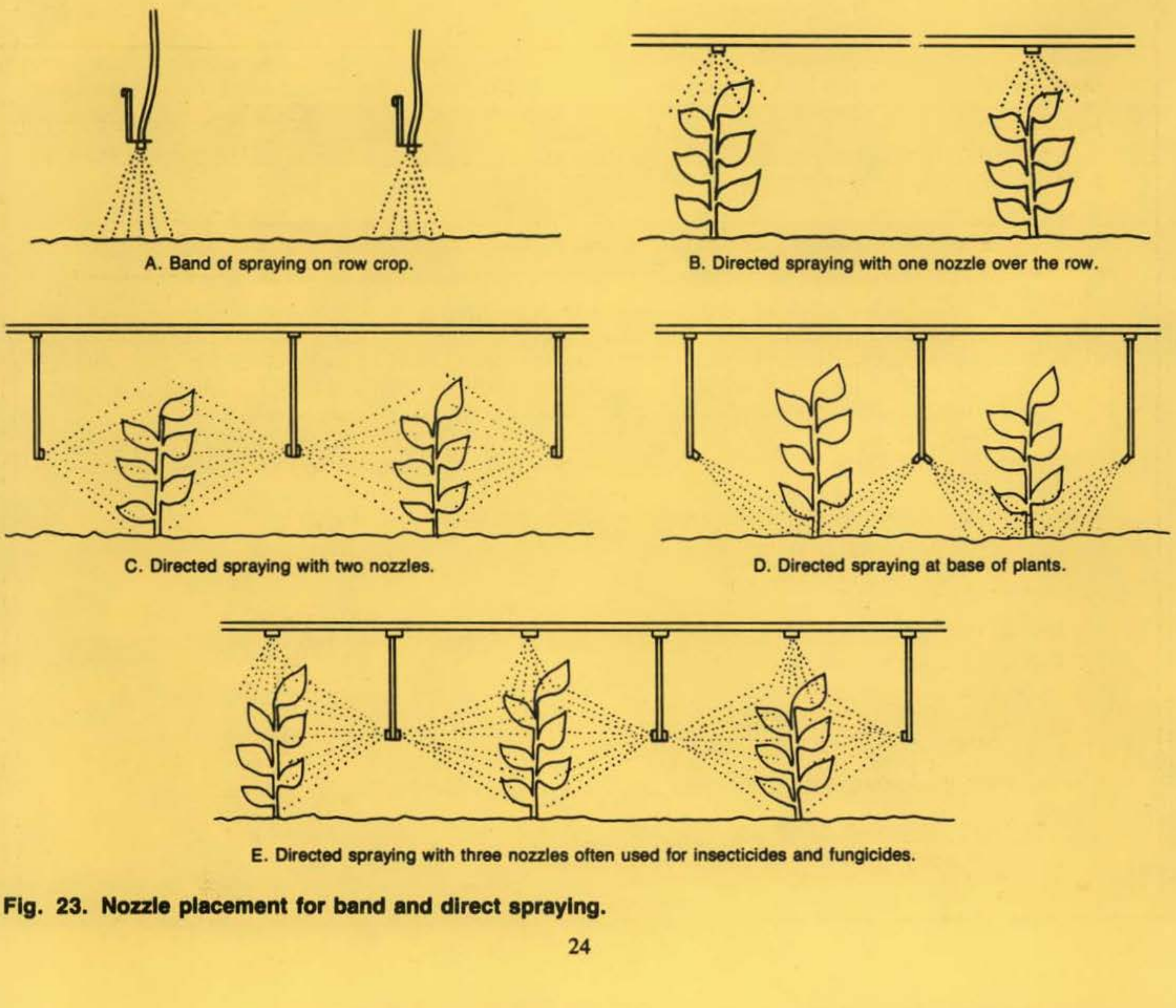

Fig. 23. Nozzle placement for band and direct spraying.

2. Measure the time (in seconds) needed to drive the required distance at normal operating speed with all equipment attached.
3. Collect the discharge from all nozzles directing spray to one row for the time measured in Step 2. All chemical added together in ounces is gallons per acre.

Hand Sprayer Calibration

Hand sprayers are usually used for applying chemicals to small areas. Hand sprayers may be calibrated as follows: determine the square feet in the area, measure the output of the hand gun for one minute, and calculate how fast the measured area should be covered. Then mix enough chemical to cover the area and apply all the chemical to the area as evenly as possible.

Example: You can measure an area 21 by 21 feet. This is approximately 1/100 acre. Your handgun puts out ½ gallon in 1 minute, and the chemical should be applied at the rate of 25 gal/acre. In this case:

$$25 \text{ gal} \times \frac{1}{100} = .25 \text{ GPA or 1 quart should be applied to the measured area}$$

If the area should be covered with 1 quart of spray and your handgun puts out ½ gal/min, you should cover the area in:

$$\frac{.25 \text{ gal}}{.5 \text{ gal/min}} = 0.5 \text{ minutes or 30 seconds}$$

Table 16. Distance for each row to spray 1/128 acre (ounces discharged from all nozzles equals gallons per acre).

Row spacing (inches)	Distance (feet)
20	204
22	186
24	170
30	136
36	113
38	107
40	102
42	97

Band Calibration

Method 1

1. Determine travel speed in the field you will be spraying. Drive at a uniform speed and measure the time to drive 300 feet.
2. Convert the time to speed in MPH from Table 12.
3. Collect the discharge in a measuring cup from individual nozzles for 30 seconds. Check for nozzle uniformity, and if variation is more than 10 percent from the average, replace the nozzles. Then go to Table 13 and plot the values. If your row spacing (nozzle spacing) is not shown, use the 40-inch nozzle spacing chart and the correction factor in Table 14.
4. This is the application per total acre.
5. To calculate rate per treated acre, use this formula:

$$\frac{\text{Rate/total acre} \times \text{row width}}{\text{band width}} = \text{rate/treated acre}$$

Method 2

1. Fill the spray tank with water.
2. Spray ½ mile in the field to be sprayed.
3. Measure the gallons needed to refill the tank.
4. Determine the row width in feet and the number of rows treated.
5. Use the following formula to calculate gallons per acre.

$$\text{GPA} = \frac{\text{No. of gallons to refill tank} \times 16.5}{\text{Number of rows} \times \text{row width (ft)}}$$

6. This is the application rate per total acre.
7. $$\frac{\text{Rate/total} \times \text{row width}}{\text{band width}} = \text{rate/treated acre}$$

How Much Chemical To Put in Tank

To determine the amount of pesticide to add to the spray tank, you need to know the recommended rate of pesticide, the capacity of the spray tank and the calibrated output of the sprayer.

Be sure your spray tank has accurate markings on the side to show the amount of spray mix remaining in the tank, so you don't add more or less chemical than is needed. Place your sprayer on level ground so an accurate reading can be made.

The recommended application rate is usually indicated as pounds per acre for wettable powders and pints, quarts or gallons per acre for liquids. The recommendation can also be given as pounds of active ingredient (lb a.i.) per acre rather than the amount of total product per acre. The active ingredient must be converted to actual product. Calculations can be done by one of the following methods:

Liquid Formulation

Example: A Trifluralin recommendation calls for 0.5 lb/a.i. per acre. Treflan 4E contains 4 lb(a.i.)/gal formulation. The sprayer being used has a 300-gallon tank and is calibrated at 10 gal/acre. How much Treflan should be added to the spray tank?

Step 1. Determine the number of acres that can be sprayed with each tankful. The sprayer has a 300-gallon tank and is calibrated for 10 gallons per acre.

$$\frac{\text{tank capacity (gal/tank)}}{\text{spray rate (gal/acre)}} = \frac{300}{10} = \text{30 acres per tankful}$$

Step 2. Determine the amount of product needed per acre by dividing the recommended a.i. per acre by the concentration of the formula.

$$\frac{\text{0.5 lb a.i./acre}}{\text{4 lb a.i./gal}} = \text{1/8 gal/acre}$$

One-eighth gallon or 1 pint of product is needed for each "acre's worth" of water in the tank to apply 0.5 lb a.i./acre.

Step 3. Determine the amount of pesticide to add to each tankful. Each tankful will cover 30 acres (Step 1), and 1/8 gallon (1 pint) of product per acre (Step 2) is needed. Add 30 pints (30 acres × 1 pint per acre = 30) of Trifluralin to each tankful. This is equal to 3¾ gallons of chemical.

Dry Formulation

Example: An Atrazine recommendation calls for 2 lb a.i./acre. AAtrex (80 percent wettable powder) was purchased. How much AAtrex should be added to the spray tank?

Step 1. Determine the number of acres that can be sprayed with each tankful. The sprayer has a 480-gallon tank and is calibrated to apply 12 gal/acre.

$$\frac{\text{tank capacity (gal/tank)}}{\text{spray rate (gal/acre)}} = \frac{480}{12} = \text{40 acres per tankful}$$

Step 2. Determine the pounds of pesticide product needed per acre. Because not all of the Atrazine in the bag is active ingredient, more than 2 pounds of the product must be added to each "acre's worth" of water in the tank. How much more? The calculation is: divide the percentage of active ingredient (80) into the total (100) and multiply by the active ingredient needed per acre. This gives the pounds of product to add to the tank for each acre covered.

$$\frac{100}{80} \times \text{2 lb a.i./acre} = \text{2.5 lb of product/acre}$$

Thus, 2.5 pounds of product are needed for each "acre's worth" of water in the tank to apply 2 lb a.i./acre.

Step 3. Determine the amount of pesticide to add to each tankful. Each tankful will cover 40 acres (Step 1), and 2.5 pounds of product per acre is needed (Step 2). Add 100 pounds (40 acres × 2.5 lb/acre = 100 lb) of Atrazine to each tankful.

Adjuvants (Spread-Sticker, Surfactant, etc.)

The manufacturer may recommend a small amount of adjuvant to be added in addition to the regular chemical. This recommendation is often given as "percent concentration."

If an adjuvant at a .5 percent concentration by volume is recommended, how much should be added to a 300-gallon tank?

Solution: .5 percent = 0.005
0.005 × 300 gal = 1.5 gal

Disposal of Excess Pesticide

The best way to dispose of chemical is to use it according to directions. To minimize this problem, buy and mix only the chemical you need.

If you must dispose of small amounts of pesticide, apply it to the same crop in another location or on a different pest or site for which the product is also registered. Always double check the container label to be certain that the chemical is registered for use at that site and that the maximum application rate and permissible residue levels will not be exceeded.

In Idaho, excess pesticide must be disposed of in an EPA-approved disposal site.

Empty Container Disposal

The first step in the disposal of an empty liquid pesticide container is triple rinsing. After you have emptied the pesticide container into the spray tank, let it drain completely. Then rinse the container, fill it about a quarter full of water, close it and then upend it so that all inside surfaces have been rinsed. Empty the rinse water into the spray tank. Let the container drain completely. Repeat the rinsing procedure two more times, adding the rinse water to the spray tank each time.

After rinsing, crush metal and glass containers. This will eliminate any other use of the containers, and they will take up less space. In Idaho, all pesticide containers — metal, cardboard, paper, glass, etc. — must be disposed of in an approved sanitary landfill.

Cleaning Sprayers

To remove residues of oil-based herbicides such as esters of 2,4-D and similar materials, rinse the sprayer with kerosene, diesel fuel or a comparable light oil.

After rinsing the equipment with oil or a water-detergent, add about one-fourth to one-half tank of a water-ammonia solution (1 quart of household ammonia to 25 gallons of water) or a water-trisodium phosphate (TSP) solution (1 cup TSP to 25 gallons of water). Circulate the solution through the system for a few minutes and let a small amount go through the nozzles. Allow the remainder of the solution to stand at least 6 hours, then pump it through the nozzles. Remove the nozzles and strainers and flush the system twice with clean water. Equipment in which wettable powders, amine forms or water-soluble liquids have been used should be thoroughly rinsed with a water-solution (2 pounds of detergent in 30 to 40 gallons of water). Water-soluble materials should be treated as water-soluble liquids. Allow the water-detergent solution to circulate through the system for several minutes. Remove the nozzles and strainers and flush the system twice with clean water.

When it is time to store your sprayer, add 1 to 5 gallons of light oil, depending on the size of your tank, before the final flushing. As water is pumped from the sprayer, the oil will leave a protective coating inside the tank, pump and plumbing. To prevent corrosion, remove the nozzle tips and strainers, dry them and store them in a can of light oil, such as diesel fuel or kerosene.

Appendix

Conversion Table for Use Of Materials on Small Areas

Rate per acre	Rate per 1,000 square feet	Rate per 100 square feet
	Liquid materials	
1 pt	¾ tb	¼ tsp
1 qt	1½ tb	½ tsp
1 gal	6 tb	2 tsp
25 gal	4½ pt	1 cup
50 gal	4½ qt	1 pt
75 gal	6½ qt	1½ pt
100 gal	9 qt	1 qt
	Dry materials	
1 lb	2½ tsp	¼ tsp
3 lb	2¼ tb	¾ tsp
4 lb	3 tb	1 tsp
5 lb	4 tb	1¼ tsp
6 lb	4½ tb	1½ tsp
8 lb	⅔ cup	1¾ tsp
10 lb	½ cup	2 tsp
100 lb	2¼ lb	¼ lb

3 teaspoons = 1 tablespoon
2 tablespoons = 1 ounce
1 cup = 8 ounces
2 cups = 1 pint
1 pint = 8 ounces
2 pints = 1 quart
4 quarts = 1 gallon

Weights and Measures

Weight
16 ounces = 1 pound = 453.6 grams
1 gallon water = 8.34 pounds = 3.78 liters

Liquid measure
1 fluid ounce = 2 tablespoons = 29.57 milliliters
16 fluid ounces = 1 pint = 2 cups
2 pints = 1 quart
8 pints = 4 quarts = 1 gallon
8 ounces = 1 cup

Length
3 feet = 1 yard = 91.44 centimeters
16½ feet = 1 rod
5,280 feet = 1 mile
320 rods = 1 mile

Area
9 square feet = 1 square yard
43,560 sq. ft. = 1 acre = 160 square rods
640 acres = 1 square mile

Speed
88 feet per minute = 1 mph

Volume
27 cubic feet = 1 cubic yard
1 cubic foot = 1,728 cubic inches = 7.48 gallons
1 gallon = 231 cubic inches

Common Abbreviations and Terms Used with Pesticide Sprayers

GPM = Gallons Per Minute
GPA = Gallons Per Acre
PSI = Pounds Per Square Inch
MPH = Miles Per Hour
RPM = Revolutions Per Minute
GPH = Gallons Per Hour
FPM = Feet Per Minute
AI = Active Ingredient

Basic Calibration Formulas

$$GPM = \frac{\text{ounces collected}}{2.13 \times \text{seconds}}$$

$$GPA = \frac{5{,}940 \times \text{GPM per nozzle}}{\text{Nozzle spacing (inches)} \times \text{MPH}}$$

$$\text{GPM per nozzle} = \frac{\text{MPH} \times \text{GPA} \times \text{Nozzle spacing (inches)}}{5{,}940}$$

$$MPH = \frac{5{,}940 \times \text{GPM per nozzle}}{\text{Nozzle spacing (inches)} \times \text{GPA}}$$

Using Pesticides Safely

In addition to the traditional recommendations of buying only the right amount of the proper chemicals and being sure they do not get stolen, eaten, drunk, spilled, mixed up or misused before you are ready to use them, the following suggestions for use of chemicals in the field are worth reviewing.

1. Read and understand all of the pesticide label before use. The label has detailed instructions on how to use the pesticide wisely. **Re-read all bold print.**
2. Don't use a tank mixture of two or more chemicals unless the mixture has label clearance.
3. When pouring and mixing chemicals, be sure the breeze blows the chemical away from you. Wear clean clothes, rubber gloves and chemical goggles when handling chemicals. Wash all clothing, gloves and caps before wearing them again.
4. Don't hurry when using chemicals. Hurrying causes most people to be more accident prone. Spilled chemicals, the wrong chemical in the sprayer and the wrong rate of application are examples of problems that hurrying promotes.
5. Reduce spray drift by applying chemicals on relatively calm days. Operate the sprayer at the lowest recommended pressure to minimize drift.
6. Mix only the amount of material needed for the job. As you empty a container, rinse it three times and pour the rinse into the sprayer tank. Dispose of rinsed containers in an approved sanitary landfill. If you have excess material, apply it on another job or save it in another container to be used later on another job. If you cannot reuse the material, it must then be disposed of in an EPA approved disposal site.
7. Thoroughly rinse sprayer tank and hoses before changing chemicals or replacing equipment. Contamination may not be completely eliminated, but it can be minimized so the resulting hazard to crops and humans is small.
8. Be familiar with symptoms of chemical poisoning. Dizziness, headaches, upset stomach, blurred vision and excessive sweating are symptoms of poisoning from several pesticides. See a doctor anytime you do not feel well and have handled a chemical within the past 12 hours. Take the label along. The label will tell the doctor which chemical has caused the poisoning so an antidote can be prescribed.
9. If a pesticide is spilled on the skin, wash the affected area with soap and water. Remove any contaminated clothing and put on clean clothes before continuing.

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