Proceedings of the 26th Annual Central Plains Irrigation Conference, Burlington, CO, February 25-26, 2014
Available from CPIA, 760 N. Thompson, Colby, Kansas

SUCCESSFUL SDI - ADDRESSING THE ESSENTIAL ISSUES

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INTRODUCTION

Overall, SDI systems have been successful in the Great Plains region despite minor technical difficulties during the adoption process. In a 2005 survey of SDI users, nearly 80% of Kansas producers indicated they were at least satisfied with the performance of their SDI system, and less than 4% indicated they were unsatisfied (Alam & Rogers, 2005). However, even satisfied users indicated a need for additional SDI management information. The most noted concern was rodent damage and subsequent repairs. A few systems had failed or been abandoned after limited use due to inadequate design, inadequate management, or a combination of both.

Design and management are closely linked in a successful SDI system. Research studies and on-farm producers consistently indicate that SDI systems result in high-yielding crops and water-conserving production practices only when the systems are properly designed, installed, operated and maintained. A system that is improperly designed and installed is difficult to operate and maintain and most likely will not achieve high irrigation water application uniformity and efficiency goals. Proper design and installation alone do not ensure high SDI efficiency and long system life, though. A successful SDI system also must be operated according to design specifications while utilizing appropriate irrigation water management techniques. SDI systems also are well-suited to automation and other advanced irrigation scheduling and management techniques. Additionally, proper maintenance is crucial for the continued life of an SDI system. This paper will review the basics of successful SDI systems.

WATER QUALITY ANALYSIS, THE STARTING POINT FOR ALL SUCCESSFUL SDI SYSTEMS

Because most SDI systems are planned for multiple-year use, water quality is an extremely important consideration. Clogging prevention is crucial to SDI system longevity and requires understanding of the potential hazards associated with a particular water source. Replacement of clogged driplines can be expensive, difficult, and time-consuming. Although nearly all water is potentially usable for SDI, the added cost of complex water filtration and chemical treatment of marginal-quality water might further reduce the feasibility of SDI use on lesser-value crops. Therefore, no SDI system should be designed and installed without first assessing the quality of the proposed irrigation water supply. In some cases, poor water quality can also cause crop growth and/or long-term soil problems. However, with proper treatment and management, many waters high in minerals, nutrient enrichment, or salinity can be used successfully in SDI systems. A good water quality test (Table 1) provides information to growers and designers in the early stages of the planning process so that suitable water treatment, management, maintenance plans, and system components can be selected. Although a good water quality test may cost a few hundred dollars, the absence of it may result in an unwise investment in an SDI system that is difficult and expensive to manage and maintain. Tests 1 through 7 are usually provided in a standard irrigation water quality test package, whereas Tests 8 through 11 are generally offered as individual tests. The test for the presence of oil may be helpful in oil-producing areas or if a groundwater well with oil lubrication has experienced surging, allowing existing drip oil in the water column to mix with the pumped water.

Table 1. Recommended water quality tests to be completed before designing and installing an SDI system including threshold hazard levels(after Bucks et al., 1979; Nakayama and Bucks, 1991; and Rogers et al., 2003a;).

1. **Electrical Conductivity (EC_b),** a measure of total salinity or total dissolved solids, measured in dS/m or mmhos/cm as the bulk EC of the irrigation water.	Ideal <0.75 dS/m
2. **pH,** a measure of acidity, where a value of 1 is very acid, 14 is very alkali, and 7 is neutral.	Ideal <7
3. **Cations** include Calcium (Ca^{2+}), Magnesium (Mg^{2+}), and Sodium (Na^+), measured in measured in meq/L, (milliequivalent/liter).	Ideal <2meq/L
4. **Anions** include Chloride (Cl^-), Sulfate ($SO4^{4-}$), Carbonate ($CO3^{2-}$), and Bicarbonate ($HCO3^-$), measured in meq/L.	Ideal <2meq/L
5. **Sodium Absorption Ratio (SAR),** a measure of the potential for sodium in the water to develop sodium sodicity, deterioration in soil permeability and toxicity to crops. SAR is sometimes reported as Adjusted (Adj) SAR. The Adj. SAR value better accounts for the effect on the $HCO3^-$ concentration and salinity in the water and the subsequent potential damage to the soil because of sodium.	Ideal <3.0
6. **Nitrate nitrogen (NO3 - N),** measured in mg/L (milligram/liter).	Ideal <5 mg/L
7. **Iron (Fe), Manganese (Mn), and Hydrogen Sulfide (H_2S),** measured in mg/L.	Ideal Fe<0.2 mg/L Ideal Mn<0.1 mg/L Ideal H_2S<0.2 mg/L
8. **Total suspended solids,** a measure of particles in suspension in mg/L.	Ideal <50 mg/L
9. **Bacterial population,** a measure or count of bacterial presence in # / ml, (number per milliliter)	Ideal <10,000/ml
10. **Boron*** measured in mg/L.	Ideal <0.7 mg/L
11. **Presence of oil****	-

* *The boron test would be for crop toxicity concern.*

** *Oil in the water would present a concern of excessive filter clogging. It may not be a test option at some labs and could be considered an optional analysis.*

Additional information on assessing water quality and developing water treatment plans are available from a number of sources (Rogers et al., 2003a; Burt and Styles, 2007a; Schwankl, et al., 2008).

FUNDAMENTAL SDI DESIGN CHARACTERISTICS

Fundamental SDI design characteristics need to be addressed early in the design process, namely dripline selection and dripline installation aspects. Interactions exist between these two and with other design aspects occur later in the design process. A complete discussion of these characteristics is beyond the scope of this paper, so the reader is referred to Lamm and Camp (2007) for further discussion. However, some brief discussion is necessary since the characteristics are so fundamental to SDI design.

Dripline Selection

The selection of a dripline involves consideration of dripline diameter and wall thickness, emitter type, discharge rate and emitter spacing.

Dripline inside diameter

Larger diameter driplines allow long lengths of run and large zone sizes without sacrificing water distribution uniformity. Although larger diameter driplines cost more per unit length, their selection may result in a less expensive SDI system because of reduction of trenching and system controls. Dripline diameters up to 1.375 inches are now available and often used in large fields to decrease the number of required zones and field obstructions posed by additional valve boxes. Each SDI system design is different, however, and the grower should not automatically choose the larger dripline diameter. Larger driplines require longer fill and drain times which can adversely affect water and chemical application uniformity and redistribution within the soil.

Dripline wall thickness

The wall thickness of SDI driplines is often greater than surface drip irrigation (DI) because of the additional risk of dripline damage during installation and because the SDI system is intended to have an extended, multiple-year life. Thin-walled, collapsible polyethylene (PE) driplines with wall thicknesses of 12 to15 mil are used primarily for SDI installations in the Great Plains. In situations where soil compaction or soil overburden may cause dripline deformation, thick-walled PE tubing (hard hose) can be selected, although it is considerably more expensive. Thicker-walled products allow greater maximum dripline pressures that can be used to open partly-collapsed driplines caused by soil compaction or overburden, or to increase flow of chemically treated water through partly-clogged emitters. In addition, anecdotal reports highlight less insect damage to hard hose driplines.

Emitter type

Subsurface drip irrigation emitters are fully contained within the dripline to avoid significant protrusions that may become damaged during the SDI system installation process. These internal emitters are typically formed using one of three different methods: 1) long, tortuous passageway is formed through an indention process within the seam of the dripline as it is formed; 2) integral short tortuous path emitter is fusion-welded to the internal wall of the PE tubing; and 3) continuous narrow strip containing the turbulent emitter passageway is fusion-welded to the internal dripline wall. Integral short path emitters sometimes have a smaller manufacturer's coefficient of variation

(CV) than those of the other processes, but all processes provide acceptable CV values with the modern manufacturing processes currently available. All three of these emitter types are used in SDI systems within the Great Plains region.

Emitter types are also classified by their emitter exponent (i.e., typically referred to as X, the exponent on the pressure term in the emitter discharge equation). An exponent less than 0.5 allows an emitter to be classified as partially pressure compensating, whereas a value of zero represents full pressure compensation (PC). An emitter with an exponent greater than 0.5 is classified as non-pressure compensating. Many current SDI driplines have emitter exponents with values close to 0.5 and, traditionally, PC emitters were considered too expensive for SDI installations on lesser-value crops. However, manufacturers continue to evolve product lines and processes, and some driplines with PC emitter characteristics are becoming more economically competitive.

Emitter discharge rate

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 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. 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.

Physical limitations exist to further reducing emitter discharge rate because smaller passageways are more easily clogged. The nominal dripline flowrate can be reduced with smaller emitter discharge rates or by increasing the emitter spacing. Limitations also exist to increasing the emitter spacing that are related to adequately supplying the crop’s water needs. Using a smaller emitter discharge rate in combination with a greater emitter spacing is often economically attractive (reduced design and installation costs) on deeper, medium-textured soils for crops with extensive root systems.

Emitter spacing

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 techniques to allow larger emitter passageways 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. The rationale for increased emitter spacing must be weighed against the need to maintain adequate water distribution within the root zone. An excellent conceptual discussion of the need to consider the extent of crop rooting in irrigation design is presented by Seginer (1979). Although the effective uniformity of microirrigation experienced by the crop is high, the actual detailed uniformity within the soil may be quite low. Emitter spacing ranging from 1 to 4 ft had little effect on corn production and soil water redistribution in a three-year study at the KSU Northwest Research-Extension Center at Colby, Kansas (Arbat et al., 2010). It should be noted that using the widest possible emitter spacing consistent with good water redistribution can cause significant problems when emitters become clogged or under drought conditions. As a result, some plants will be inadequately watered. Generally, emitter spacing of 1 to 2 ft are used for SDI systems in the Great Plains.

Dripline installation aspects

Some dripline installation aspects require basic decisions about dripline spacing, dripline depth, and zone size (length and width). As noted earlier in the paper, these installation aspects may interact with the selection of the dripline.

Dripline spacing

Crop row, or bed spacing, is usually set by cultural practices for a given crop in a given region and by planting and harvesting equipment specifications. As a general rule, SDI dripline spacing is a multiple of the crop row spacing, whereas emitter spacing is usually related to the plant spacing along the row. Providing the crop with equal or nearly equal opportunity to the applied water should be the goal of all SDI designs. This presents a conflicting set of constraints when crops with different row spacing are grown with SDI. Mismatched crop row/bed and dripline spacing may not only result in inadequate irrigation and salinity problems, but also in increased mechanical damage to the SDI system. Adoption of similar row/bed spacing for crops on a farming enterprise may be advantageous, provided that the crops produce adequate yields under that spacing.

Dripline spacing in the Great Plains region is typically one dripline per row/bed or an alternate row/bed middle pattern (Figure 1) with one dripline per bed or between two rows. The soil and crop rooting characteristics affect the required lateral spacing, but general agreement exists that the alternate row/bed dripline spacing (about 5 ft) is adequate for most of the deeper-rooted agronomic crops on medium- to heavy-textured soils. Closer dripline spacing may be used for high-valued crops on sandy soils, for small seeded crops where germination is problematic, and in arid areas to ensure adequate salinity management and consistent crop yield and quality.

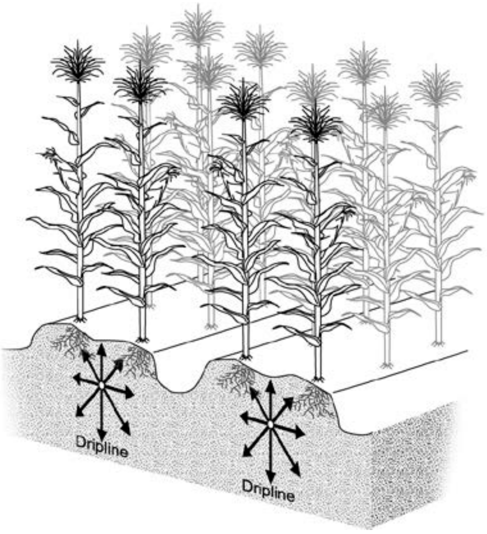


Figure 1. Alternate row/bed 5 ft SDI dripline spacing for corn rows spaced at 2.5 ft. Each plant row is approximately 1.25 ft from the nearest dripline and has equal opportunity to the applied water.

Dripline depth

The choice of an appropriate dripline depth is influenced by crop, soil, and climate characteristics, anticipated cultural practices, grower experiences and preferences, the water source, and prevalence of pests. In an extensive review of SDI, Camp (1998) reported that the placement depth of driplines ranged from less than an inch to as much as 28 inches. In most cases, dripline depth was probably optimized for the local site by using knowledge and experiences about the crop for the soils of the region. For example, driplines for alfalfa are sometimes installed at deeper depths so that irrigation can continue during harvest. When irrigation is often required for seed germination and seedling establishment, shallower dripline depths are often used. Deeply placed driplines may require an excessive amount of irrigation for germination and can result in excessive leaching and off-site environmental effects.

Soil hydraulic properties and the emitter flowrate affect the amount of upward and downward water movement in the soil and thus are factors in the choice of dripline depth. When surface wetting by the SDI system is not needed for germination or for salinity management, deeper systems can reduce soil water evaporation and weed growth. Deeper dripline placement minimizes soil water evaporation losses, but this must be balanced with the potential for increased percolation losses while considering the crop root-zone depth and rooting intensity. Soil layering or changes in texture and density within the soil profile affect the choice of dripline depth. Driplines should be installed within a coarse-textured surface soil overlaying fine-textured subsoil so that there is greater lateral movement perpendicular to the driplines. Conversely, when a fine-textured soil overlays a coarse-textured subsoil, the dripline should be installed within the fine-textured soil to prevent excessive deep percolation losses. An excellent discussion of how soil texture and density affect soil water redistribution is provided by Gardner (1979).

For lesser-valued commodity crops (fiber, grains, forages, and oilseeds), SDI systems are usually set up exclusively for multiple-year use with driplines installed in the 12 to 18 inch depth range. Most of these crops have extensive root systems that function properly at these greater depths. Corn, soybean, sunflower, and grain sorghum yields were not affected greatly by dripline depths ranging from 8 to 24 inches on a deep Keith silt loam soil at Colby, Kansas (Lamm and Trooien, 2005; Lamm et al., 2010). Their results suggest that, in regions that typically receive precipitation during the growing season, dripline depth will not be the overriding factor in crop development and soil water redistribution. The dripline should be deep enough that the anticipated cultural practices can be accommodated without untimely delays, soil compaction, or damaging the SDI system. Pests such as rodents and insects are often more troublesome at the shallow dripline depths.

Zone size (length and width) considerations

The overall field size that can be subsurface drip irrigated is limited by the available water supply and SDI system flowrate. However, the ability to economically adjust the size of the irrigated field to the available water supply is a distinct advantage of SDI systems as compared to center pivot sprinklers. If sufficient water supply is available to adequately irrigate the crop for the overall field size, then system flowrate, field shape, and topography, along with the dripline hydraulic characteristics (i.e., emitter discharge characteristics and dripline diameter) are used to determine the number of zones and the zone dimensions. Minimizing the number of necessary zones and using longer driplines typically results in a more economical system to install and operate, which is of great importance to those growers using SDI on lesser-valued crops.

Systems are sometimes designed so that irrigation zones can be sub-divided into flush zones. Flushing, discussed in detail later, is an important maintenance requirement for SDI systems.

The combination of the emitter discharge, emitter spacing, and dripline spacing determine the flowrate per unit area. The flowrate per unit area in combination with the water supply flowrate (i.e., system or well flowrate) in turn determines the zone size. The system flowrate can be used to determine the total number of acres that can be reliably irrigated.

The irrigation capacity (IC) of an irrigation system is the depth of water that the system could apply to the entire field in one day. As a rule of thumb, a net IC of about 0.25 inches per day is sufficient to meet corn water needs for the deep silt loam soils of western Kansas. Irrigation capacity can also be reported in gpm/acre, so an IC of 0.25 in/day is equivalent to 4.7 gpm/acre. Typical surface-irrigated (flood) systems need 8 to 10 gpm/acre, while center pivot systems might need 5.2 to 5.6 gpm/acre range to have the same net IC and SDI systems would need around 5.0 gpm/ac to match a net IC of 4.7 gpm/acre. There is some evidence to suggest that SDI systems may allow more effective utilization of precipitation and some systems have been installed with gross IC as low as 3.4 gpm/acre. This allows the available water supply to be stretched over more land area but does leave the SDI system's crop vulnerable to crop water stress during drought years.

The design process may require several iterations to select the correct emitter discharge, emitter spacing, dripline spacing (usually fixed at twice the row spacing) with zone size, field size and system flowrate given the producers desired level of irrigation system reliability.

SDI COMPONENTS FOR EFFICIENT WATER DISTRIBUTION AND SYSTEM LONGEVITY

SDI system design must consider individual management restraints and goals, as well as account for specific field and soil characteristics, water quality, well capabilities, desired crops, production systems, and producer goals. However, certain basic features should be universal throughout all SDI systems (Figure 2). The long-term efficient operation and maintenance of the system is seriously undermined if any of the minimum components are omitted during the design process. Minimum SDI system components should not be sacrificed as design and installation cost-cutting measures. If 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.

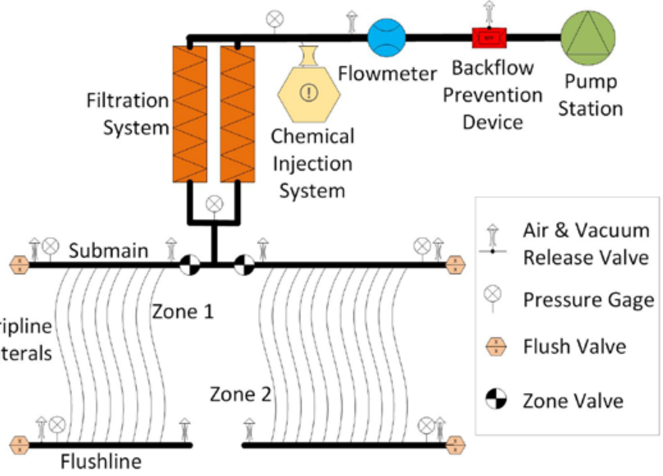
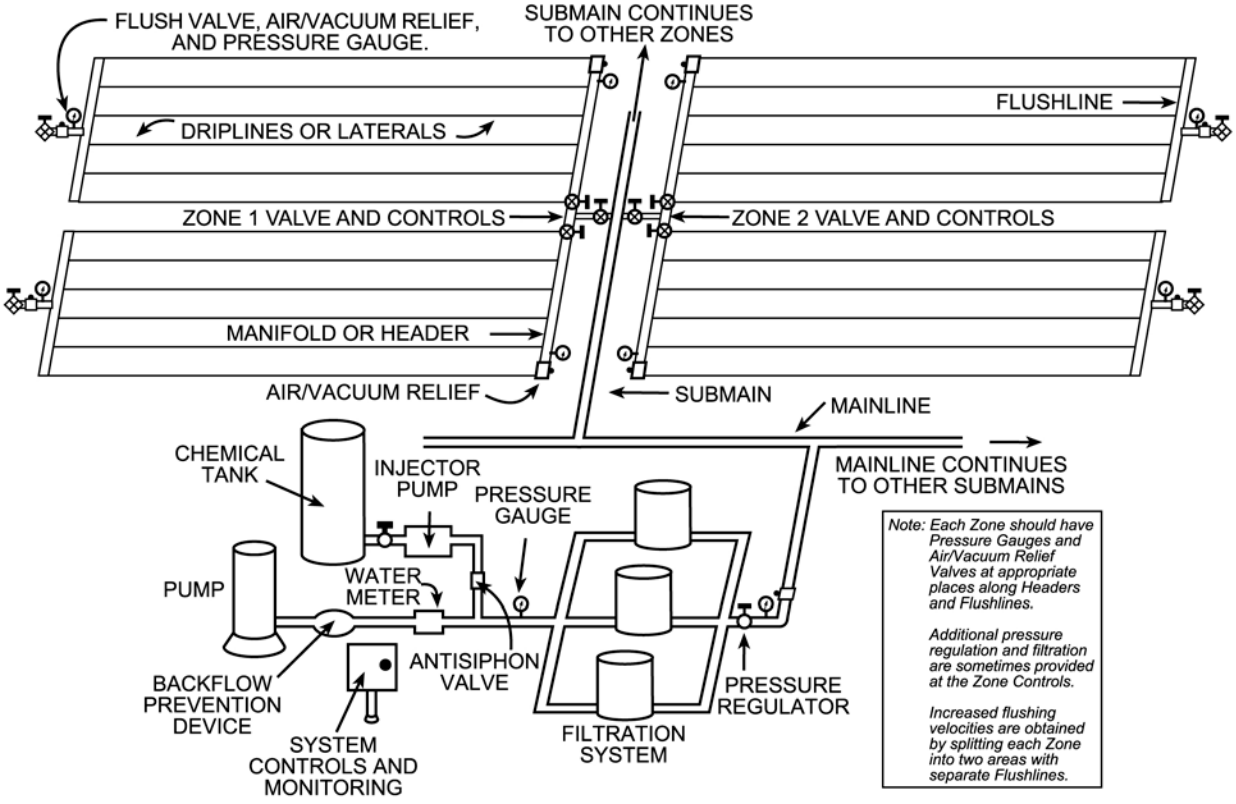


Figure 2. Minimum required components of an SDI system. Components are not to scale. After Rogers, 2003b.

Water distribution components of an SDI system include the pumping station, the main, submains and dripline laterals. Sizing requirements for the mains and submains are somewhat similar to underground service pipe to center pivot sprinklers or main pipelines for surface-irrigated gravity systems and are determined by the flowrate and acceptable friction loss within the pipe. In general, the flowrate and friction loss determine the dripline size (diameter) for a given dripline lateral length and land slope. An SDI system consisting of only the distribution components has no method to monitor system performance or conduct system maintenance, and the system would not have any protection from clogging. Clogging of dripline emitters is the primary reason for SDI system failure. In addition to basic water distribution components, other components allow the producers to monitor SDI system performance, allow flushing, and protect or maintain performance by injection of chemical treatments. The injection equipment can also be used to provide additional nutrients or chemicals for crop production. A backflow prevention device is required to protect the source water from accidental contamination if backflow should occur.

The actual characteristics and field layout of an SDI system vary from site to site, but irrigators often add additional capabilities to their systems. For example, the SDI system in Figure 3 shows additional valves that allow the irrigation zone to be split into two flushing zones. When the well or pump does not have the capacity to provide additional flow and pressure to meet the flushing requirements for the irrigation zone, splitting the zone into two parts may be an important design feature.



Note: Each Zone should have Pressure Gauges and Air/Vacuum Relief Valves at appropriate places along Headers and Flushlines.

Additional pressure regulation and filtration are sometimes provided at the Zone Controls.

Increased flushing velocities are obtained by splitting each Zone into two areas with separate Flushlines.

Figure 3. Schematic of a complete SDI system. After Lamm and Camp (2007).

Filtration system

The heart of the protection system for the dripline emitters is the filtration system. Many types of filtration systems (Figure 4) are commercially available and the selected type depends on the quality characteristics of the irrigation water and the clogging hazards.

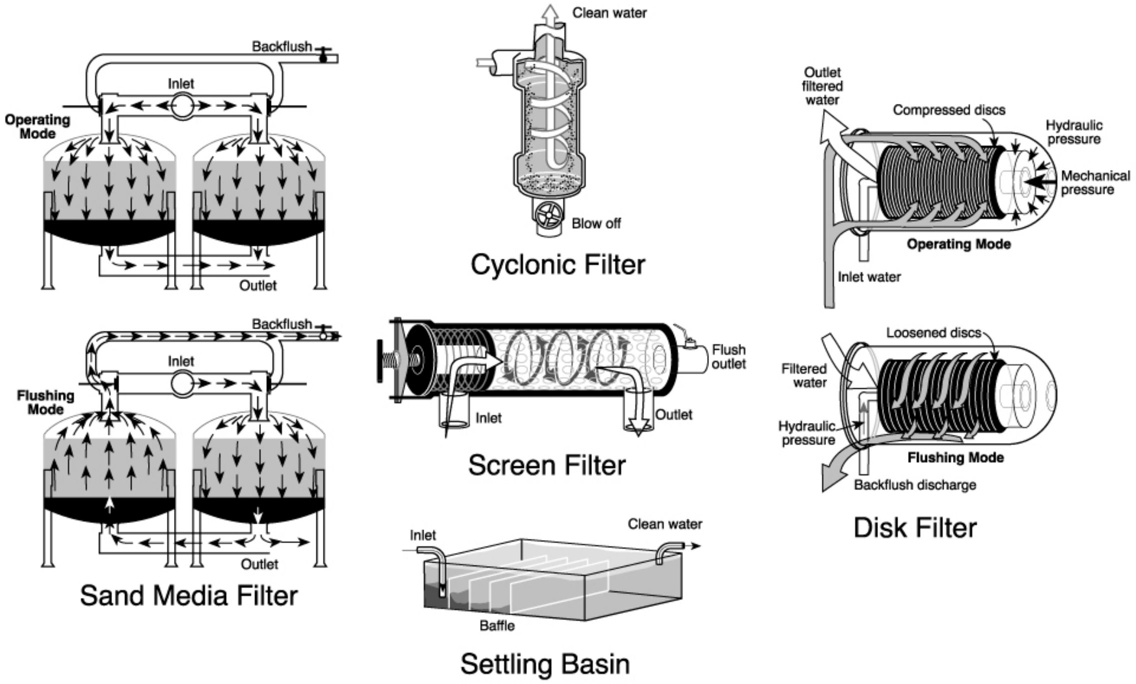


Figure 4. Schematic description of various filtration systems and components. (Courtesy of Kansas State University).

Screen filters are the simplest type of filtration and provide a single plane of filtration. They are most often used in situations where the water source is relatively clean. Sand media filtration systems, which consist of two or more large pressure tanks with specially graded filtration sand, provide three-dimensional filtration and are well-suited for surface water sources. Surface water supplies may require settling basins and/or several layers of bar screen barriers at the intake site to remove large debris and organic matter. Another common type of filtration system is the disc filter which also provides three-dimensional filtration. In some cases, the filtration system may be a combination of filtration components. For example, a well that produces a large amount of sand in the pumped water may require a cyclonic sand separator in advance of the main filter.

Clogging hazards are classified as physical, biological or chemical. Sand particles in the water represent a physical clogging hazard, whereas biological hazards are living organisms, or life by-products, that clog emitters. Water sources that have high iron content are also vulnerable to biological clogging hazards, such as an iron bacteria flare-up within the groundwater well. Control of bacterial growth generally requires water treatment in addition to filtration. Chemical clogging hazards relate to the chemical composition or quality of the irrigation water. As water flows from a well to the distribution system, chemical reactions occur due to changes in temperature, pressure, air exposure, or the introduction of other materials into the water stream. These chemical reactions may form precipitates that result in emitter clogging.

Producers should always follow the filter manufacturer’s guidelines for sizing and when they should be flushed. Automatic flushing is available for many filtration systems and the flushing cycle may be specified by the pressure differential across the filter and/or a set interval of time.

Flushlines

Filter systems are generally sized to remove particles that are approximately 1/10 the diameter of the smallest emitter passageway. However, small particles still pass through the filter and into the driplines, and over time, they may clump together. Also, biological or chemical processes produce materials that need to be removed in order to prevent emitter clogging or a build-up of material at the outlet or distal end of the system. A good design should allow flushing of all pipeline and system components. Opening the flushline valves allows water to rapidly pass through the driplines, carrying away any accumulated particles. The American Society of Agricultural and Biological Engineers (ASABE) recommends a minimum flushing velocity of 1 ft/s for microirrigation lateral maintenance (ASAE EP-405, 2008). This flushing velocity requirement needs to be carefully considered at the design stage and may dictate larger sizes for submains and flushlines to assure that maximum operating pressures for the driplines are not exceeded (Lamm and Camp, 2007).

The frequency of flushing is largely determined by the quality of the irrigation water and, to a degree, the level of filtration. Evaluation of the amount of debris caught in a mesh cloth during a flushing event is an indicator of the required frequency of flushing. When only a small amount of debris is found, the flushing interval may be increased. Heavy accumulations of debris, however, mean more frequent flushing is needed.

Chemical injection system

In addition to SDI system protection, the chemical injection system may also be used to inject nutrients or chemicals into the water to enhance plant growth or yield. A variety of injectors can be used, but the choice of unit depends on the desired injection accuracy for the chemical, the rate of injection, and the chemical being injected. When a wide variety of chemicals are likely to be injected, then more than one type of injection system may be required. Also, state and federal laws govern the type of injectors, appropriate chemicals, application amounts, and required safety equipment that may be used in SDI systems, as illustrated by Figure 5.

Many different chemicals can be injected, including chlorine, acid, dripline cleaners, fertilizers, and some pesticides. Producers should avoid injecting any chemical into their SDI system without knowledge of the chemical compatibility with irrigation water. For example, various phosphorus fertilizers are incompatible with many water sources and may only be injected using additional precautions and management techniques. All applicable laws and labels should be followed when applying chemicals.

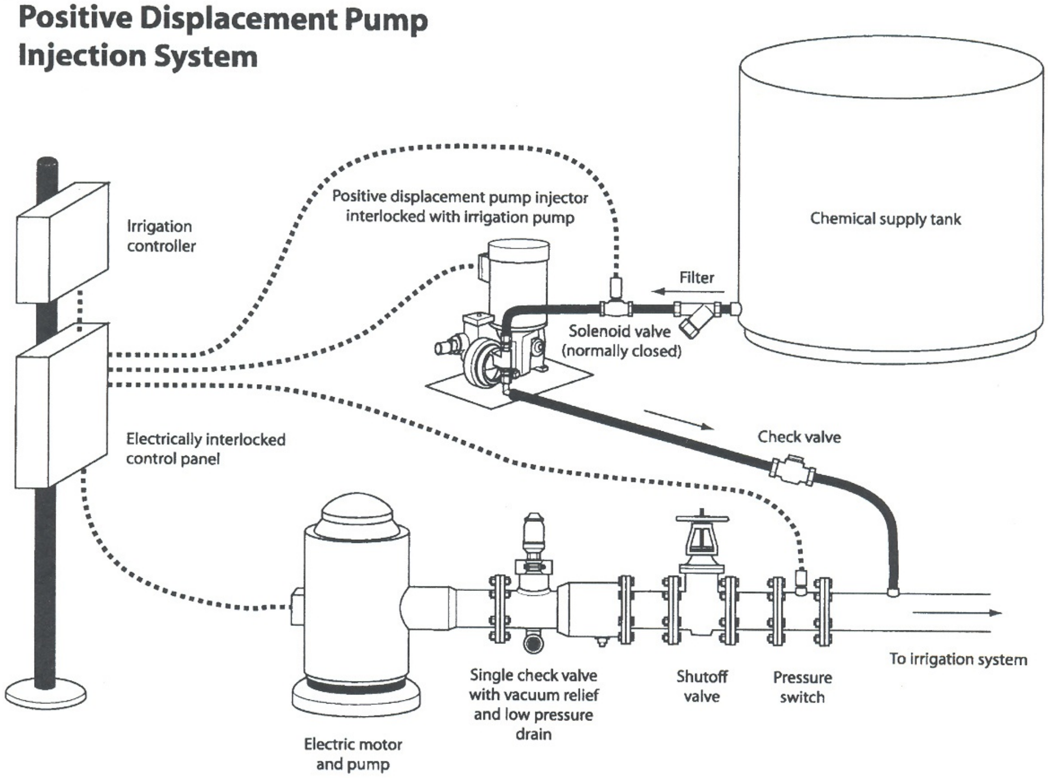


Figure 5. Layout of a chemical injection system with safety interlocks and backflow prevention devices (Courtesy of L.J. Schwankl, Univ. of California-Davis).

The injection systems in Figures 2 and 3 have a single injection point located upstream of the main filter, but some agrochemicals may require an injection point downstream from the filter to prevent filter damage. Care needs to be exercised in the location of the injection port to prevent system problems such as corrosion within the filters or chemical precipitation beyond the filter resulting in emitter clogging.

Chlorine is commonly used to disinfect the injection system and minimize the risk of clogging from biological organisms. Acid injection can also reduce the pH chemical characteristic of the irrigation water. For example, water with a high pH clogs easily because minerals drop out of solution in the dripline after the water passes through the filter. A small amount of acid added to the water reduces the pH to minimize the potential for chemical precipitates.

MONITORING THE SDI SYSTEM

In SDI systems, all water application is underground. Because surface wetting seldom occurs in properly installed and operated systems, no visual cues of system operation are available to the manager. Therefore, the flow meter and pressure gauges must be used to provide operational feedback cues. The pressure gauges along the submain of each zone measure the inlet pressure to driplines. Decreasing flowrates and/or increasing pressure may indicate clogging, and increasing flowrates with decreasing pressure may indicate a major line leak. The inlet pressure gauges, along with those at the distal ends of the dripline laterals at the flushline valve, help establish the baseline performance characteristics of the system. Good quality pressure gauges should be used at each of these measurement locations and the gauges should be periodically replaced or inspected for accuracy. The flowrate and pressure measurements should be recorded and retained for the life of the system. A time series of flowrate and pressure measurements can be used as a diagnostic tool to discover operational problems and determine appropriate remediation techniques (Figure 6).

Anomaly A: The irrigator observes an abrupt flowrate increase with a small pressure reduction at the Zone inlet and a large pressure reduction at the Flushline outlet. The irrigator checks and finds rodent damage and repairs the dripline.

Anomaly B: The irrigator observes an abrupt flowrate reduction with small pressure increases at both the Zone inlet and the Flushline outlet. The irrigator checks and finds an abrupt bacterial flare-up in the driplines. He immediately chlorinates and acidifies the system to remediate the problem.

Anomaly C: The irrigator observes an abrupt flowrate decrease from the last irrigation event with large pressure reductions at both the Zone inlet and Flushline outlet. A quick inspection reveals a large filtration system pressure drop indicating the need for cleaning. Normal flowrate and pressures resume after cleaning the filter.

Anomaly D: The irrigator observes a gradual flowrate decrease during the last four irrigation events with pressure increases at both the Zone inlet and Flushline outlet. The irrigator checks and finds that the driplines are slowly clogging. He immediately chemically treats the system to remediate the problem.

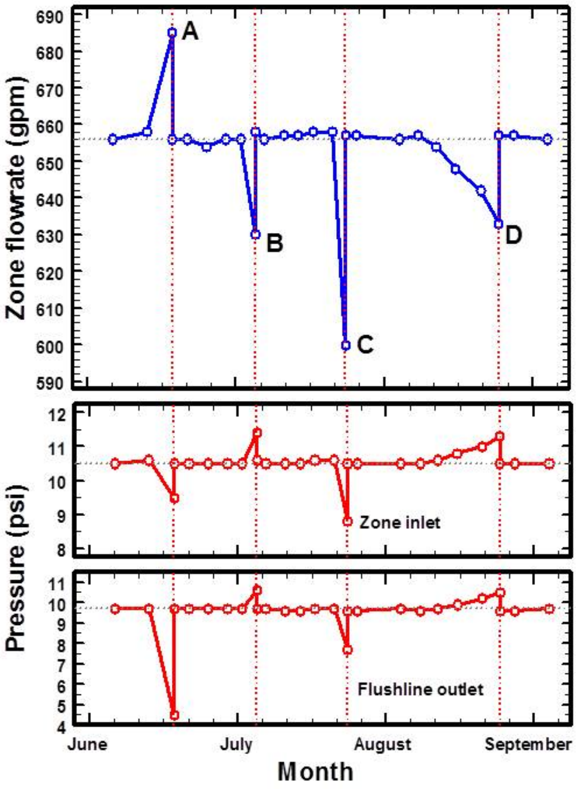


Figure 6. Hypothetical example of how pressure and flowrate measurement records could be used to discover and remediate operational problems. After Lamm and Camp (2007).

RODENT MANAGEMENT

Burrowing mammals, principally of the rodent family, can cause extensive leaks that reduce SDI system uniformity. Most rodents avoid digging into wet soil, so dripline leaks presumably are not caused by the animals looking for water. Rather, rodents must gnaw on hard materials, such as plastic, to wear down their continuously growing teeth. The difficulty in determining the actual location of a dripline leak is compounded by the fact that the leaking water may follow the rodent burrow path for a considerable distance before surfacing. Anecdotal reports from the Great Plains describe some of the typical habitat scenarios that tend to increase rodent problems. These scenarios include the close proximity of permanent pastures and alfalfa fields, railroad and highway easements, irrigation canals, sandy soils, crop and grain residues during an extended winter dormant period, or absence of tillage.

Cultural practices such as tillage and crop residue removal from around SDI control heads and above-ground system apparatus seem to decrease the occurrence of rodent problems. Some growers have used deep subsoiling and/or poison bait around the SDI system field perimeters as a means of reducing rodent subsurface entry into the field. Isolated patches of residue within a barren surrounding landscape provide an "oasis" effect conducive to rodent establishment. After the smaller rodents become established, other burrowing predators such as badgers can move into the field, further exacerbating the damage. Caustic, odoriferous, pungent, and unpalatable chemical materials have been applied through SDI systems in attempts to reduce rodent damage, but the success of these trials has been varied. Anecdotal reports have indicated reduction in rodents by installing owl houses on high poles around the edges of the fields (Burt and Styles, 2007b). Periodic wetting of the soil during the dormant period has been suggested as a possible means of reducing rodent damage. Deeper SDI depths (18 inches or greater) may avoid some rodent damage (Van der Gulik, 1999) since many of the burrowing mammals of concern in the United States have a typical depth range of activity that is less than 18 inches (Cline et al., 1982).

PRODUCER RESPONSIBILITIES

As with nearly all investments, the decision of whether an SDI investment is sound lies with the investor. Wise decisions generally require a thorough understanding of the fundamentals of the particular opportunity and/or the recommendations from a trusted and proven expert. While the microirrigation (drip) industry dates back nearly 50 years and SDI application in Kansas has been researched since 1989, the network of industry support is still evolving in portions of the Great Plains region. Individuals considering SDI should spend time to determine if SDI is a viable systems option for their situation. They might ask themselves:

What things should I consider before purchasing an SDI system?

1. Educate yourself before contacting a service provider or salesperson by
    a. Seeking out university and other educational resources. A good place to start is the K-State SDI website at www.ksre.ksu.edu/sdi
    Read the literature or websites of microirrigation companies as well.
    b. Review SDI minimum design components as recommended by K-State.
    http://www.ksre.ksu.edu/sdi/Reports/2003/mf2576.pdf
    c. Visit other producer sites that have installed and are using SDI. Most current producers are willing to show their SDI systems to others.
2. Interview at least two companies.
    a. Ask them for references, credentials (training and experience) and completed sites (including the names of contacts or references).
    b. Ask questions about design and operation details. Pay particular attention if the minimum SDI system components are not met. If not, ask why. System longevity is a critical factor for economical use of SDI.
    c. Ask companies to clearly define their role and responsibility in designing, installing, and servicing the system. Determine what guarantees are provided.
3. Obtain an independent review of the design by an individual that is not associated with the sale. This adds cost but is relatively minor in comparison to the total cost of a large SDI system.

CONCLUSION

SDI can be a viable irrigation system option, but many issues should be carefully considered by producers before any financial investment is made.

OTHER AVAILABLE INFORMATION

Additional SDI-related bulletins and irrigation-related websites are listed below:

MF-2361 *Filtration and Maintenance Considerations for Subsurface Drip Irrigation (SDI) Systems*
http://www.ksre.ksu.edu/sdi/Reports/2003/mf2361.pdf

MF-2576 *Subsurface Drip Irrigation (SDI) Components: Minimum Requirements*
http://www.ksre.ksu.edu/sdi/Reports/2003/mf2576.pdf

MF-2578 *Design Considerations for Subsurface Drip Irrigation*
http://www.ksre.ksu.edu/sdi/Reports/2003/mf2578.pdf

MF-2590 *Management Consideration for Operating a Subsurface Drip Irrigation System*
http://www.ksre.ksu.edu/sdi/Reports/2003/MF2590.pdf

MF-2575 *Water Quality Assessment Guidelines for Subsurface Drip Irrigation*
http://www.ksre.ksu.edu/sdi/Reports/2003/mf2575.pdf

MF 2589 *Shock Chlorination Treatment for Irrigation Wells*
http://www.ksre.ksu.edu/sdi/Reports/2003/mf2589.pdf

Subsurface Drip Irrigation website: www.ksre.ksu.edu/sdi

General Irrigation website: www.ksre.ksu.edu/irrigate

Mobile Irrigation Lab website: www.mobileirrigationlab.com

ACKNOWLEDGEMENTS

This paper is also part of SDI technology transfer effort beginning in 2009 involving Kansas State University, Texas A&M University and the USDA-ARS and is funded by the Ogallala Aquifer Program. To follow other activities of this educational effort, point your web browser to http://www.ksre.ksu.edu/sdi/.

Watch for this logo.

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