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Maintaining Subsurface Drip Irrigation Systems

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Subsurface drip irrigation (SDI) systems can deliver water at low flow rates very uniformly. A permanent system, properly designed and maintained, should last more than 20 years. A maintenance program includes cleaning the filters, flushing the lines, adding chlorine, and injecting acids. These preventive measures will reduce the need for major repairs and extend the life of the system.

The purpose of preventive maintenance is to keep the emitters from plugging. Emitters can be plugged by suspended solids, magnesium and calcium precipitation, manganese-iron oxides and sulfides, algae, bacteria and plant roots.

Each SDI system should contain a flow meter and at least two pressure gauges–one gauge before the filters and another after the filters (Fig. 1). Flow meters and pressure gauges, which should be inspected daily, indicate whether the system is working properly. A low pressure reading on a pressure gauge indicates a leak in the system (such as a leaking component or broken pipe). A difference in pressure between the filters may mean that the system is not being backflushed properly and that the filters need to be cleaned. In larger systems, pressure gauges should be installed in each field block or zone (Fig. 1).

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Plugging potential of irrigation water

Chemical property	Low	Moderate	Severe
PH	< 7.0	7.0 - 8.0	>8.0
Bicarbonate (ppm)		<100.0	
Iron (ppm)	<0.2	0.2 - 1.5	>1.5
Sulfides (ppm)	<0.2	0.2 - 2.0	>2.0
Manganese (ppm)	<0.1	0.1 - 1.5	>1.5

Water quality determines the relative risk of emitter plugging and other problems; therefore, the properties of the water should be taken into account in the system maintenance program. Examples of water quality parameters and their effect on emitter plugging potential are summarized in the following table.

Maintaining filters

Filters are essential components of an SDI system; they remove suspended solids from the water. There are three main types of filters: cyclonic filters (centrifugal separators); screen and disk filters; and media filters. It is common practice to install a combination of filters to remove particles of various sizes and densities effectively.

Centrifugal separators

These filters need little maintenance, but they require regular flushing. The amount of sediment in the incoming water, the volume of water used, and the capacity of the collection chamber at the bottom of the filter will determine how often and

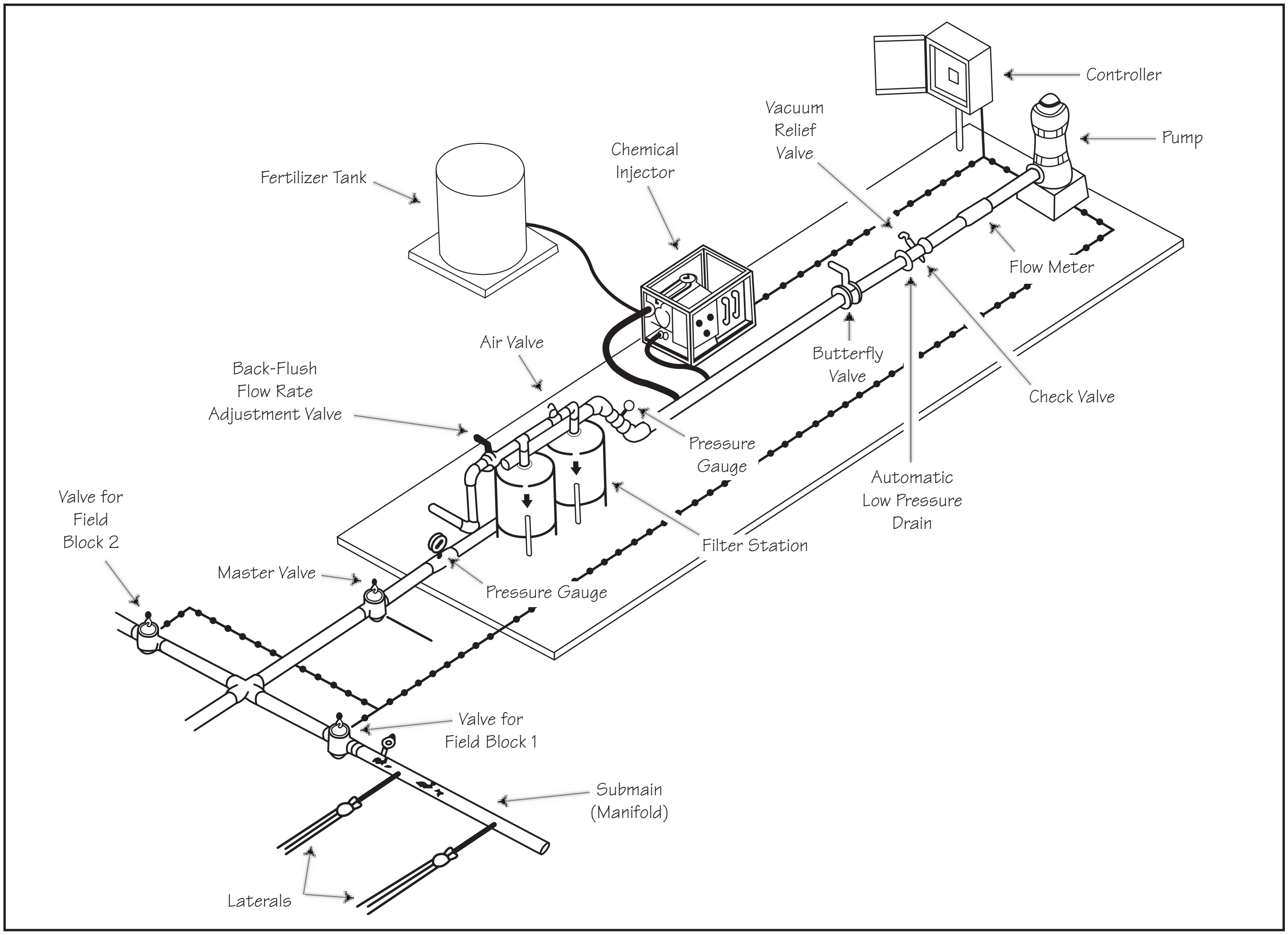

Figure 1. Typical layout of the irrigation system.

how long the flushing valve needs to operate. The sediment can be released manually or automatically. If it is done manually, the bottom valve of the filter should be opened and closed at regular intervals. Or, an electronic valve controlled by a timer can automatically open the bottom valve. Automated operation of the valve should be checked at least every other day during the season.

Screen and disk filters

Small screen filters use a nylon strainer or bag, which should be removed and checked periodically for small holes. The flush valve controls the flushing of the screen filter. This can be operated manually or automatically. Flush the screen filter when the pressure between the two pressure gauges drops 5 psi (one gauge is located before the filters and the other after them). Automatic filters use a device called a “pressure differential switch” to detect a pressure drop across the filters. Other systems use a timer, which is usually set by the operator. The flushing can be timed according to the irrigation time and the quality of the water. The interval between flushing can be adjusted to account for differences in pressures across the filters. Automated flushing devices should be checked at least every other day on large systems.

Sand media filters

With these filters the most important task is to adjust the back-flush adjustment valve (Fig. 1). If the backflow rate is too high, sand filter media will be washed out of the filter container. If the backflow rate is too low, contaminating particles will not be washed out of the filter. Bacterial growth and the chemistry of the water can cause the sand media to cement. Cementing of the media causes channels to form in the sand, which can allow contaminated water to pass unfiltered into the irrigation system. Chlorination can correct or prevent sand media cementing.

Evaluating the System

One way to evaluate clogging problems is to place a container under selected emitters as shown in Figure 2. The emitter flow rate (volume over time) collected at different locations should be compared against the design flow rate. The upper picture of Figure 3 shows a field where plants are stressed because emitters are clogged by manganese oxides. The general condition of a drip system can be easily evaluated by checking system pressures and flow rates often. If emitters become plugged, system pressures will increase and flows will decrease.


Figure 2. Evaluating emitter flow rate to identify clogging problems.

Figure 3. (Top) Plants in this field are drought-stressed because emitters are clogged. (Bottom) Acid injection can reduce clogging problems so fields are irrigated uniformly.

Flushing lines and manifolds

Very fine particles pass through the filters and can clog the emitters. As long as the water velocity is high and the water flow is turbulent, these particles remain suspended. If the water velocity slows or the water becomes less turbulent, these particles may settle out. This commonly occurs at the distant ends of the lateral lines. If they are not flushed, the emitters will plug and the line eventually will be filled with sediment from the downstream end to the upstream end. Systems must be designed so that mainlines, manifolds (submains) and laterals can all be flushed. Mainlines and manifolds are flushed with a valve installed at the very end of each line. Lines can be flushed manually or automatically. It is important to flush the lines at least every 2 weeks during the growing season.

Injecting chlorine

At a low concentration (1 to 5 ppm), chlorine kills bacteria and oxidizes iron. At a high concentration (100 to 1000 ppm), it oxidizes (destroys) organic matter.

Bacteria produced by iron and manganese

The most serious problems with bacteria occur in water that contains ferrous or soluble iron or manganese. Iron and/or manganese concentrations higher than 0.1 ppm can promote bacterial growth and chemical precipitation that clogs emitters. Iron bacterial growth looks reddish, whereas manganese bacterial growth looks black. These bacteria oxidize iron and manganese from the irrigation water. In the western part of Texas, these bacteria often are found in well water.

Be extremely cautious when injecting chlorine into irrigation water containing dissolved manganese, because chlorine can oxidize this element and cause precipitation beyond the filter system. Figure 4 shows an emitter plugged by manganese oxides.

Figure 4. An emitter clogged by manganese oxides.

It is hard to eliminate iron bacteria, but it may be controlled by injecting chlorine into the well once or twice during the season. It might also be necessary to inject chlorine and acid before (upstream of) the filters. When the water contains a lot of iron, some of the iron will feed the bacteria and some will be oxidized by chlorine to form rust (or insoluble iron, ferric oxide). The precipitated ferric oxide is filtered out and flushed from the system. If the iron concentration is high and problems persist, aerating the irrigation water will help to oxidize the iron and settle the sediment. Aerate the water by pumping it into a reservoir and then re-pumping it with a booster pump to the irrigation system.

Use a swimming pool test kit to test for free or residual chlorine in the water at the end of the lateral line. It is worth noting that some of the injected chlorine may be removed from solution (tied up) through chemical reactions with other constituents or absorbtion by organic matter in the water. If chlorine is continuously injected, a level of 1 ppm of free residual chlorine at the ends of the laterals will be enough to kill most bacteria. With intermittent injection (once every several days), the chlorine concentration at the ends of the laterals should be maintained at 10 to 20 ppm for 30 to 60 minutes.

If emitters are already partially plugged by organic matter, "superchlorination" treatment is warranted; it involves maintaining a concentration of 200 to 500 ppm chlorine in the system for 24 hours.

Some extra chlorine should be injected to account for the tied up chlorine.

Injecting Acid

Acids are injected into irrigation water to treat plugging caused by calcium carbonate (lime) and magnesium precipitation. Water with a pH of 7.5 or higher and a bicarbonate level higher than 100 ppm has a risk of mineral precipitation, depending on the hardness of the water. Hardness of water, which is determined by the concentrations of calcium and magnesium, is classified as follows: soft (0 to 60 ppm of Ca and Mg); moderate (61 to 120); hard (121 to 180); very hard (more than 180 ppm). Moderate, hard and very hard water needs acid injection.

Sulfuric, phosphoric, urea-sulfuric, or acetic acid can be used. The type most commonly used in drip irrigation is 98% sulfuric acid. Acetic acid, or vinegar, can be used in organic farming, although it is much more expensive. If the irrigation water has more than 50 ppm of calcium, phosphoric acid should not be injected unless enough is added to lower the pH below 4.

Acid is usually injected after the filter so that it does not corrode the filter. If the filter is made of polyethylene, which resists corrosion, acid can be injected before the filter.

Injection rate for chlorine

Calculate the injection rate with these formulas:

English units calculation

$$IR = \frac{0.006xFxC}{P}$$

Where:
IR = Injection rate, gallons/hr
F = Flow rate of the system, GPH
C = Concentration of chlorine wanted, ppm
P = Percentage of chlorine in the solution*

Metric units calculation

$$IR = \frac{0.36xFxC}{P}$$

Where:
IR = Injection rate, liters/hour
F = Flow rate of the system, LPS
C = Concentration of chlorine wanted, ppm
P = Percentage of chlorine in the solution*

*The percentage of chlorine for different compounds is as follows:
calcium hypochlorite—65%
sodium hypochlorite (household bleach)—5.25%
lithium hypochlorite—36%

Example:
A farmer wants to inject chlorine into his system at a concentration of 5 ppm in a system with a flow rate of 100 GPM. He is injecting household bleach that has a chlorine concentration of 5.25%.

$$IR = \frac{0.006xFxC}{P} = \frac{0.006x100x5}{5.25} = 0.571 \text{ GPH } \textit{sodium hypochlorite (household bleach)}$$

The following tables show the necessary injection rate of chlorine in gallons per hour.

Desired chlorine level in ppm	Gallons of chlorine (5.25% solution) per hour Gallons per minute (GPM) of irrigation water								
	100	150	200	250	300	350	400	450	500
1	0.114	0.171	0.229	0.286	0.343	0.400	0.457	0.514	0.571
2	0.229	0.343	0.457	0.571	0.686	0.800	0.914	1.029	1.143
5	0.571	0.857	1.143	1.429	1.714	2.000	2.286	2.571	2.857
10	1.143	1.714	2.286	2.857	3.429	4.000	4.571	5.143	5.714
15	1.714	2.571	3.429	4.288	5.143	6.000	6.857	7.714	8.571
20	2.286	3.429	4.571	5.714	6.857	8.000	9.143	10.286	11.429
25	2.857	4.286	5.714	7.143	8.571	10.000	11.429	12.857	14.286
30	3.429	5.143	6.867	8.571	10.286	12.000	13.714	15.429	17.143
50	5.714	8.571	11.429	14.286	17.143	20.000	22.857	25.714	28.571

Desired chlorine level in ppm	Gallons of chlorine (10% solution) per hour Gallons per minute (GPM) of irrigation water								
	100	150	200	250	300	350	400	450	500
1	0.060	0.090	0.120	0.150	0.180	0.210	0.240	0.270	0.300
2	0.120	0.180	0.240	0.300	0.360	0.420	0.480	0.540	0.600
5	0.300	0.450	0.600	0.750	0.900	1.050	1.200	1.350	1.500
10	0.600	0.900	1.200	1.500	1.800	2.100	2.400	2.700	3.000
15	0.900	1.350	1.800	2.250	2.700	3.150	3.600	4.050	4.500
20	1.200	1.800	2.400	3.000	3.600	4.200	4.800	5.400	6.000
25	1.500	2.250	3.000	3.750	4.500	5.250	6.000	6.750	7.500
30	1.800	2.700	3.600	4.500	5.400	6.300	7.200	8.100	9.000
50	3.000	4.500	6.000	7.500	9.000	10.500	12.000	13.500	15.000

The amount of acid to use depends on the characteristics of the acid you are using and the chemical characteristics of the irrigation water. A titration curve of the well water used for drip irrigation can be developed by a laboratory. It will show the amount of acid needed to reduce the pH to a certain level. If a titration curve is not available, use a trial-and-error approach until the pH is reduced to 6.5. Colorimetric kits or portable pH meters can be used to determine the water pH at the ends of lines. Many farmers inject 1 to 5 gallons of sulfuric acid per hour, depending on the water pH, water quality and well capacity.

Most chemicals used in drip system maintenance are extremely hazardous. Sulfuric acid is very corrosive and must be handled with proper personal protection equipment. Store sulfuric acid in polyethylene or stainless steel tanks with extra heavy walls. **Always add acid to water; do not add water to acid.** Never mix acid and chlorine or store them together in the same room; a toxic gas will form.

Besides clearing clogged emitters, acid injected into irrigation water may improve the infiltration characteristics of some soils and release micronutrients by lowering the soil pH. To reduce the cost, acid can be injected only during the last third of the irrigation time.

Other necessary maintenance

Keep out plant roots

It is important to keep plant roots from penetrating the drip emitters (Fig. 5 shows a root intrusion problem). Metam sodium and trifluralin are two compounds that control roots. In cotton, metam sodium is generally used at defoliation to keep roots out as the soil dries,

Figure 5. Roots penetrating a drip emitter.

while trifluralin is used before harvest. Superchlorination at a dosage of 400 ppm chlorine also will keep roots out. Fill the tapes with chlorine and leave it overnight.

Prevent back-siphoning

Back-siphoning is the backflow of water from the soil profile back into the tape at the end of an irrigation cycle. It is caused by a vacuum that develops as residual water in the tape moves to the lower elevations in the field. Back-siphoning may pull soil particles and other debris through emitters and into the tape. Figure 6 shows some live worms that were flushed from SDI lines during normal maintenance. It is thought that the eggs or cocoons of worms were pulled into the drip lines at the higher elevations in the field when zone valves were closed. Once in the drip lines, the eggs hatched and the worms started to grow. Worms and other contaminants were removed during normal flushing cycles (every 2 weeks).

Figure 6. Worms flushed from an SDI system. Flushing twice a week solved the problem.

Texas Water Resources Institute
make every drop count

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