Subsurface Drip Irrigation (SDI) Components: Minimum Requirements

K·STATE Research and Extension

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Subsurface drip irrigation (SDI) systems provide water and nutrients directly to the plant root zone through built-in emitters within polyethylene tubes that are buried below the soil surface. Experience in the Great Plains has shown that properly designed and managed systems can maintain or potentially improve yields, while saving water, fertilizer, and energy, and be economically competitive with alternative irrigation system options. However, to be able to perform effectively, SDI systems must be properly designed and installed and have consistent management to function properly. Proper design and management is also essential to ensuring a long system life, which is a major factor in determining whether SDI is cost competitive with other irrigation systems. A good first step toward maintaining a profitable SDI system is proper selection of the system components.

This publication discusses the basic components of a subsurface drip irrigation system and has a brief overview of accessory options. The basic components required for any system is shown in Figure 1, which also illustrates the general organization of the components. More details on many of these components are discussed in additional K-State Research and Extension bulletins in this SDI series. These bulletins are listed in the reference section at the end.

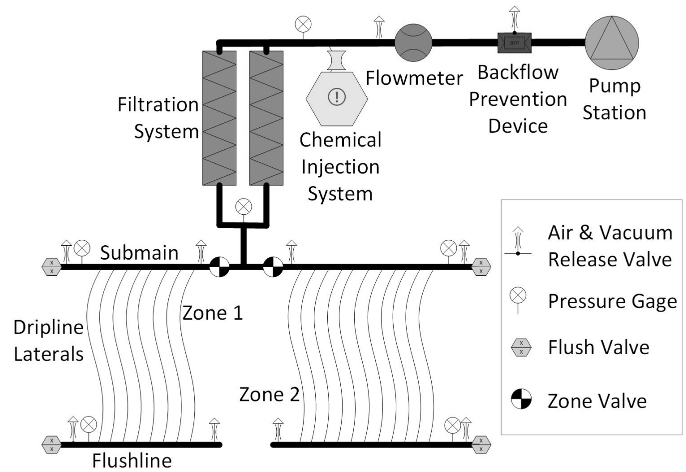

Figure 1: Organization of an SDI system with the minimum required components. (Components not to scale.) (Drawing courtesy of K-State.)

Required System Components

An SDI system can function without all of the components shown in Figure 1, but it may either be difficult to manage and maintain or cause poor performance. Eventually, the system may fail due to the lack of cues to the manager on the status of performance or insufficient dripline and emitter protection (e.g., clogging or leaks). Usually there are several versions of each component; these are listed as options below. A specific option may or may not be acceptable for a particular system application depending on site and system conditions. The major factors that should be considered when selecting each component are listed under considerations. The specific site and system characteristics are addressed in the SDI system design. Proper consideration of these issues prior to SDI system installation will be time well spent. If the minimum SDI components cannot be included as part of the system, an alternative type of irrigation system or a dryland production system should be considered.

1. Pump. SDI systems generally have low pressure requirements (< 35 psi). Typically, only one pump is required, as is the case for most irrigation systems in the Great Plains. The pressure requirement is in the range of most low-pressure center pivot sprinkler irrigation systems. The size of the pump depends on flow rate and total head requirements. The total head requirements include pumping lift, friction/losses, elevation changes, system pressure and, for SDI systems, the pressure loss across the filter and other structural components, such as control valves, flow meter, check valves, main, and submain supply lines.

- **Considerations.** The size of the pump will depend on the flow rate and the total pressure requirements for the pumping lift and system pressure needs. Because most irrigation water supplies in the Great Plains are from wells, the sustainable flow rate from the well will be the beginning point of the system design and often determines the number of acres that can be reliably irrigated for the given flow rate. When developing a new SDI system or upgrading an older pumping plant, consideration of a water-lubricated turbine pump may be in order so as to reduce potential for oil clogging of filtration components.

2. Backflow preventer. These devices prevent the contamination of the water supply from the backflow of fertilizers, chemicals, or particulates. They are installed between the water supply or pump and the chemical injection line.

- **Options.** An atmospheric vacuum breaker, a pressure vacuum breaker, or a double-check valve are some of the available options to prevent backflow.
- **Considerations.** Reducing the potential hazard of the

chemical that can backflow (toxic or nontoxic) is the most important environmental and legal consideration. Additionally, component reliability, ease of inspection and maintenance, and hydraulic characteristics (e.g., back pressure) should be considered. Always follow state and local regulations and codes as well as application labels from the chemical manufacturer.

3. Flowmeter. The flowmeter measures the volume of water moving through the system, either as a flowrate or as an accumulated total volume. The flowmeter provides the operator with information on how the system is performing, how and when to schedule the water application, and in some instances, how much water is available to manage.

4. Chemical injection system. A chemical injector precisely injects disinfectants, line cleaners, fertilizers, pesticides, or other liquid chemicals into the SDI system. Although the location of the chemical injection system is portrayed in advance of the filtration system in Figure 1, the actual location of the injection port or ports may vary according to the chemical being injected or the purpose of the injection.

- **Options.** There are two main types of chemical injection systems:
  1. Constant rate (positive displacement): diaphragm, piston, or gear pumps, and
  2. Variable rate: venturi pressure differential injectors, bladder tanks, or proportional injectors.
- **Considerations.** The types of chemicals used, rate of injection, method of injection, safety requirements, and the injector precision are determining factors in the selection of the best type of injector. The required number of injection systems and their injection point location depend on the clogging hazard and/or the material being injected. An SDI system may have multiple injection ports (e.g., installed before and after the filtration systems; separated by a distance for chemical compatibility issues; etc.) and systems may have multiple chemical injectors to handle different volumes of injected material or to handle different materials. Often state or local regulations or chemical labels will specify the required type of chemical injection system.

4a. Chemigation inline check valve. This valve, installed between the injector and the water source, prevents backflow of water into the chemical supply tank in case of injector failure. This valve is often an integral part of an injector unit and can handle both backpressure and back-siphonage.

- **Considerations.** All state and local codes must be followed as well as any label requirements from the chemical manufacturer.

5. Filtration system. The filtration system is sometimes considered the most important part of the SDI system and definitely is a major component not typically needed in other methods of irrigation in the Great Plains. The filtration system removes suspended particles from the irrigation water to prevent or reduce emitter clogging. Sometimes a bank or group of filters must be installed in parallel to handle greater total flow rates. Additionally, a combination of filter types is sometimes used to improve filtration.

- **Options.** Screen, disc, and sand media filtration systems are commonly used depending on water quality. Centrifugal sand separators (aka hydrocyclone filters) may be used in advance of the primary filtration system when the water supply carries a heavy load of sand. Settling basins to remove sediment load for surface water supplies may be required in addition to the primary filtration system. Many filtration systems have the option of automatic backflush capability.
- **Considerations.** Water quality, emitter passageway dimensions (i.e. controlling maximum allowable particle size), and system flow rate are important factors in specifying the filtration system. Water quality for filtration relates to the amount, size, and type of particles (organic or mineral) that need to be removed before entering the driplines. For example, surface water typically has much higher organic matter content than groundwater, which affects the type of filter that can be used. Generally, disc or sand media filtration systems, which essentially provide three-dimensional filtration as compared to single-plane filtration for screen filtration systems, are chosen when organic loads are greater. The level of filtration required is determined by the smallest emitter passageway. That information is provided by the manufacturer and must be followed to help minimize emitter clogging. As a general guideline, filtration is used to remove all particles that are 1⁄10 the size of the smallest passageway or larger.

6. Pressure-sustaining valve. Depending on the type of filtration system, the SDI system may need to be equipped with a pressure-sustaining valve downstream of the filter to facilitate greater flushing pressures (automatic or manual). They automatically partially open or close as required to maintain the set pressure on their inlet port.

7. Mainline, submain, and/or header manifold. The mainline and submains are the delivery pipelines that deliver water from the pumping plant to the header manifolds connecting the dripline laterals. The header manifold delivers water from the submain to the laterals and links a number of driplines together into one controllable unit or zone. In many cases, the submain serves as the header manifold.

- **Considerations.** The main and submain pipe sizes are selected based on the flow rate for the system and the friction pressure losses from the water supply to the irrigation zone in relation to the pipe cost and anticipated energy costs over time.

8. Zone valve. These valves are opened or closed to control the flow to appropriate zones.

They can be automatically controlled using an electronic or pneumatic control system. Sometimes the zone valves also serve as a pressure regulation valve. In some SDI systems, these zone valves are manually operated when the zone size is appreciably large and the irrigation event set times fit into the daily work schedule.

9. Pressure regulation valves or pressure regulators. These components are typically used to regulate pressure downstream of the filtration system to maintain the proper pressure in zones of the SDI system. Typically regulation is achieved through the use of a diaphragm that is controlled by either a spring or pneumatic system that reacts to the incoming pressure. This reaction to the incoming pressure causes a change in the degree of closure in outlet area of the valve. Higher inlet pressure results in more closure, therefore more pressure loss in the smaller exit area. The result is the outlet pressure will remain constant over the operational pressure range of the valve. Typically the inlet pressure must be 5 or more psi greater than the rated outlet pressure for the valve to be able to function.

- **Considerations.** The manufacturer's emitter rating and the pipeline pressure losses during the delivery of the water to the dripline connection point are important considerations in selecting the specifications of this component. Emitters are typically rated by manufacturers to provide a specific flow rate if operated at a given nominal pressure. The regulation valve or regulator must be sized to provide this pressure while accounting for pressure losses that occur between the valve or regulator and the emitter. The ability to override the nominal pressure setting is a desirable feature to have in order to allow greater operating pressure during the flushing event. Care should be used to prevent exceeding the maximum allowable dripline pressure (burst pressure).

10. Pressure gauges. The filter system should have pressure gauges at the inlet and outlet points to indicate the inlet/outlet pressure differential particularly for initiating flushing of the filtration unit, whether this occurs manually or automatically. Always follow the manufacturer's recommendation on the pressure differential value at which flushing should be initiated. It also is recommended to have pressure gauges at the zone inlet and at the distal end of the system fitted immediately prior to the flushline outlet. The flow rate from the meter and the pressure readings of the system provide cues to the operator about emitter performance and clogging. See MF2590 Management Consideration for Operating a Subsurface Drip Irrigation System for use of pressure gauge readings to aid SDI management.

11. Air and vacuum release valves. These valves allow air to exit the pipeline at system startup and allow air entry for vacuum release at system shutdown. These valves reduce the potential for damage from water hammer and help prevent soil or particulate material from being sucked back into emitters when the SDI system is turned off or when driplines are drained. They do not reduce backpressure, only back-siphonage. All high elevation points of the SDI system should have air or vacuum relief, which can present some design challenges on fields with undulating topography.

12. Dripline. The dripline is a polyethylene tube that includes the built-in emission points (emitters). Driplines are often referred to as drip tapes.

The selection of the emitter spacing along the dripline should take into account the crop rooting characteristics and the ability of the soil to redistribute applied irrigation water. Emitter spacings ranging from 4 to 30 inches are readily available from the manufacturers, and other spacings can be made to meet a specific application. Increasing the emitter spacing can be used as a technique to allow larger emitter passageways that are less subject to clogging, to allow for economical use of emitters that are more expensive to manufacture, or to allow for longer length of run or increased zone size by decreasing the dripline nominal flowrate per unit length. Emitter spacings of 12 to 24 inches are common and sufficient for most Great Plains crops.

Wide ranges of emitter discharge rates are available from the various dripline manufacturers. The evapotranspiration (ETc) needs of the crop have little direct influence on the choice of emitter discharge rate because most emitter discharge rates at typical emitter and dripline spacings provide SDI system application rates greatly in excess of peak ETc. Some designers prefer emitters with greater discharge rates because they are less subject to clogging and allow more flexibility in scheduling irrigation. However, when emitters with greater discharge are chosen, the length of run may need to be reduced to maintain good uniformity and to allow for adequate flushing within the maximum allowable operating pressure. In addition, the zone size may need to be reduced to keep the total SDI system flowrate within the constraints of the water supply system. In general, designers in the Great Plains region prefer emitter discharge rates in the range of 0.15 to 0.25 gal/hr, so that zone length and zone area can be maximized, thus lowering SDI system costs. The choice of emitter discharge rate must also account for the soil hydraulic properties in order to avoid backpressure on the emitters and surfacing of water, although this problem is not common on SDI systems in the Great Plains. That is, the emitter discharge rate must not be too great as to greatly exceed the ability of the soil to uniformly redistribute the applied irrigation water.

Driplines are available in a variety of wall thicknesses, diameters, emitter spacings, and flow rates. Most SDI systems in the Great Plains use driplines with 8 (0.250 mm) to 15 (0.375 mm) MIL wall thickness. Thinner wall thicknesses are more susceptible to stretching and damage during the subsurface installation process.

SDI systems for row crops tend to use large diameter (7/8 inch or greater diameter), thin-walled, and lower emitter discharge driplines. Larger diameter and lower emitter discharge allow for longer length of runs and larger zone size that are appropriate for the typical field sizes in the Great Plains. Pressure-compensating (PC) driplines are available and may be an appropriate choice in some designs.

- **Considerations.** Dripline diameter, tubing wall thickness, emitter spacing, discharge rate, soil texture, and the characteristics of soil water redistribution are all important factors in the selection of a dripline for the SDI system.

12a. Connectors. Connectors are needed to attach the dripline to the manifold or submain. The number and type depend on system layout. There are many types of connectors. Connector options include glued, grommet, barb, and compression. These can have a direct dripline connection or may receive a supply tube that is attached to the dripline. The dripline connector options are wired, clamped, or interference (compression) fit.

- **Considerations.** Use care in selecting a methodology or connection schemes that are reliable and easily repeatable by a wide range of workers' skill. There are a large number of these connections within the SDI system, so even a small percentage of failed connections can be a time-consuming and costly remediation.

13. Flushlines. The flushlines are similar to header manifolds but are located at the distal end of the driplines. They serve three purposes:

1. Allow any sediment and contaminants to be flushed from dripline laterals at a centralized location,
2. Assist in equalization of pressure in the dripline laterals, and
3. Allow positive pressure on both sides of a dripline break to prevent soil ingestion into the dripline.

- **Considerations.** Sizing of the flushline must account for backpressure on the driplines when the flushing operation is performed. Greater flushing velocities that may be required in some designs or by cost-sharing regulations in some states may increase the required internal diameter of the flushline. Many designers consider flushline sizing to be the controlling factor in the initiation of the SDI system design.

Optional Automatic System Control

Automatic control may be useful for precise delivery of water and nutrients according to design or crop need. This also reduces the labor required for manual control that may not match well with other work activities and schedules. As crop production becomes more advanced, the ability to control the SDI system automatically will be an increasingly attractive option. The SDI system should be designed to allow for easy addition of monitoring and automatic control of the system even if it is not installed during the initial installation.

Automatic controls. Pumps, valves, and injectors can be turned on and off or opened and closed to allow automatic timing and sequencing of the irrigation zones and events. These components may be linked to automatic timers, soil water sensors, or weather-based models to determine when the irrigation and chemigation system should be operating. Computerized control and monitoring is an option, but is not required for some levels of automation.

Summary

SDI systems have higher initial investment costs as compared to traditional types of irrigation systems used in the Great Plains, so efforts to minimize initial investment costs whenever possible is a practical goal. However, cost reductions should be attempted only if system design and operating integrity are not compromised. Cost cutting that results in a poor design or a difficult to manage system may increase operating costs, decrease system performance, and increase the chance of system failure.

Related KSRE SDI Resources

MF3408 Subsurface Drip Irrigation (SDI) in Kansas: An Overview

MF-2361 Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems

MF-2578 Design Considerations for Subsurface Drip Irrigation

MF-2590 Management Consideration for Operating a Subsurface Drip Irrigation System

MF-2575 Water Quality Assessment Guidelines for Subsurface Drip Irrigation

MF-2589 Shock Chlorination of Irrigation Wells

MF-2727 Subsurface Drip Irrigation (SDI) with Livestock Wastewater

This publication is also part of an SDI technology transfer effort that began in 2009 involving Kansas State University, Texas A&M University, and the USDA-ARS that was funded by the Ogallala Aquifer Project.

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