UT652.0605 State Supplement

(a) General Information

This part contains additional technical information required for the design of the various types of irrigation systems. Section UT652.0605(b) addresses surface irrigation systems. Section UT652.0605(c) addresses sprinkler irrigation systems. Section UT652.0605(d) addresses micro (drip) irrigation systems.

The following Table UT6-1 is provided for guidance in determining the recommended minimum irrigation efficiency to use in the various system designs. The efficiencies shown are for the farm efficiency. Farm efficiency considers all water losses beginning at the water source and ending at the plant and soil profile.

Table UT6-1 Potential Farm Efficiency of Irrigation Systems

Irrigation System or Condition	Farm Efficiency
Surface Irrigation Systems	
Average system no treatment	25-35%
Land leveling, delivery pipeline, to design standards	50-60%
With surge valve	60-70%
Tailwater recovery system with land leveling, delivery pipeline, drainage system, with or without surge valve	85%
Sprinkler Systems (other than center pivot)	
Hand Line	60%
Fixed gun	60%
Solid set	65%
Traveling gun	65%
Side roll	65%
Center Pivot Systems	
Impact nozzles	75%
Spray nozzles (6 ft. above surface)	85%
Low Energy Precision Application (LEPA)*	95%
End gun	55%
Micro Irrigation Systems	
Surface drip/trickle emitters**	90%
Subsurface drip tape/hose (SDI)	95%

The efficiency values are potential efficiencies that one could realistically obtain. The values used have been collected from various sources. For sprinkler and micro irrigation systems, the following assumptions are made so as to be able to attain the efficiency shown on the table:

- The water is conveyed to the field through a pipeline and there are no water losses between the point where water is extracted from the well or other extraction point.

- The water applied is less than or equal to the soil water moisture deficit at the time of irrigation and there is no water lost to deep percolation.

The only resulting inefficiency to equal water being applied to all points in the field is that due to variations in the distribution and uniformity from emitter and sprinkler nozzle spray patterns, flow variation due to pressure variation, and overlap.

(b) Surface Irrigation

(1) SRFR - Surface Irrigation Model

In Part 652.0601 Surface Irrigation, the Surface Irrigation Model, SRFR is referenced so that "SRFR methodology will be used as the basis for future surface irrigation designs in NRCS." (Part 652 page 6-3)

SRFR is CCE-certified and is available for Windows NT machines. It is available on the NRCS Supplemental CD

The README File in the directory with the program gives information about how to use the progam and should be refered to in addition to the help buttion of the program.

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The Utah NRCS state office engineer with lead responsibilities for irrigation

(c) Sprinkler Irrigation

(1) Periodic Move Sprinkler Design Sheet

Wheel lines and Hand line sprinkler irrigation systems can be designed using this spreadsheet. It is available in the Utah eFOTG. It contains the weather data and crop data needed to design most systems in the state.

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(2) Pivot Design Sheet

Center Pivot sprinkler irrigation systems can be designed using this spreadsheet. It is available in the Utah eFOTG. It contains the weather data and crop data needed to design most systems in the state.

Note: When possible, it is best to change the depth applied so that one pass is not a whole day (24.0 hrs.) or multiple of whole days so that when running continuously, the same portions of the field are watered during the daytime when evaporation and wind are highest.

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(d) Micro Irrigation

(1) System Components

For a schematic of the general system, refer to Part 652.0603 Figures 6-14, 6-19.

Injection System--In addition to the information provided in Part 652.0603(f)(8), if injecting fertilizer or chemicals into a system which is connected directly to a ground water or surface source (well, river, or pond), then the injection system must meet the requirements of Utah State Law, in particular a check valve is required.

Drains--Drain valves or plugs should be installed at all low points in the system. Drain plugs should be installed at the end of the manifold and the lateral lines.

This will permit drainage and also periodic flushing of the system.

Other

- Lateral lines installed along the ground surface should be "snaked" along the rows. This allows for contraction and expansion due to temperature changes. Five percent of the total length is added to compensate for the variation.
- Five extra feet should be added to the end of the manifold and laterals (beyond last emitter). This provides temporary storage for sediments that pass through the filter(s). These may be flushed out periodically.
- Cutoff valves should be installed at the front of each lateral line to permit greater flexibility in system operation. Individual lines can be shut off for repair and maintenance while the remainder of the system operates. The valves also help when flushing the system or when injecting fertilizer or chemicals. A system design with the valves could allow for removal of laterals for storage after the season or allow access for tillage.
- Fixtures (pressure regulators, gauges, filters, etc.) should be mounted off the ground surface to prevent breakage. Install guard posts as needed to protect fixtures from machinery, livestock, etc.

(2) Design Criteria

The majority of the design criteria can be found in Part 652.0603(g)(8).

- Water pressure at the source (after the filter) will depend on the type of emitters to be used. For stem crops (trees and shrubs), the pressure at the emitters is generally 20 psi. Emitters for other crops may have a lower pressure. The starting pressure will need to be higher to make up for the pressure loss in the distribution lines. If necessary, use a pressure regulator to maintain the starting pressure.
- When sizing the main line and laterals, try to hold the pressure drop across any lateral to 10 psi or less (10 percent of desired operating pressure) when the system is operating. This will result in a more uniform emitter discharge.

(6) Subsurface Drip Irrigation (SDI)

(i) General--This section provides direction for the design of SDI systems. Much of the following information comes directly from professional papers provided from references written by Kansas State University (KSU) Research and Extension engineers. KSU continues to develop appropriate methodology for successful utilization of SDI technology in the U.S. Central Great Plains. Information pertaining to this technology is available at the KSU SDI website:
http://www.oznet.ksu.edu/sdi/

Parts 652.0603 and 652.0604 provide some general assistance with drip (trickle) and subsurface drip irrigation design and can serve to supplement the information in this paper. Irrigation and nutrient amounts must be managed together to prevent leaching. The SDI system must also be properly designed to ensure system longevity.

(ii) Crops and Soils Consideration--The crop and soil type will dictate SDI system capacity, dripline spacing, emitter spacing, and installation depth. The SDI system capacity must be able to satisfy the peak water requirement of the crop through the combination of the applied irrigation amount, precipitation, and stored soil water. If sufficient water supply is available, the field size, shape, and topography, along with the dripline hydraulic characteristics, will dictate the number of zones.

Wide spacing will not uniformly supply crop water needs and will likely result in excess deep percolation for many soil types. Studies on silt loam soils in western Kansas conducted by KSU have indicated that 60-inch dripline spacing is optimal for a cornrow spacing of 30 inches. Though a slightly wider spacing may work for 36-inch cornrow spacing, this might limit successful use of the system for crops grown in a narrow row pattern or a corn and wheat or other crop rotation. As a rule of thumb, dripline spacing is related to crop row spacing while emitter spacing is more closely related to crop plant spacing. To achieve water conservation and water quality protection, careful attention should be given to dripline spacing and emitter spacing.

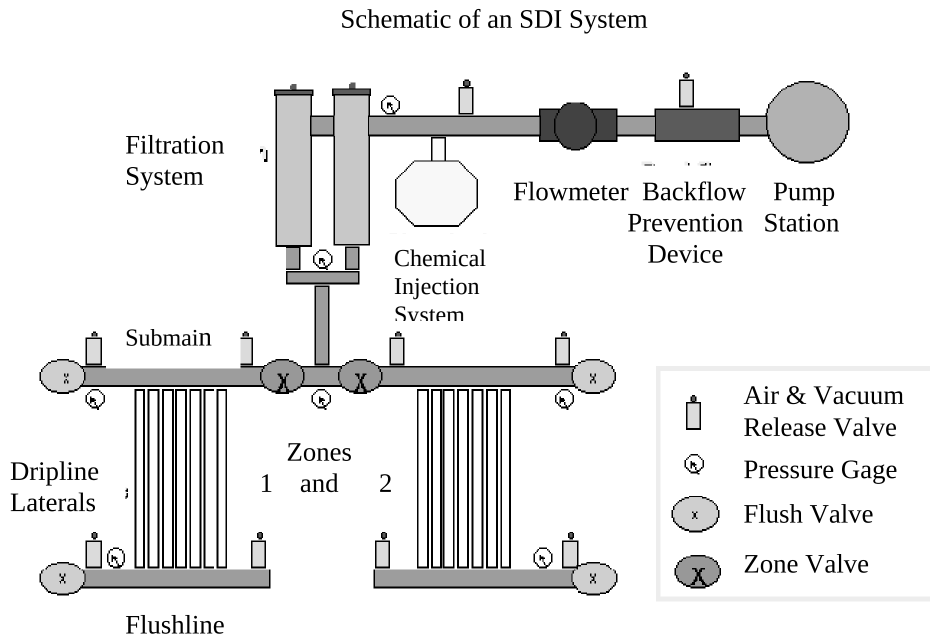
Deep installations reduce the potential for soil evaporation and also allow for a wider range of tillage practices. There may also be some reduced potential for chemical, biological, and root plugging of the emitters for the deeper installations. Acceptable results have been obtained with depths of 16 to 18 inches in KSU studies in western Kansas on deep silt loam soils. Some producers in the Central Great Plains region are opting for installations in the 12 to 14 inch depth range to give more flexibility in germination. Dripline should probably be installed above any restrictive clay layers that might exist in the soil.

The orientation of driplines with respect to crop rows has not been a critical issue with SDI systems used for corn production on the deep silt loam soils. KSU research has shown either parallel or perpendicular orientations are acceptable.

(iii) Hydraulic Design--Water distribution problems may be difficult or impossible to correct for an improperly designed SDI system (Lamm, Rogers, and Spurgeon. 1998). A schematic of a typical SDI system showing the necessary components is shown in Figure UT6-1. The actual requirements in equipment, their sizes, and their location is dependant on the actual design; but elements of all these components should be present in all systems.

Successful operation of an SDI system begins with a proper hydraulic design. The design needs to satisfy constraints dictated by crop, soil type and characteristics, field size, shape, topography, water source, and supply. Disregarding design constraints will likely result in a system that is costly in both time and money to operate and will likely increase the chance of system failure.

Figure UT6-1 Component Requirements of a Subsurface Drip Irrigation (SDI) System



(Courtesy of F. R. Lamm, D. H. Rogers, and W. E. Spurgeon. 1998. Design and management considerations for subsurface drip irrigation systems.)

System failure might result in the loss of the total capital investment (Lamm, Rogers, and Spurgeon. 1998).

a) Dripline--Whenever possible, dripline laterals should be installed downslope on slopes of less than 2 percent. On steeper terrain, the driplines should be made along the field contour, and/or techniques for pressure control should be employed.

Drip tubing comes in various inside diameters (ID) and wall thicknesses. Depending on the manufacturer, the tubing may be available in ½-inch, $^{5}/_{8}$-inch, $^{7}/_{8}$-inch, 1-inch, and $1^{3}/_{8}$-inch ID. The larger the diameter, the longer the fill and drain time.

b) Emitters--Many lay-flat drip tape products have an emitter exponent of approximately 0.5. A 20 percent change in pressure along the dripline would result in a 10 percent change in flowrate if the exponent were 0.5. As a rule of thumb, flowrates should not change more than 10 percent along the dripline in a properly designed system. The overall effect on uniformity is specific to the field slope, length of run, dripline capacity, and diameter.

Uniformity criteria established by ASAE Engineering Practice EP-405.

Flow variation < 10%

Emission Uniformity (Eu) > 80%

The coefficient of manufacturing variation, Cv, is a statistical term used to describe this variation. Some dripline products are inherently difficult to manufacture with consistency and, therefore, may have a high Cv. Other products may suffer from poor quality control. The American Society of Agricultural Engineers (ASAE) has established Cv ranges for line-source driplines. A Cv of less than 10 percent is considered good.

Very small emitters in SDI systems may be prone to clogging by the various constituents of the wastewater (0.15 and 0.24 gal/hr/emitter in a Gray County, Kansas, study experienced plugging). Higher-flow emitter sizes (0.4, 0.6, and 0.92 gal/hr/emitter) showed little sign of clogging in the ongoing field test in Gray County, Kansas (Trooien et al. 1999). However, small emitters have been successfully used without problems for fresh water sources.

The absence of emitter clogging indicates that emitters of these sizes may be adequate for use with lagoon wastewater. For the silt loam soils in western Kansas, 24-inch emitter spacing appears to work satisfactorily for corn, wheat, and alfalfa. Using the lowest practical emitter flow rate minimizes costs. Decreasing the length of run or the zone area increases the cost of both installation and operation.

For the installation of drip tubing, the outlets should always face upward. This reduces potential for clogging by allowing any fine sand, silt, clay, or other inorganic particles to settle in the pipe below and away from the outlets. Additionally, with the outlets at the top of the tubing provides better uniformity for time of application throughout the line and zone.

c) Filtration, flushing, and water treatment plugging of the dripline emitters is the major cause of system failure. Plugging can be caused by physical, chemical, or biological materials. <u>The filtration system is one of the most important components of the SDI system</u>. Improper filter selection can result in an SDI system that is difficult to maintain and a system prone to failure.

Screen or sand media filters are used to remove the suspended solids such as silt, sand, and organic and inorganic debris. Refer to 652.0603(f)(3) and UT652.0605(d)(1)(v) for additional information on media filters. Surface water often requires more extensive filtration than ground water, but filtration is required for all systems. Wastewater use will require filtration with disk or sand media filters. Screen filters will probably not be adequate. In the Ingalls, Kansas, installation, an automated spin-disk filter was selected. It is programmed to backflush whenever the pressure drop across the filter reaches a programmed threshold (7 psi change across the filter system), or on a minimum time interval, whichever happens first. Backflush water is discharged back into the lagoon (Trooien et al. 1999).

Chemical reactions in the water can cause precipitates, such as iron or calcium deposits to form inside the driplines. Plugging can be caused by either natural water conditions or by chemicals such as fertilizer added to the water.

To avoid chemical clogging, the water must be analyzed to determine what chemicals are prevalent and which chemical additives should be avoided. Injection of chlorine into the driplines on a periodic basis is required to stop the biological activity. *A thorough chemical analysis of the water source should be made prior to development of the SDI system*.

A flushing system is recommended at the distal end of the dripline laterals (Figure UT6-3) to assist in removing sediment and other materials that may accumulate in the dripline during the season. This is in addition to a proper filtration system. A useful way to provide for flushing is to connect all the distal ends of the driplines in a zone to a common submain or header that is called the flushline. This allows the flushing to be accomplished at one point. Two distinct advantages that exist for having a flushing line system are:

--If a dripline becomes plugged or partially plugged, water can be provided below the plug by the interconnected flushline.

--If a dripline break occurs, positive water pressure on both sides of the break will limit sediment intrusion into the line. Generally, a minimum flow velocity of 1 to 2 feet/second is considered adequate for flushing dripline laterals (Lamm et al. 1997). This flow velocity will require careful sizing of the mains, submains, flushline mains, and valving.

Pressure gages should be installed on riser pipes at each of the four corners of the closed-loop zone. Recorded pressures from these gages and flow rates from the system flowmeter can be compared from one event to the next to help reveal system performance problems. Checkvalves, air vents, and vacuum breakers may be required at various points in the system to prevent back-siphoning of chemically treated water into the water supply and also to prevent ingestion of soil into the driplines at system shutdown.

d) Installation--The installation of SDI systems warrants comment. The six-page paper Installation Issues for SDI Systems, by Lamm et al. 1997, available at the KSU SDI website http://www.oznet.ksu.edu/sdi/, provides a concise explanation of items that need to be addressed before and during the installation of a subsurface dripline.

NRCS state standards and specifications series 430 (for the various types of underground pipeline) should cover the installation of the mainline and submains. One needs to make sure that the dripline and dripline connectors are compatible.

5) Management--Improper management of an SDI system can result in system failure, which might mean the loss of the total capital investment.

The performance of the SDI system components can be evaluated by monitoring the flowrate and pressures in each zone. Pressure gages should be installed on riser pipes from the submain and flushline at each of the four corners of the zone. Disregarding day-to-day management can result in problems such as poor water distribution, low crop yields, and even system failure. Irrigation scheduling must be employed as some of the visual indicators of overirrigation (such as runoff) no longer exist with this type of irrigation. Overirrigation can dramatically increase deep percolation, which can increase ground water contamination.

The irrigation frequency is important. When salts in the root zone are a problem, a rain that does not saturate essentially the entire root zone will permit salts to move upward into the root zone if the normal irrigation schedule is not maintained. Frequent wetting of the soil every 2 or 3 days for 2 to 4 hours (rather than 8-hour sets) is more effective in maintaining lateral and upward capillary movement of the water. Longer water applications tend to allow gravity to draw water downward below the root zone.

(iv) Dripline Hydraulic Characteristics--Pressure losses occur when water flows through a pipe due to friction. These friction losses are related to the velocity of water in the pipe, the pipe inside diameter and roughness, and the overall length. The Hazen-Williams friction coefficient used for the tubing is C=130 or 140 (depending on the manufacturer).

The drip tubing manufacturers are using computer programs to calculate the friction loss (pressure drop) per 100 feet along the drip tubing for their designs. The programs are using the Darcy-Weisbach equation for computing friction loss. The equation is based on a Reynolds number for pipe roughness. (This number ranges between 2,000 and 100,000, according to a manufacturer's representative from Roberts Irrigation.) The final equation is head loss $h_L = (k) \times (Q^x)$; with $k = 0.5256$, $x = 1.75$, and Q in gal/min (gpm). The equation then becomes:

$$\text{Head loss } h_L \text{ (psi/100 ft.)} = (0.52567) \times (Q^{1.75})$$

Using this value and the ID, the pressure loss can be calculated in the same manner that PVC and PE headloss is figured for mainline, submains, etc.

The emitter flow rate (Q) can generally be characterized by a simple power equation:

$$Q = k\,H^x$$

Where:

k is a constant depending upon the units of Q and H
H is the pressure
x is the emitter exponent.

The value of x is typically between 0 and 1, although values outside the range are possible. For an ideal product, x equals 0, meaning that the flowrate of the emitter is independent of the pressure. This would allow for high uniformity on very long driplines, which would minimize cost. An emission product with an x of 0 is said to be fully pressure compensating. An x value of 1 is noncompensating, meaning any percentage change in pressure results in an equal percentage change in flowrate. Many lay-flat drip tape products have an emitter exponent of approximately 0.5. A 20 percent change in pressure along the dripline would result in a 10 percent change in flowrate if the exponent were 0.5. As a rule of thumb, flowrates should not change more than 10 percent along the dripline in a properly designed system. Most manufacturers can provide the emitter exponent for their product. (Lamm et al, 1998).

- ***(v) Dripline Hydraulic Designs*****--**In the majority of states where SDI is being installed at this time, the actual designs are drawn up by the drip tubing manufacturers (or dealers) who use the computer programs for pipe design that the manufacturers supply them. A copy of the design hydraulics, including friction loss in the individual line, can be made available. It is also possible to obtain a copy of the hydraulics computer programs from some of the manufacturers.
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