Nozzle Wear As It Affects Output In Spraying

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The basic function of a pesticide applicator is to distribute a small amount of material over a rather large area. This might be done in a number of ways, the options being:

1. To dispense the undiluted material with extreme accuracy so that the desired amount per unit area is achieved.
2. To mix the material with an inert filler and spread it.
3. To spray the material within a high speed jet of air which carries the finely atomized spray into the sprayed zone. The pesticide laden air displaces the pesticide free air and the small droplets impinge the foliage.

The main difficulty with the first option is that it requires extremely accurate equipment and equipment operation. Any error in coverage is critical. However, much research is being carried on to make this method practical because of its time and cost saving features.

The second option is probably the most widely used because it allows the use of reasonably accurate equipment and is much more forgiving than the first, in the case of equipment or operator errors. The equipment which can do a good application job using option 2, is normally within the budget of almost any person who has a need for an aquatic pesticide sprayer.

Option three is the second most widely used method for this purpose and the main reason that it is not used more is the cost of the equipment. The equipment used is roughly the same as that used for sprayers in option 2 but with a fan, ducting and often a power unit to drive the fan. This method is usually restricted to growers with large acreages and custom operators who can justify the initial cost because of the time it saves by the fact that air, which is readily available to the fan, is one of the diluents. Therefore a lot less time is required for refilling the tank with water and hauling water from the source to the machine.

Regardless of what type of equipment you use they all have one common goal in aquatic spraying, which is to kill noxious plant pests. The only way this is done is by getting the specified amount on the treated area. Therefore, the equipment must be calibrated as accurately as possible.

The application rate (gpa) applied by most aquatic sprayers is dependent upon the following variables: 1, system pressure; 2, orifice - size and discharge coefficient; 3, boom width in the case of boom sprayers and effective swath width in the case of hand guns; and 4, vehicle speed.

It should be pointd out that system pressure and the orifice characteristics are completely independent of the boom width and vehicle speed on most sprayers. Actually, you have two systems which must be properly coordinated to achieve the correct gallons per acre.

The combination of system pressure and orifice characteristics yield a certain gallons per minute. The gallons per minute output is the same whether the sprayer is moving or still for the orifice. Pressure systems know nothing about acreage or aquatic weed control.

The boom-speed combination determines the acreage covered per minute and it must be coordinated with the system flow to result in the correct gallons per acre.

The factor most responsible for good application rate, though not a direct factor, is the operator and the only factor involved with the capacity to think.

A sprayer which has been calibrated must be recalibrated at regular intervals. The cause for recalibration being, mainly due to the change of orifice flow. Orifice flow can change with use due to (1) pump wear with a resulting lower pressure and flow, (2) orifice wear which results in greater flow. The changes in the orifice are usually of much greater importance than the pump wear problem, and the net effect is an increased flow due to wear.

The orifice properties which cause the flow increase are an enlarged orifice area and a higher discharge coefficient. The frequency of recalibration is dependent on the material sprayed and the orifice tip wear resistance. Wettable powders wear faster than liquids and brass nozzles wear much quicker than chrome plated brass or hardened stainless steel.

Tests conducted by ARS at Stoneville, Mississippi indicated that brass nozzles had a 19 percent increase in flow after 18 hours of use while stainless steel and chrome plated brass showed increases of only 4 and 0.5 percent respectively (Figure 1). The nozzles were rated at 0.2 gpm at 40 psig and the material sprayed was 1.6 pounds of Diuron wettable powder in 25 gallons of water.

The increased flow due to higher discharge coefficient occurs before a measurable increase in the orifice area can be detected. The pressure side of the orifice plate becomes rounded and the stream does not neck down like it does in a new sharp-edged orifice consequently more flow results. Visual inspection of the nozzles is not sufficient to tell whether they should be changed because the amount of wear required to cause appreciable changes in flow is not detectable by the naked eye. The only practical check is a *recalibration*.

A little history about the discharge coefficient might be in order so that its importance is appreciated. From theoretical considerations it was determined that the flow through an orifice discharging into the atmosphere should be:

$$Q = AV$$

where: Q = Flow, ft.^{3} per sec
A = orifice area, ft.^{2}
V = Stream velocity, ft. per sec

The velocity was theoretically equal to:

$$V = \sqrt{2gh}$$

where: g = acceleration of gravity, 32 ft. per sec^2
h = pressure, ft. of head of the sprayed liquid

Flow tests were conducted to check the equation and the results showed the actual flow to be less than the

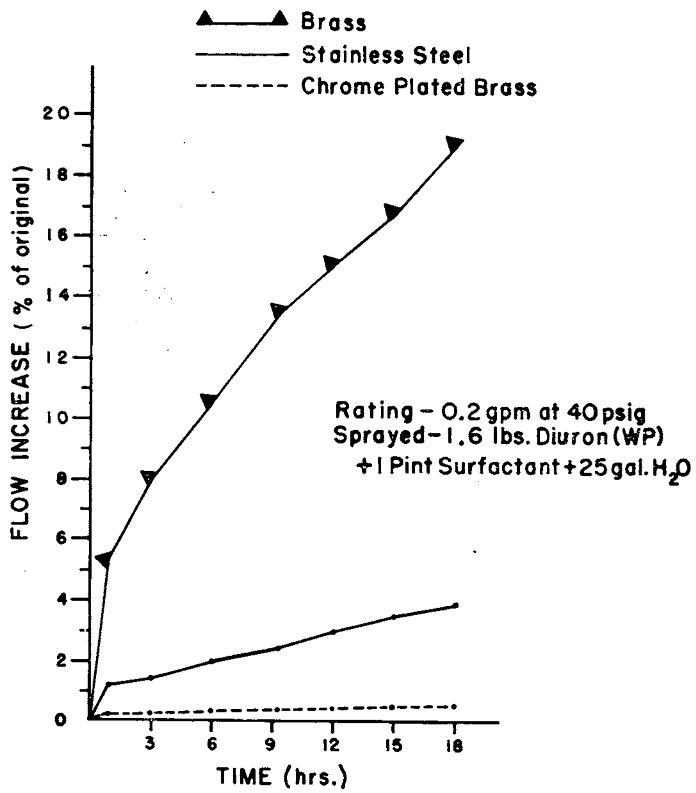

Figure 1.—Flow increase versus time.

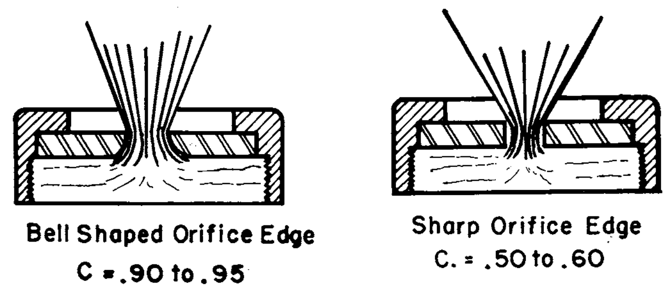

Figure 2.—Discharge coefficients of a new sharp edged orifice and a worn bell shaped orifice.

theoretical flow. The amount less was a function of the shape of the entry into the orifice. A sharp edged entry (like that of a new orifice plate) would yield a flow of only 50% of the theoretical amount while a rounded entry yielded as high as 95% of the theoretical amount.

Using the data from the flow tests the equation for the flow through the orifice was changed to

$$Q = CAV$$

"C" being the discharge coefficient which corrects the theoretical flow equation. Discharge coefficients have been determined for orifices of different geometries and are listed in many engineering handbooks.

The reduced flow through a sharp edged orifice is due to greater turbulence losses and also the effective area of the orifice is less than the actual physical area due to a necking down of the stream.

The practical importance of changing discharge coefficient can be seen by comparing the coefficient of a new sharp-edged orifice to the orifice with the worn, rounded entry. The coefficient values being 0.50 versus 0.95 which indicates a possible 90% increase in flow from the worn nozzle even though the actual orifice areas are equal (Figure 2).

Users of spray equipment tend to become complacent about wear because of the fact that the nozzles are metal and they just cannot visualize much wear due to spraying liquid through the metal nozzles. Actually this line of reasoning is correct to a point because the flow does not cause a great amount of wear, but this type of reasoning falls apart when you consider just how little wear causes a sizable flow increase. An orifice of 0.05 inch diameter has about 45% more area after wearing only 0.005 inches and will deliver about 45% more flow. (Figure 3). The percentage increase in area and flow, since the flow varies directly with the area, due to a unit amount of wear increases as the diameter of the orifice decreases. Most nozzles used in agriculture are very small making nozzle wear a very important factor.

Frequent recalibration is the only way to keep the sprayer delivering the desired flow. The desired frequency of recalibrations cannot be arbitrarily given because it depends on 1) the amount of use, 2) the material sprayed and 3) the nozzle wear resistance. No harm can come from overly short calibration intervals while considerable harm can result from overly long intervals.

In the early stages of nozzle wear all that need by changed to bring the sprayer back into calibration will be a reduction in pressure. However, the time will come when the pressure necessary to yield the desired flow is so low that the stream velocity is not enough to cause proper atomization. The resulting coverage is so poor that the aquatic pest is no longer controlled. Exactly when the nozzle disk should be replaced depends on a number of factors. The operator must observe his results and when in his judgment the control is no longer satisfactory the nozzle tips should be changed.

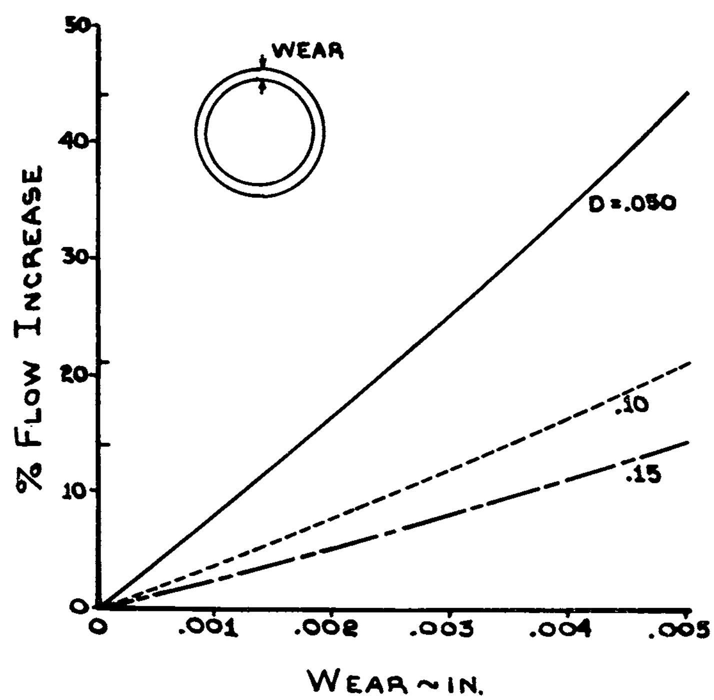

Figure 3.—Flow increase versus wear for three different size nozzles.