

Grower's Guide to Surge Flow Irrigation

by
Guy Fipps¹
Extension Agricultural Engineer

Surge flow is not magic, and it is difficult to predict whether it will work for a particular situation. However, where it does work, there are significant benefits. This paper provides a brief overview of surge flow irrigation, and highlights important considerations if you are planning on experimenting with surge flow.

What is Surge Flow Irrigation?

Surge flow irrigation was first developed in the late 1970's and has the potential to increase surface irrigation efficiencies to levels usually associated with sprinkler or drip irrigation systems. Another advantage of surge flow is that it makes automation of furrow irrigation possible. Twice the area can be irrigated with the same amount of water at the same time with an automatic surge valve.

Figure 1 shows a typical surge flow set-up. In surge, water is applied in a series of on-off cycles or watering periods which, on most soils:

- 1) increases the rate of water advance down the furrow,
- 2) reduces deep percolation losses,
- 3) produces an even wetting front along the furrow, and
- 4) produces a more even depth of water penetration into the soil.

Thus, higher irrigation efficiencies result which reduces the total amount of water applied.

In many situations, surge gives you the ability to apply more precise levels of water. Thus, instead of applying 4-6 inches, for example as in conventional furrow irrigation, you can put out as little as 1-2 inches. However, surge does not work on all soils and situations. Adequate furrow stream (flow per furrow) is also necessary to see benefits.

¹Guy Fipps, PhD, P.E. Professor and Extension Agricultural Engineer, Bio and Ag Engineering, Texas A&M Agrilife Extension Service, 2117 TAMU, College Station, TX 77843-2117; gfipps@tamu.edu. Revised 09/13.

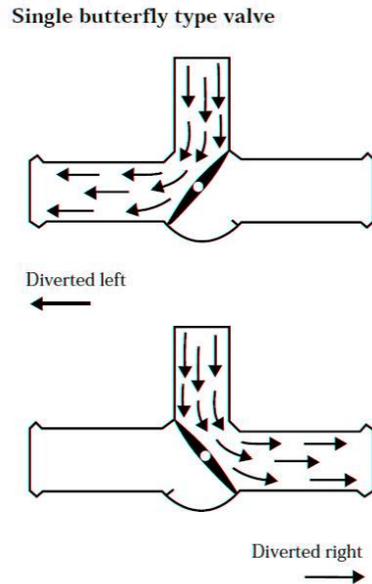


Figure 1. Surge flow valve operation.

How Does Surge Work?

Why does alternating on-off cycles of water increase furrow irrigation efficiencies? The prevailing view is that there are two factors involved: surface sealing and intake rate. Once wetted, in many soils as they dry out, a surface seal forms. Soil intake rate or infiltration rate is not constant but decreases as over time during irrigation as the soil moisture level increases. Soil roughness is also a factor, as the largest benefits of surge are seen during the first few irrigations when the soil is still rough.

Terms

Common terminology used related to surge flow is listed below. The advance phase of surge irrigation is getting the water to the end of the furrow. The fill (or soaking) phase are the cycles used to fill the root zone with the targeted amount of water.

Phases of Furrow Irrigation

Advance Phase	The phase in which the dry furrow is wetted.
Out Time	The time required for water to reach the end of the furrow.
Soaking Phase	The phase in which the required application depth is infiltrated.
Soaking Time	The time it takes the required application depth to infiltrate.
Recession Phase	The phase that starts when application of water to the furrow is stopped, and ends when water disappears from the soil's surface.
Opportunity time	The total time that water is present at each point in the furrow.

Diagram of a split-set gated pipe system used for surge flow irrigation. Flow is alternated from side to side.

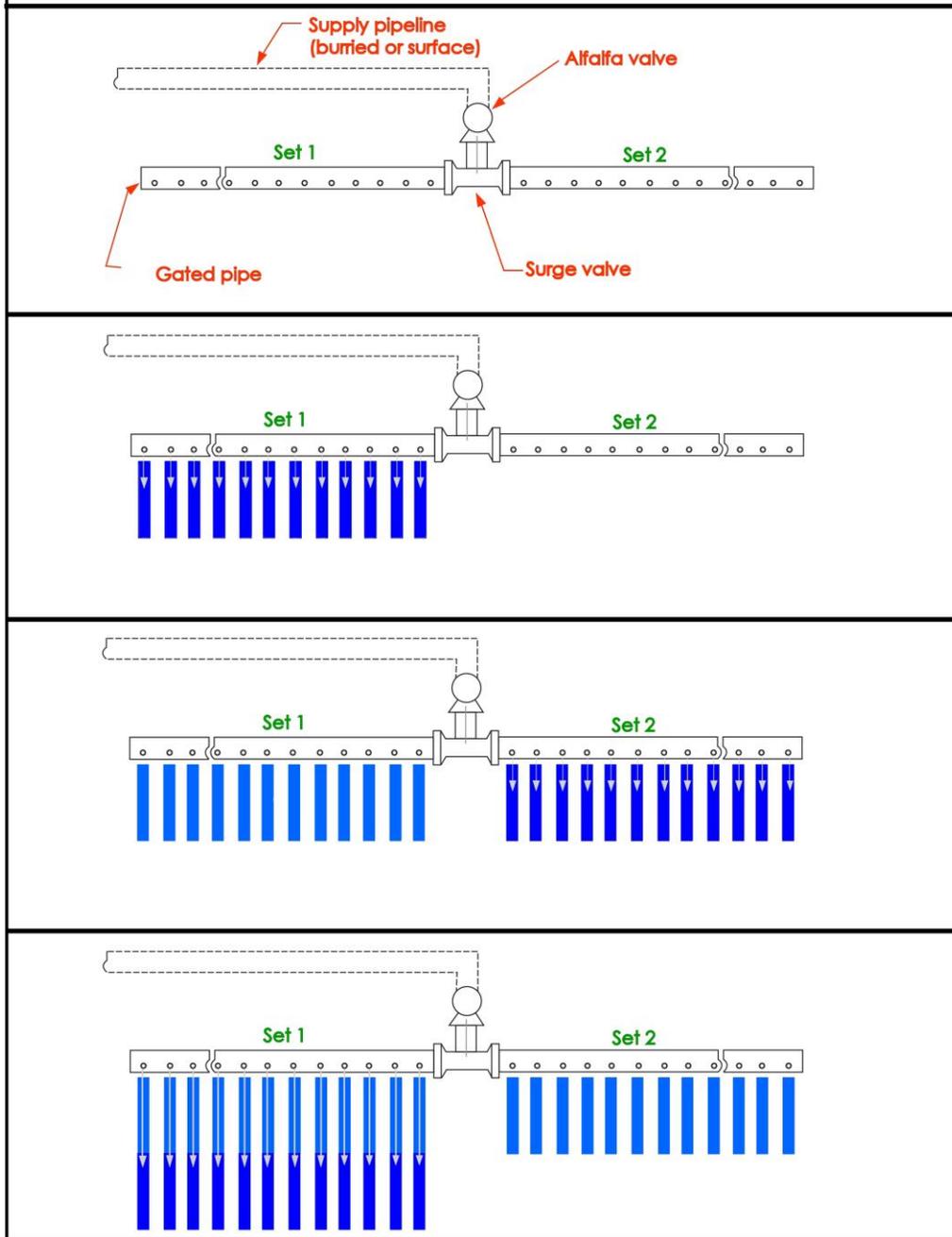


Figure 2. Typical surge flow set up.

Surge Terminology

- On-Time The time water is applied to one side of the surge valve before it is switched to the other side.
- Off-Time The time water is not applied to one side of the surge valve (usually the same as *on-time*).
- Cycle-Time The time required to complete one on/off cycle (*on-time* plus *off-time*.)
- Cycle-Ratio The ratio between the *on-time* and the *cycle time*. (A *cycle-ratio* of 0.5 is commonly used).

Equipment

The United States has two major manufacturers of automatic surge flow valves. These are actually very simple devices consisting of a programmable controller, a valve, a battery and solar cell recharging panel (see photos below).

Surge valves come in several sizes as shown in Table 1. Beware, however, that larger valves can be quite heavy. Thus, size your surge valve according to the flow that you have available.

Table 1. Surge Valve Sizes, Capacity and Weight for Two US Manufactured Surge Valves.

Valve Pipe Size	Capacity gpm	Weight lbs
4"*	300	19
6 "	625 - 700	31 - 37
8"	1100 - 1200	44 - 46
10"	1700 - 2000	50 - 54
12"	2500 - 3000	67 - 90

* only one US manufacturer makes a 4 inch valve



Figure 3. Two automatic surge flow valves manufactured in the United States.

Gated Pipe and Polypipe

Surge is used with either gated aluminum pipe or polypipe. If using polypipe, it is important that the holes be punched precisely to achieve the targeted furrow stream size (gpm per furrow). Polypipe manufacturers have on-line guides and special hole punchers that will allow you to do this. Another alternative when using polypipe are insertion gates which pop into the punch holes which can be adjusted like aluminum gated pipe.



Plastic adjustable gate used with polypipe.



Polypipe insertion gate shown with sleeve to reduce erosion at the head of the furrow.

Figure 4. Recommended insertion gates and sleeve when using polypipe for furrow irrigation.

General Guidelines

For most soil types, surge has been found to be very effective in reducing the volume of water during the first irrigation following tillage. Its effectiveness on subsequent irrigation has varied. Typically surge has improved efficiencies from 8 to 30%.

General management guidelines are as follows:

1. Advance phase should be completed in 4-6 surges.
2. The next to the last advance phase should stop just short of the end of the field.
3. Cycle times should be such that individual surges do not overlap or coalesce.
4. Furrow stream (gpm per row) should be near the maximum non-erosive value.

Programming Surge Valves

There are two basic approaches used in surge irrigation as discussed below. Automatic valves allow you to experiment with both approaches. In addition, automatic valves allow you to update the current programming based on the time or distance that the advance reaches certain points along the furrow, and will automatically calculate variable cycle times based on such factors as soil type, length of furrow and slope.

NRCS Recommendations

The USDA Natural Resources Conservation Service (NRCS) uses two basic approaches for management of surge irrigation. As with continuous furrow irrigation, they recommend use of the maximum non-erosive furrow stream size with the following two approaches:

- I. The variable-distance, constant-time method.

An on-time is selected, usually the time required for the first surge to reach about 25% of the total furrow length. This on-time is repeated until the advance is complete.

Upon completion of the advance, they recommend reducing the on-time for the post-advance surges so the wetted advance reaches 75-80% of the furrow length by cutoff, thus allowing the advance to “roll-on” to the tail. This minimizes tailwater losses during the post-advance phase.

II. The constant-distance, variable-time method.

The on-time during the advance phase is set so that the advance progresses a set distance during every surge (such as 20-25% of the total furrow length). The post-advance phase is dealt with as in (I) above.

Surge Soaking Time

Once the water has reached the end of the furrow, the soaking phase normally will require less time than the advance time. As a starting point, this soaking phase on-time is set at about 75% of the advance time.

The objective is to minimize the amount of tailwater while still allowing enough soaking to occur at the lower end of the furrow. Soaking on-times that are too long will result in excessive runoff, and on-times that are too short will result in excessive water on the upper end of the furrow while the lower end of the furrow does not receive enough.

Once the best soaking phase on-time has been achieved, the surges should continue until the desired application depth is achieved. A soil probe is useful in determining when the application depth has been reached.

Flow Requirements

As with conventional furrow irrigation, the largest furrow stream (gpm per furrow) without causing serious erosion provides the best results. Generally, the best results are obtained with a minimum of at least 15-25 gpm per furrow.

In situations where water is supplied from irrigation canals, be aware that a constant flow rate is needed. Poor results occur in situations where flow is not constant such as when water levels fluctuate in the irrigation supply canal.

The term "head of water" is not a good guide for determining how much flow you have. You should have your flow rate measured. Some irrigation districts and NRCS offices have potable propeller test meters (Fig. 5). To be successful with surge, measure don't guess you flow rate.



Figure 5. Portable flow test meter with a quick connector for easy insertion into existing pipelines or alfalfa valves.

These portable test meters can be ordered with handles, straightening veins to improve accuracy, and a pressure gauge. Usually, a smaller pipe-size than the existing pipeline is used to ensure a full pipe in the test meter.

Soils

Cycle times with surge irrigation vary, depending upon soil texture, slope and furrow length.

- Fine-textured soils respond less to surge irrigation than coarse soils which have higher intake rates.
- Surge works better on leveled fields and furrows with small slopes than on steep slopes.
- On soils with low intake rates such as heavy clays or soils with compacted layers, surge is likely to be ineffective in reducing irrigation advance times below those of continuous flow. However, surge may provide a more uniform application of water.
- Surge has shown the largest benefits in the first few irrigations following tillage. Later in the season, there tends to be less difference between surge and continuous flow when the furrows are smooth.

Will Surge Work For You?

One simple test is to run two furrows of continuous flow alongside two furrows in which flow is interrupted and reapplied. If the rate of advance is greater with the interrupted streams, surge would work on your soils.

A more effective field test would be to irrigate two blocks of land using surge and another block with continuous flow. Measure the depth of water penetration in the surge/continuous blocks with a soil probe or soil moisture sensors. If the depths of water penetration at the lower and upper sections of the furrows are more uniform with surge, then surge would work for you.