Design, Use and Installation of Dosing Siphons for On-site Wastewater Treatment Systems
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Introduction

Automatic dosing siphons are nothing new. They’ve been used for 100 years or more to flush livestock yards, in sewage treatment plants to dose trickling filters, and to dose recirculating sand filters. What is new is that as increases in suburban and rural populations have spurred development of innovative and alternative wastewater management methods, dosing siphons have become commonplace in single family and small community systems where they are used to dose gravity and pressurized drainfields as well as sand filters.

Dosing siphons are useful devices for dosing fixed, finite volumes of liquid at flow rates ranging from a few gallons per minute to several hundred gallons per minute. In on-site wastewater systems, siphons are especially useful in converting small, continuous flows into large intermittent dosing flows. Modern siphons are made of corrosion resistant materials, have no moving parts, require no power source, are easy to install, and require very little maintenance. They are a cost-effective alternative to pumps in many situations, especially in remote areas and other sites where electricity is difficult to obtain.

One criterion must be met in any siphon system: the area to be dosed must be downhill from the dosing tank. A siphon will discharge only to a lower elevation.

Basic Siphon Operation

Nomenclature
An automatic dosing siphon has two main components—the bell and the trap (Figure 1). The bell includes the bell housing itself, a vertical inlet pipe, an intrusion pipe, and a sniffer pipe. The trap includes a long leg, a short leg, and a discharge fitting with an air vent. Depending on the siphon drawdown, the trap may be outfitted with an external trigger trap. The bell and trap are connected with threaded fittings.
Single Siphon Operation
Following installation in a tank, a siphon must have its trap(s) filled with water. When fluid rises above the open end of the snifter pipe, air is sealed in the bell and long leg of the siphon. As the fluid in the tank rises further, the pressure on the confined air increases and forces water out of the long leg of the trap. Once the pressure is great enough to force all the water out of the long leg, the trapped air escapes through the short leg to the air release vent pipe. At this point, the siphon has been “tripped” and fluid is discharged from the siphon until the liquid level in tank drops to the bottom of the bell. Air is then drawn under the bell which “breaks” the siphoning action and the process begins again. Figure 2 shows one complete cycle of a single siphon. At the end of a dosing cycle, incoming flow may seal off the bottom of the bell before the bell is fully recharged with air. The snifter pipe, with its open end an inch or more above the bottom of the bell, allows a full recharge of air beneath the bell at the end of each cycle. Because the end of the snifter pipe is the elevation at which air becomes trapped under the bell, shortening or lengthening the snifter pipe is an effective way to increase or decrease the “on” or “trip”
level of the siphon. There are limits, however, to the amount of adjustment allowable. Installers should consult the siphon manufacturer before altering the length of the snifter pipe.

2a. Trap must be primed (filled with water) prior to raising liquid level above bottom of snifter pipe.

2b. Water is discharge from long leg as water level rises above snifter pipe.

2c. Just before triggering, water level in long leg is near bottom of trap.

2d. Siphon is triggered when air is vented through vent pipe.

2e. Siphon continues to dose until water level drips to bottom of bell.

2f. Air under bell “breaks” the siphon. Sniffer pipe ensures full recharge of air under bell.

Figure 2
Some siphons require an additional mechanism called a trigger trap to exhaust all of the air from under the bell at the beginning of the cycle. Whether or not a siphon requires a trigger trap depends on several variables: bell diameter, bell height, trap diameter, and the height over the bell at which the siphon activates. For a given bell configuration, it is determined mathematically and experimentally whether a trigger trap is necessary. The trigger trap actually starts the siphon cycle. Siphons needing trigger traps typically have relatively short drawdowns as compared to the siphon diameter and thus have lower available driving head to exhaust air. Without a trigger trap, the full volume of trapped air fails to exhaust and the siphon goes into what is called a drooling, or trickling mode. In this mode—with some air still trapped under the bell—the water level has risen inside the bell above the intake of the inlet pipe and liquid is exiting the siphon at a fraction of the full siphon discharge rate. Absent a true siphoning effect, the water level in the tank will not drop below the level of the inlet pipe’s intake. Since this intake is above the bottom of the snifter pipe, the siphon cannot be recharged with air and will continue to operate indefinitely in a trickling mode.

It is possible to force a siphon that should have a trigger trap (but doesn’t) into seemingly working properly by filling the tank very quickly. This rapid filling provides extra driving head to force all the air out of the bell. However, most tanks with an installed siphon fill much slower than this rapid rate. A recent study has shown poorly designed siphons (needing trigger traps) to be a primary cause of failures in the field. Coincidentally, the same circumstance—filling the tank too rapidly at the end of a dosing cycle—can also cause a properly designed siphon to go into a trickling mode. In this case, water is entering the tank so fast that the snifter pipe is sealed before the bell is fully recharged with air.

**Alternating Siphons**

Two identical siphons, installed in a single chamber at the same elevation (Figure 3), will alternate automatically. Because of slight variations in dimension and/or slight variations in the elevation of the two bells, one of the two siphons will trigger first. The siphon that triggered first will end the first dosing cycle with its trap full. The siphon that didn’t trigger will have lost much of the water in its trap at the end of the first dosing cycle. When the tank fills up a second time, the second siphon will trip first since its trap is only partially full and requires less pressure to trip. The third time the tank fills up, the first siphon, with its trap only partially full, will trip first. This alternating process will repeat itself indefinitely. In Figure 3, the on level of the first cycle will be a distance H’ above the bell. All subsequent cycles will operate at height H, since all cycles after the first are triggered from a partially full trap. For most siphons, H is approximately one inch lower than H’.

**Multiple Sequencing Siphons**

Near the turn of the century, several methods were designed to alternate three, four, or more siphons to dose sewage. These include various types of sequencing starting bells and other mechanical devices. Now, electrical or air operated solenoid valves are also used. However, troubleshooting and maintenance of multiple sequencing siphon systems can be difficult. There are simpler, more reliable ways to design systems that avoid multiple sequencing siphons. These include flow splitting devices prior to any number of single or alternating dosing siphons.
3a. Alternating siphons with traps primed prior to first cycle.

3b. Water is discharged out of the long leg of both siphons as the water level rises in the tank above the snifter pipe.

3c. Because of slight variations in the two siphons, siphon B in this example triggers before the other.

3d. End of first cycle-siphon that didn’t trigger (A) has partially full trap.

3e. Siphon A, needing less pressure on its partially full trap, triggers the second cycle.

3f. End of second cycle-siphon B now has partially full trap and will trigger next.

Figure 3
Siphon Sizes

The size of a siphon refers to the diameter of its trap. Siphons are most commonly available in diameters from two inches to eight inches. Common drawdowns may range from four to 48 inches. Most manufacturers use three digit model numbers. The first digit refers to the siphon’s diameter and the last two digits indicate the drawdown. A model 324, for example, designates a three inch diameter siphon with a 24 inch drawdown. Custom siphons can be built with virtually any diameter and drawdown.

Siphon discharge flow rates are normally given in gallons per minute (gpm) in one or all of the following forms: maximum flow rate, minimum flow rate, and average flow rate. These flow rates are measured at open discharge and thus do not include transport pipe friction losses or head losses due to trapped air. As discussed later, pressurized systems are usually designed using a flow rate somewhat below the average flow rate of the siphon.

Installation Configurations

Siphons can be installed in virtually any type of tank, basin, or reservoir that holds a fluid. In wastewater systems, siphons are installed most often in concrete or fiberglass dosing septic tanks ranging in size from 500 to several thousand gallons. They also may be installed in smaller basins ranging in size from about 50 gallons to a few hundred gallons. Basins are commonly constructed of concrete, fiberglass, PVC, or polyethylene.

For small flow rate systems (30 gpm or less), the most cost-effective installation is a two inch siphon mounted in a screened vault which is placed directly in a single compartment septic tank (Figure 4), so that a second dosing tank or chamber is not required. Two inch vault-mounted siphons may also be installed in compartmented septic tanks or separate dosing tanks. This type of siphon suspends from the top of the tank and is easily removed for cleaning and maintenance of both the siphon and the tank.

Figure 4: Single Compartment Dosing Tank
Systems that are designed for flow rates greater than 30 gpm require a three inch or larger siphon installed in a compartmented septic tank or separate dosing tank (Figures 5 & 6). Three inch and larger siphons are located in the tank with the bottom of the trap positioned in one of three places: above the bottom, on the bottom, or through the bottom of the tank (Figures 6, 7, & 8). Placement depends on the dimensions of the tank and siphon and the desired trip level. The two most common methods of installation are bolt-in-place and cast-in-place. If the trap of the siphon does not need to extend beneath the bottom of the tank, either method may be used. A fiberglass bolt-in bracket is simplest, quickest, and most cost effective in this situation (Figures 5 & 6). If the trap of the siphon needs to extend below the bottom of the tank (Figure 7), the cast-in method must be used. Installations through the tank floor are more difficult and time consuming than other methods.

**Filtering**
Regardless of the type of siphon or method of installation, filtering the effluent before it reaches the siphon is required. A filter helps protect the performance of the siphon, the distribution network, and the disposal area. A key benefit of filtering is keeping the siphon’s sniffer pipe clear. If blockage, even momentary, of the sniffer pipe occurs during the end of the discharge cycle, the siphon may cease to operate and fail in a trickling mode. Momentary blockage may be caused by floating debris that subsequently floats away or disintegrates, with the result that the siphon ceases to function for no apparent reason. Three methods of filtering are used: a screened vault (two inch siphons only), an outlet filter installed in a tank or chamber prior to the siphon chamber (Figure 5), or a screen that surrounds the siphon itself (Figure 6). For siphons three inch and larger, the preferred method of filtering is the outlet filter.

![Figure 5: Bolt-In method of installation in a single compartment dosing tank](image)
Siphon Applications

In on-site treatment systems, siphons commonly discharge to gravity or pressurized drainfields. Distribution to gravity drainfields is done most effectively by directing the siphon discharge to a Hydrosplitter. Pressurized by the siphon, a Hydrosplitter distributes flow evenly to each individual trench. Flow can be split unevenly (with the use of flow control orifices in the Hydrosplitter) to
accommodate differing trench lengths. A siphon can also discharge into common drop and distribution boxes. The flow rate of the siphon is usually not as critical when discharging to a gravity box as it is when discharging to a

![Figure 8: Cast-In method of installation (above tank floor)](image)

Hydrosplitter. On a system using a Hydrosplitter, the flow rate of the siphon must be matched with the flow control orifices so that when the siphon discharges, the transport line will backfill to a height to provide pressure at the Hydrosplitter.

Sizing siphons for pressurized drainfields is similar to sizing those with Hydrosplitters in that the discharge rate of the siphon must be large enough to cause the transport line to backfill. The pressure at the orifices (squirt height) is created by the vertical elevation (static head) of the backfilled portion of the transport line as shown in Figure 9.

![Figure 9: Squirt height relationship to transport line](image)
Siphons are regularly used in septic tanks to dose intermittent sand filters. A two inch siphon may also be installed in a sand filter collection basin. If siphons are used for both functions, a complete sand filter system with pressure dosed drainfield can be installed with no power required. Of course, this is limited to a fairly well sloped site since there must be fall from the septic tank to the top of the sand filter and from the bottom of the sand filter to the disposal field.

A siphon may be discharged to a flow splitter basin to divide large flows. Similar to Hydrosplitters, flow splitter basins are adapted to higher flow rates and are more versatile for field adjustments and maintenance. A siphon discharging to a flow splitter basin that feeds several tanks with alternating dosing siphons is a method that can be used to avoid multiple sequencing siphons for large disposal fields.

Effluent pumps may be used effectively in conjunction with dosing siphons. For example, a disposal field requires a high flow rate to pressurize it, but it’s at a higher elevation than the dose tank. Instead of a large horsepower pump in the dose chamber, a small, easy to maintain effluent pump might be used to transport effluent to a second higher-elevation dosing tank containing a high flow-rate siphon. Pump/siphon combinations are also useful for disposal fields that are far from the collection point. A small effluent pump can be used to pump the effluent in a small diameter PVC line to a tank with a dosing siphon. This eliminates the need for large diameter transport lines capable of handling the dosing flow rate.

**Siphon System Design**

To gravity drainfields (without Hydrosplitters), the flow rate is usually not critical. Therefore, the following discussion refers mainly to pressurized systems. The details involved in achieving ideal transport line conditions, however, are applicable for all siphon and pump systems. Accurate information on the topography of the site is essential for laying out a siphon system. The transport line length and profile are critical in determining how or if the system will operate. It is important to allow open channel flow along the length of the transport line so that the air that is displaced can vent to an air vent located at the start of the transport line. If open channel flow cannot be maintained, additional air venting will be necessary. Manning’s equation can be used to determine if the slope is steep enough to maintain open channel flow. The designer must, however, be aware of the limitations of theoretical calculations.

The ideal transport line is one pipe diameter size larger than the siphon and is as short as possible with a constant slope from the outlet of the siphon to the disposal field (Figure 10). Unfortunately, many sites fall short of ideal. Long transport lines with changes in slope are often unavoidable. Nevertheless, steps can be taken to head off potential problems. The most common problem in transport lines is air binding caused by significant changes in slope (Figure 11). In the example shown in Figure 11, the problem is that the initial slope out of the siphon is less than the friction head loss of the pipe flowing full. Thus, the pipe may be flowing full at the change to a steeper slope and the air in the lower portion of transport line cannot exit the air vent near the tank.
Additionally, the flow just out of the siphon is unsteady and turbulent, which could cause additional air binding problems. An air release device positioned just below the change in slope normally will remove air accumulations. The single easiest way to avoid air binding problems is to use a transport line one size larger than the siphon itself. Note: for large siphons same size may be ok. Even on a very steep slope, using a transport line the same diameter as the siphon is not advisable, since turbulent, unsteady flow may be encountered. Air binding also occurs when a transport line has a “belly”, i.e., a section of pipe that is always full of liquid. Some type of venting is necessary following a “belly.” In a transport line where a long section of the bottom of the transport line is flat, a belly may be inevitable. To avoid having to fill this section of pipe each cycle, the system designer may purposely make this section of pipe lower than the discharge point. However, this situation should be avoided whenever possible.

The first step in specifying a siphon for a pressurized system is to verify that the elevation difference, or fall, is adequate to provide the desired pressure at the disposal location. Second, the flow rate required by the distribution network or splitter is determined. In general, the siphon selected should have an average discharge rate higher than the flow rate necessary to pressurize the system. Next, the transport line size is selected, generally one pipe size larger than the siphon size. Depending on the length and slope of the transport line, siphons of six inch diameter and larger may not need a larger transport line size. Again, Manning’s equation may be used to help in this determination. The transport line volume and any distribution network volume that is necessary to provide the desired pressure is then calculated. This piping volume is important in determining the dose volume needed to achieve the desired system pressurization. It is possible, using calculus, to roughly approximate the minimum dose volume required to reach the system design pressure. Using generalizations or “rules of thumb” for the required
dose volume is not good practice. Calculations should be performed for each system. A method for performing these calculations is presented in a separate paper. Finally, using the dose volume and the dimensions of the siphon chamber, the drawdown depth is calculated.

**Venting**
There are three common methods of venting siphon systems. An open standpipe is the most frequently used. Air release valves—with carbon filters for odor control—can be installed on transport lines where an open standpipe is not acceptable. A transport line that has trapped air may also be vented back to itself at a higher position. Most siphons are manufactured with an integral air vent, for venting the air trapped beneath the bell. A vent should always be installed just outside the siphon chamber, usually where the pipe size is increased.

When a system is installed, the transport line should not be buried until proper operation has been verified. Access to the pipe is essential if additional venting becomes necessary. If low flow rates suggest that air entrapment is occurring, a portable drill with a 1/8th inch bit is useful for finding the locations of the air pockets. If a hole is drilled and air is not released, the hole is easily plugged with a stainless steel tapping screw.

**Monitoring Devices**
Monitoring of a single siphon is usually done with a float switch connected to a battery operated digital counter. The float, installed in the dosing chamber, is positioned to activate near the on level of the siphon. If the siphon fails to cycle (trickles), the liquid level in the tank will not reach the on position and no cycles will be recorded. Alternating siphons can be monitored using the same counter described above, with the addition of another counter in one of the drainfields. The float for the drainfield counter is contained in a small canister that is connected to a drainfield lateral. When the drainfield is dosed, the canister fills with liquid, raising the float and activating the counter. In a properly operating alternating system, the dose counter in the tank records twice as many doses as the counter at the drainfield. Siphon monitors are a quick, easy method of checking siphon performance and are recommended for all siphon systems. High water alarms are not useful since siphon failure does not result in a high water condition.

**Maintenance**
Maintenance of siphons is limited mainly to checking for proper operation. Dose counters are recommended on all siphons for this purpose. Counters should be checked monthly and a written record kept. Siphons that lapse into a trickling mode can usually be put back into operation by blowing air under the bell or by lowering the liquid level in the tank below the bottom of the bell. Two inch vault-mounted siphons need only be lifted enough to expose the bottom of the bell. Note that as the siphon chamber is filling, liquid is forced out of the siphon trap into the discharge pipe. This flow should not be confused with trickling mode.

If filters or screens are installed, they should be inspected periodically and cleaned as necessary.