University of Idaho
College of Agriculture
Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 569
February 1981

Nozzle Management and Leak Prevention For Sprinkler Irrigators

D. C. Larsen and T. S. Longley

Idaho has had a continuing shift over the years to sprinkler irrigation. In 1960, only 8.5 percent of the irrigated land was sprinkled. This figure had increased to 21.4 percent by 1970 and to 45 percent by 1979. Today, 1,778,000 acres are sprinkler irrigated in Idaho.

More than 1.5 million acres of new irrigated land has been developed since 1950, using water from deep wells or water pumped from rivers with lifts up to 700 feet. Farm practices and the design and development of sprinkler equipment and many pumping plants were based on the low energy costs prevailing from 1960 to 1975.

Energy costs, however, are rapidly increasing because of shortages in fossil fuel supplies and an increased demand for electrical power. New power plants are expensive to build and will increase electrical costs as they are brought on-line. Predictions are that energy costs will increase four to eight times in the next 15 years (the anticipated life of a sprinkler system). As power costs increase, many irrigators are looking for ways to conserve energy by reducing the amount of water pumped while maintaining adequate moisture for crops.

Nozzle management and leak prevention can reduce water use and consequently save energy. Nozzle management can be separated into three categories: (1) replacement of worn nozzles, (2) use of the same size nozzles and (3) installation of nozzle flow controls where needed.

This publication describes how nozzle management and leak prevention can be employed to lower irrigation pumping costs.

Nozzle Wear

As nozzles wear and enlarge over time, several things may happen:

1. If the pump is not operating at peak power, it will tend to work harder. The pressure will remain the same or decrease slightly even though more water is being pumped. The total horsepower required by the pump will increase as will the power bill.
2. If the pump is operating at its peak horsepower, the pressure will fall as the flow increases. This condition will usually reduce the power bill but will result in uneven water distribution. If the pressure falls low enough, the irrigator may think that the pump is not working properly.
3. Irrigation systems are designed to operate at peak efficiency, and any change in system pressure and discharge such as those described above will reduce the pump efficiency.
4. The nozzles may become so enlarged that the application rate exceeds the soil intake rate, causing compaction, runoff and nonuniformity of water application.

A nozzle wear survey conducted during 1977 and 1978 indicated that 77 percent of the nozzles on systems using canal water were worn. On systems where well water was used, only 52 percent of the nozzles were worn. The data showed that 40 percent of the nozzles on systems using canal water discharged more than 107 percent of rated discharge. This figure dropped to 14 percent on systems where well water was used. Table 1 gives these test results.

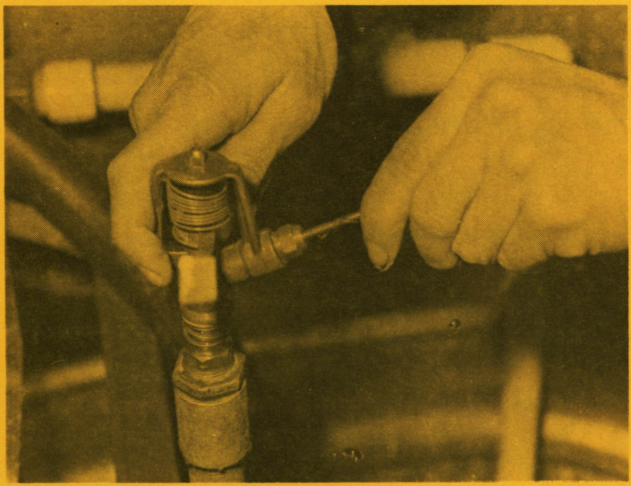
Table 1. Results of 1977-78 nozzle wear survey.

Nozzle condition	Nozzles affected (by water source) Canals	Wells
	(%)	(%)
Not worn	23	48
Worn	77	52
Badly worn*	40	14

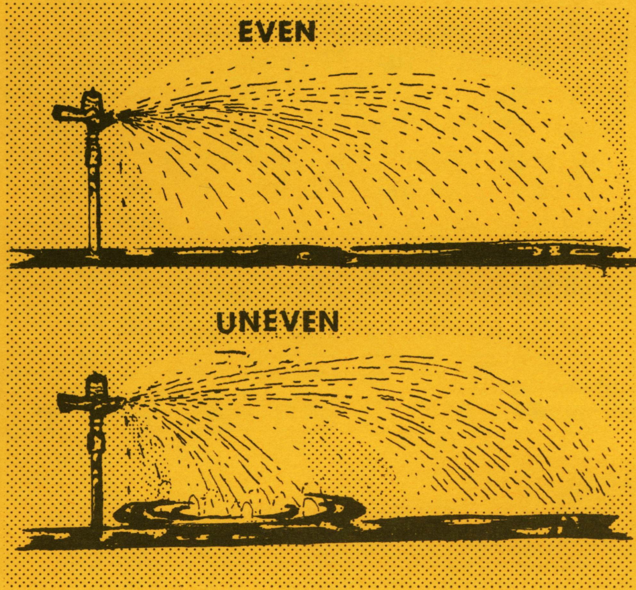
*Worn so that discharge increased at least 7 percent.

Nozzles are worn by silt and sand particles being pumped through the system. The rate of wear depends upon the quantity and the abrasiveness of the particles. In some areas, this wear makes it necessary to change brass nozzles quite frequently.

The following test will determine nozzle wear. Insert the shank of a drill into the nozzle orifice while the system is working. The drill should be the same size as the nozzle rating. Because of the hydrodynamics of impact sprinkler heads, nozzles tend to wear on one side of the orifice. The distance the water is sprayed out in the test is a good measure of how worn the nozzle is.



If the nozzle is new or has no wear, you will get practically a watertight fit with just a few drops coming out. If the wear is slight, a fine spray will reach out less than 10 feet. If the nozzle is moderately worn, a large spray will reach out 10 to 15 feet. With a heavily worn nozzle, a coarse spray will reach out 15 to 20 feet. In the latter two cases, the discharge will be 7 to 20 percent greater than the design discharge and will result in a costly, nonuniform over application.



Nozzle Size

The key to successful irrigation is uniform distribution of water over the field. If you use different nozzle sizes on the same lateral, you will **not** get uniform water application. An increase in the orifice diameter of a nozzle of 1/64 inch will increase the discharge by more than 20 percent.

Data from the nozzle wear survey show that one out of every three laterals checked contained different nozzle sizes. Sixteen percent of the laterals checked contained two different sizes of nozzles, and 17 percent contained three different sizes. In one case, water distribution varied more than 167 percent along the lateral because of different nozzle sizes.

To determine what nozzle sizes to use on laterals, first check with your irrigation dealer about the soil infiltration rate and his recommended nozzle size for your soil. Next, insure that all nozzles are the same size on each lateral. You can use spray paint and make each size a different color. Color coding is probably the easiest way to help irrigation labor keep nozzle sizes the same in every lateral.

Nozzles get mixed up over time as nozzles clog or heads fail and are replaced by what is handy at the time. Determine what size is to be used and keep them readily available in the shop.

Flow Control

Because of the unevenness in water application by sprinkler systems because of rolling or hilly ground (dry hills; flooded low spots), several irrigation manufacturing companies have begun making flow control devices. These devices deliver the same amount of water regardless of the pressure at which it is supplied. Thus, differences in pressure along a lateral because of elevation changes (hilly ground) will not affect the amount of water discharged. In other words, a uniform amount of water is applied to the crop even though the pressure varies along a lateral.

To determine the best mode of operation for new flow control nozzles, the uniformity of water application was tested at various pressures. Fig. 1 shows the water discharge down the lateral in gallons per minute (gpm) from a 9/64-inch brass nozzle vs. the discharge from a 4-gpm flow control nozzle. In this case, it was evident that the flow control nozzles gave a much more even distribution of the water (the curve was flatter).

Tests were conducted with different sizes of flow control nozzles operating over a wide range of wind conditions. Two conclusions can be drawn from these tests.

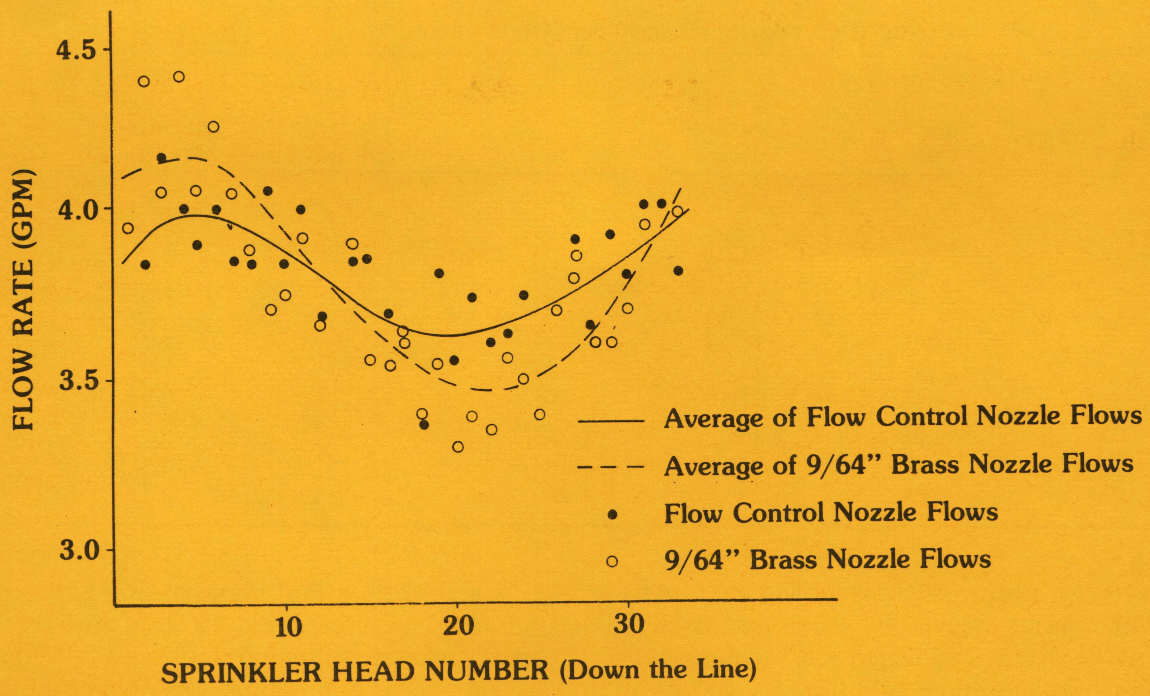
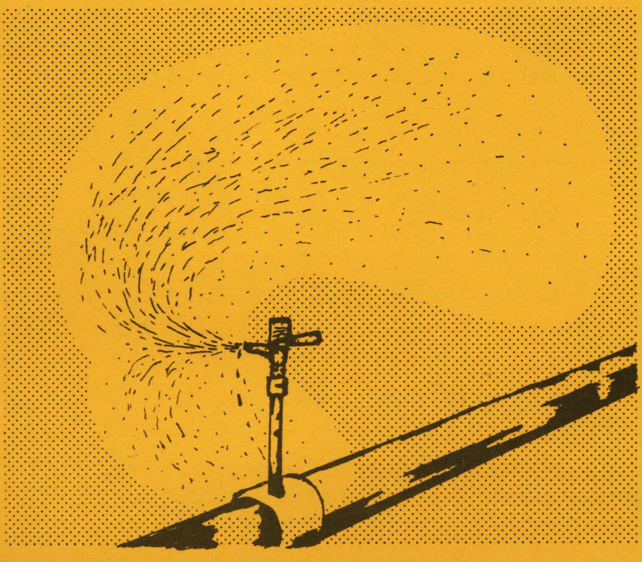


Fig. 1. Flow rate from sprinkler heads down a lateral with 21 foot elevation change.

1. Wind plays an important part in the uniformity of water application regardless of the kind of nozzle being used. In Idaho, high wind periods (May and June) come before peak crop water use periods (July and August). This gives some latitude in when (day or night) a needed irrigation can be started. If possible, irrigate at night or during periods of lower wind.
2. Nozzle flow controls perform adequately at pressures greater than 45 psi at the nozzle in light or moderate winds. Therefore, you should have your system operating so that the design pressure is in excess of 45 psi. In another set of tests, nozzle flow controls did not give adequate uniformity of application unless stream straighteners were used. These straighteners also help increase the length of throw from the sprinkler head.



Another test was performed to determine whether in-line flow controls were superior to nozzle flow controls in terms of head loss or pressure loss through the flow control device and other operating factors. The extensive testing indicated that there was more than a 20 percent pressure loss through an in-line flow control regulator compared to a 2 to 3 percent pressure loss through a flow control nozzle.

Flow control nozzles, then, are recommended over in-line flow control regulators. These nozzles have less pressure loss. Also, in case of plugging, it is much easier to dislodge debris from a nozzle flow control than an in-line flow control device. In order to clear an in-line flow control, the entire sprinkler head and flow control has to be removed to clean out the debris. This is extremely time consuming and probably should be avoided.

Leak Prevention Program

Sprinkler system leaks are expensive in wasted water, lost production and energy use. Eliminating leaks caused by hardened gaskets, punctured pipes, etc. is a good way to save energy.

Several sprinkler laterals with and without visible leaks were checked in nine tests (Table 2). Although these data are site specific, they do indicate the seasonal cost of leaky systems.

Table 2. Effects of leaks and worn nozzles on sprinkler lateral operation.

Test	Pumping lift	Measured flow	Design flow	Design flow	Horsepower required to pump added flow	Cost/ season
	(ft)	(gpm)	(gpm)	(%)	(hp)	($)
4a	15	260.1	232.2	112	2.7	$ 89.20
4b	15	148.2	126.3	117	3.4	113.80
5	4	141.1	96.8	146	1.9	52.31
6	280	190.9	140.5	136	8.9	244.55
8	8	116.5	89.5	130	1.9	52.35
9	600	188.6	168.7	112	6.0	165.67
10	280	151.7	153.5	99	0	0
11	3	107.4	102.0	105	0.3	7.60
12	130	230.5	200.0	115	3.5	94.53

The average additional horsepower required to provide the water wasted by leaks and/or worn nozzles in the lateral lines tested was 3.6 horsepower per lateral. The average additional cost of this power was $102.50. If a grower has 20 lines operating in this fashion, the cost of the energy wasted would pay for a new car in 2 to 3 years.

A leak from a faulty gasket in a ball and socket coupling was measured to compare the cost of energy wasted compared to the cost of replacing the gasket. With a pumping lift of 400 feet and an operating pressure of 80 psi at the pump, the cost of the power would be $28.53 if the leak of 3.7 gallons per minute remained the same all season. A new gasket would cost $1.75.

In another case, an end plug was leaking 2.5 gallons per minute. The pumping lift was 280 feet, and pressure at the pump was 61 psi. The cost of the energy wasted was $11.17. A new gasket would have solved the problem.

In conclusion, nozzle management and leak prevention can contribute greatly to a successful harvest in terms of a uniform, well-developed crop. A management and prevention program also tends to minimize expenditures for power by maximizing the efficiency of the irrigation.

About the Authors

D. C. Larsen is associate Extension professor of agricultural engineering and Extension irrigationist in the District 2 Extension Office, Boise. T. S. Longley is assistant research professor of agricultural engineering at the University of Idaho Research and Extension Center, Aberdeen.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture, Fred E. Kohl, Acting Director of Cooperative Extension Service, University of Idaho, Moscow, Idaho 83843. We offer our programs and facilities to all people without regard to race, creed, color, sex or national origin.

1500 2-81

10 cents per copy