## ABSTRACT

Conventional automatic drip disposal designs typically use solenoid valves to provide dosing and flushing as two separate cycles of system operation. The drip field dosing cycle provides low flow dosing to the drip emitters at a pressure sufficient to provide constant flow throughout the field. A solenoid valve is activated on the return side of the field piping network to activate the flushing cycle. The additional velocity creates turbulent flow which is designed to scour any solid material from inside the drip tubing and manifold piping networks. This material can be wasted back to the septic or dose tank as necessary. An additional solenoid valve is often incorporated to provide flushing of the system filter which helps to extend the mean time between manual filter cleaning.

In addition to flushing functions, solenoid valves also must provide a means to drain a system protecting from freezing in cold climates. However from a hydraulic standpoint, the typical drip system solenoid valve only provides a limited ability to fully open and fully close under low pressure conditions. Therefore the need to rapidly drain the entire field and manifold networks can not be met with the conventional system design. Furthermore solenoid valves have proven to be mechanically unreliable in the effluent application.

As a solution both flushing and dosing cycles were combined into one phase using a fixed orifice to split and balance flows thereby eliminating the problematic solenoid valves altogether. This design allows rapid, unimpeded system drain-back paramount to reliable cold weather operation. An additional fixed orifice was added to provide constant flushing of the system filter thereby allowing the system to a) dose the drip field, b) flush the drip lines, and c) flush the filter simultaneously. Of over twenty systems monitored which were originally implemented soon after regulatory approval in Idaho and Eastern Washington, none to date has had a single freeze related problem.

## INTRODUCTION

During the first decade of the 21st century, the advantages of drip wastewater disposal became more apparent to the design and regulatory communities of Idaho and Washington. Regulations evolved, and drip was commonly accepted as a viable wastewater disposal method. Advantages of drip were apparent as illustrated in numerous studies available at the time. The majority of these studies had been conducted in southern states where freezing was of no concern. Prior drip system implementation identified the following points as functional design limitations to the conventional drip design:

1. Conventional solenoid valve low pressure operation limitations inhibit rapid drain-back of the complete drip field system after dosing operation. Testing has shown that it’s nearly impossible to drain the valves below approximately 1.5 feet of backpressure. Therefore any part of the system behind the valve and 1.5 feet higher remains full of water and susceptible

to freezing. While drain-back would be less of a concern in warmer climates, the moderately cold winters of Idaho and E. Washington necessitate rapid drain-back to maintain field functionality.

2. Like all electromechanical devices, solenoid valves eventually fail. Over time, the failure of a solenoid valve in a wastewater drip disposal system could go undetected and dramatically impact long term field functionality.
3. The drip system headworks have typically been placed in an additional valve vault, which can make drain-back between the headworks and the dose tank difficult. The additional vault and fill soil around the dose tank installation is prone to settling which increases the likelihood of broken piping between vessels. The vault itself is typically set shallow further increasing a freeze risk in that portion of the system.
4. Drip dosing pump systems must be designed with two (2) operating points in mind. One for field dosing, which is often a higher pressure, low flow condition, and one for field flushing, which is a low pressure, high flow condition. These two conditions contradict conventional pump sizing and industry "best efficiency point" mentality. Out of necessity, neither of the two points fall within the best efficiency range of a pump capable of both and therefore, engineers often face a design dilemma that severely limits the normal operating life of drip system pumps.
5. Drip pump and electric solenoid operation require a complex network of control equipment and programming to accurately dose and flush the drip network. These systems are not only unreliable, but matching design intentions and field setup can be problematic even with start-up and inspection safeguards in place.

## EVALUATION AND PROBLEM SOLVING

We first examined any and all drip research we discovered through Internet searches and manufacturer referrals. Many articles were available that related to drip effectiveness in warm climates, but few studies focused on the effects of freezing soils and drip system components in cold climates as well as Scott D. Wallace's paper, *Design and Performance of Drip Systems in Freezing Environments*. Wallace studied four systems during the cold Minnesota winter months of 2000 and 2001. He found that all systems operated successfully, despite freezing soil at the drip emitters. Wallace cited the proper use of insulation and drain back strategies as the primary contributor to the success of these systems. We examined and implemented the key design concepts outlined in the Wallace paper as a starting point for the drip designs constructed in Idaho and E. Washington. These key designs elements are as follows:

1. Elimination of a separate headworks system was considered. As outlined in the Wallace paper, we moved the headworks components to inside the dose tank. This improvement eliminated the need for an additional valve box and also solved all of the drain back fall issues between the head works vault and the dose tank. Without the external head works, the

supply and return manifolds were designed to drain straight back to the dose tank which improved drain back of the field and manifold piping.

2. The complex and problematic solenoid valves used to flush the drip field and system filter system must be eliminated. As outlined in the Wallace paper, these valves can be eliminated with a constant flushing/dosing scheme. By eliminating the solenoid valves and replacing them with a constant flow return orifice, the following advantages became apparent:
    a. Solenoid valves do not fully open or close under low pressure. We accurately predicted that these valves would not fully drain near the end of the drain back cycle. These valves tended to drain back very slowly and sometimes not at all when subjected to lower pressures. With residual water trapped in the drip manifold system, we feared freezing problems would result.
    b. In an irrigation application, a solenoid valve failure often results in an improperly watered zone which can be easily identified and repaired. However due to the lack of maintenance requirements on drip disposal systems, a failed solenoid valve could go undetected and ultimately lead to the complete and costly failure of the disposal network.
    c. Combining the drip system operation phases eliminated the multiple pump operating point issues, and therefore the problems with poor performance and early pump failure. With one target flow and head condition, high head pumping units easily met our hydraulic requirements. We selected high head pump designs because of their steep pumping curves, high number of rated daily starts, and extraordinarily proven reliability. The use of high head pumps can sacrifice tank volume due to their minimum liquid level requirements, but this loss of tank capacity was not substantial vs. low head pumping units.
    d. Additional electrical wiring and panel complexity are required with solenoid valve systems. Without the additional electrical and control requirements, wiring from the drip panel to the head works can be eliminated, and the standard timed dose panel can be used.
    e. With the solenoid valves eliminated, we found locating the remaining headworks components in the dose tank riser a much easier design problem to solve.
3. Some continuous flushing systems use a ¼ turn ball valve for flow and pressure equalization of both the return and filter flush flows. We found the disadvantages of ball valves in this application to be numerous and include:
    a. Improper valve setting during startup
    b. Valve drifting over time
    c. Valve erosion over time
    d. Hydraulic modeling can be difficult to predict with variable adjustment. Actual conditions may not reflect design intention.
    e. Valves can be tampered with by homeowner or others.

Any of these events can lead to catastrophic system failure. R. C. Worst & Co., Inc. engineered and currently holds a patent on the continuous flush, fixed orifice drip system. Both return and filter flush flow regulation is accomplished by hydraulically modeling the complete drip network with proprietary software. Selecting the appropriate orifice for each flushing function is simply a matter of picking orifices that meet the design needs of each system. The pre-manufactured headworks is designed and assembled for each job specifically with the correct orifices installed at the factory.

4. Flat, shallow sloped sites often require excessively deep headworks to maintain drainage to the tank. This depth makes servicing difficult. R. C. Worst & Co., Inc. designed a cartridge headworks that simply lifts out of the tank riser for servicing.

Based on our experience with both conventional and fixed orifice continuous flush drip systems, we strongly feel the fixed orifice system provides numerous advantages to the conventional system in freezing and nonfreezing conditions.

**DEBUNKING A FEW CONTINIOUS FLUSH DRIP MYTHS**

Some conventional drip system proponents have formulated a few loose and unfounded arguments for using conventional drip vs. the continuous flushing drip strategy as outlined above. Some of these claims have been made directly by drip manufacturers. We suspect they have been made to protect market share diminished by the continuous flush systems. These arguments are presented and discussed below:

1. **"The only advantage of continuous flush is that it is cheap."** As we have outlined above, continuous flush drip systems maintain many advantages over the conventional head works drip systems, and they are vital in cold conditions. We are not convinced that "cheap" is one of them, but if that were so, would less expensive be so bad? We think not.
2. **"It carries with it risks and operating costs that outweigh the lower initial cost."** Because they tend to be more complex, the conventional system would also be more costly to operate. In the event of a conventional drip solenoid valve failure, the cost could be catastrophic.
3. **"The "flush" volume is so large that without using a settling basin ahead of the pump tank, the solids in the bottom of the tank will be stirred up and go round and round increasing in concentration at each cycle."** As outlined in the Idaho and Washington rules, all dosing and flushing flows must be filtered to 100 micron before entering the drip disposal network. Furthermore, the effluent that enters the dose tank from the septic tank, or secondary treatment system, must be filtered to 1/16". This precaution is incorporated to reduce or eliminate solid material that may enter the dosing system. We therefore contend that very little solid material enters the drip dose tank. In the remote likelihood this becomes a problem, we recommend diffusing and redirecting the return water

horizontally inside the tank "clear zone," which would help to maintain a settled solid layer in the bottom of the dose tank. In systems with the required field filters, the "solids issue" would ultimately create plugging in the field filter mechanism. Excessive solids would accumulate in the filter unit requiring frequent maintenance. This issue would not cause plugging problems in the field itself because of the presence of the field filter. Once again, most continuous field flush systems have continuous flush filtration as well. In five years of drip system operation and maintenance, our staff has not witnessed a single plugged field filter. More importantly, the field filters seem to be thoroughly cleaned by constant and frequent flushing during the dosing cycle.

4. **"…the solids in the pump tank will build up rapidly and will need to be pumped out more frequently than in a more conventional system."** We should all agree that this would be a nonissue with a properly functioning aerobically pretreated system due to the low suspended solids discharge typical of these units. With the presence of prescreening on the septic tank effluent systems, the accumulation of solids would be minimal and the dose tank pump-out frequencies would be much longer than that of the septic system itself. Sludge measurements inside the drip tanks in Idaho and E. Washington have confirmed this assertion.
5. **"Pumping about twice the volume of water requires more energy**." Theoretically true, but the actual fluctuation of amperage between the left and right hand side of the operating curve is nominal. Furthermore, we have found our pump size on the typical residential system has increased from a ½ HP to a ¾ HP unit. Without factoring in additional flushing cycles required of the conventional system, a typical drip pump would operate about 5 minutes per dose with a total of 12 doses per day maximum, which is about 1 hour of total run time per day. At an average local rate of $0.08 per KW/hr, the ½ HP would cost $1.62 per month vs. $2.25 per month for the continuous flush design. A difference of 63 cents per month overall. We feel that is a small price to pay for a simple, reliable, system.

**CONCLUSIONS**

A properly designed fixed orifice continuous flushing drip design is far superior to the conventional solenoid actuated drip system on nearly all points, and the only option in freezing soil conditions.