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**Evaluation of Siphon Performance For On-site
Systems**

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EVALUATION OF SIPHON PERFORMANCE FOR ON-SITE SYSTEMS

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Siphons have an advantage over pumps because of their design simplicity, but are limited to sites where the effluent is moved downhill. In the past, the majority of siphons were frequently installed where a relatively large volume of septic tank effluent (STE) was to be discharged into soil absorption beds containing large diameter perforated pipe. Today, with the advent of mounds and in-ground pressure distribution networks commonly used in trenches and beds for both residential and commercial sites, siphons are being used to pressurize the distribution system.

Siphon Theory

A cross section of a typical dose tank containing a siphon is shown in Figure 1. The bell traps the air, and the auxiliary vent aids in supplying air to the bell after each siphon. The vent pipe vents the siphon and

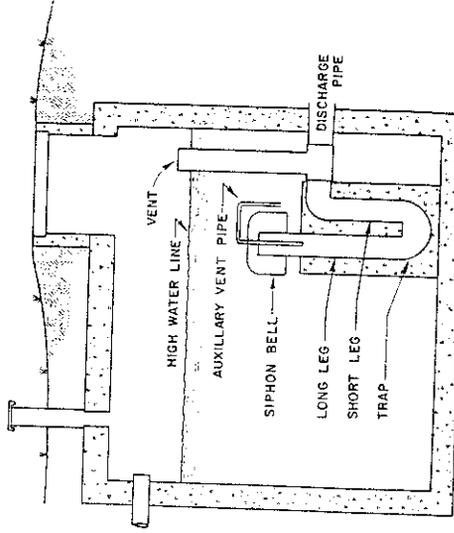


Figure 1. Typical siphon tank installation for dosing septic tank effluent into soil absorption systems. Note location of siphon and vent pipe in relation to tank opening, especially vent pipe.

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provides overflow protection in case the siphon should plug or malfunction. As the effluent in the tank rises, the air under the bell is compressed and forces the effluent out the long leg into the short leg, resulting in the loss of effluent out the discharge pipe (Figure 2a). When the liquid level reaches the bottom of the trap, further addition of effluent into the dosing tank forces air into the short leg. This creates an imbalance which results in a sudden escape of the air, allowing the effluent in the tank to enter the trap, activating the siphon. The siphon action continues until the liquid level reaches the bottom of the bell, at which time the siphon is broken. As effluent enters the dose tank, it seals the auxiliary vent, thus trapping air under the bell for another cycle.

If two siphons of the same size are placed in a tank, they will automatically alternate. Even though both siphons are installed correctly, one will discharge before the other because of slight variations in their construction and installation. Initially the traps of both siphons are filled with water (Figure 2). As the water level in the tank increases, the air beneath the bells forces the liquid from the traps. When the air reaches the bottom of the trap, a slight liquid level increase in the tank causes one of the siphons to operate (Siphon A in Figure 2). When the siphon is broken, the trap of the first siphon is refilled, but the trap of the second siphon has been partially emptied (Siphon B in Figure 2). During the next cycle, the second siphon will discharge because there is less water in its trap.

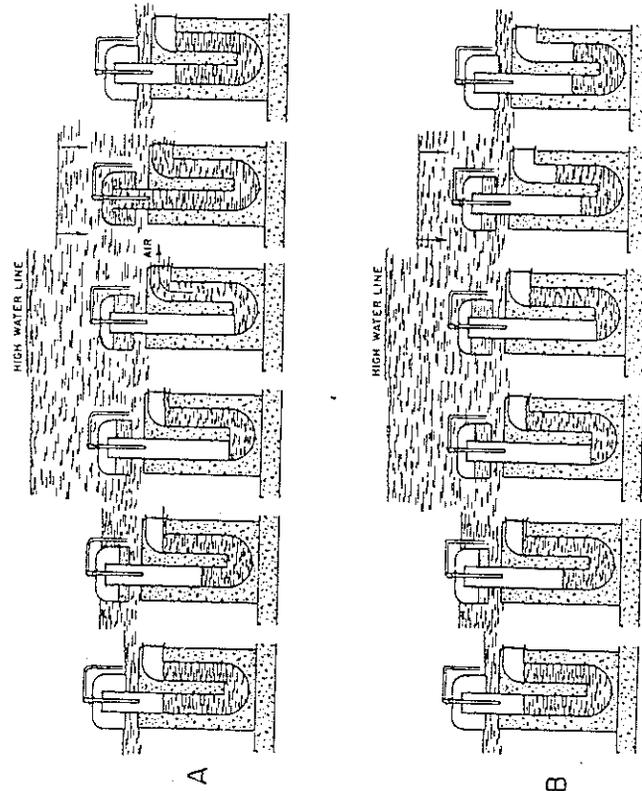


Figure 2. Schematic of siphon showing effluent location in trap in relation to liquid level in tank (top portion). Sequence of events (both A&B when two siphons are located in the same tank where System A activated first).

Because of their simplicity, many users assume that siphons are maintenance-free. However, experience has shown that siphons do not always function properly. On occasion, siphons are found to be "trickling." This phenomenon occurs when only a portion of the trapped air escapes from under the bell, allowing the liquid to rise under the bell to the point it is able to spill over the lip of the trap. Once trickling begins, the siphon may never reactivate without maintenance.

Trickling is a common problem. Cousin (1973) surveyed some septic tank systems in Canada which used siphons and found 75 to 80% of the siphons to be trickling. Reports from homeowners and installers in Wisconsin also suggested that problems were frequent. Therefore, this study was undertaken to: 1) determine the frequency of siphon dysfunction, and 2) to delineate corrective action where possible.

Procedure

The study included field and laboratory investigations. The field study consisted of evaluating the siphon performance of operating on-site systems. In the laboratory, attempts were made to simulate siphon malfunctions to determine their probable causes.

Field Study: The initial phase of the field study consisted of inspecting 10 systems over a period of 14 months to determine the nature and frequency of malfunctions. Periodic visits were made to each site. On the first visit, the system was characterized by measuring the high and low water level elevations, distribution lateral elevations and system dimensions. Water was added to the siphon tank until the liquid level was up to or above the high water line. If the siphon did not activate or began to trickle, air was blown beneath the bell through a J-shaped tube. On each subsequent visit, visual observation and liquid level measurements were made for comparison with previous measurements to determine if the siphon was cycling. If accessible, observations into the vent pipe were made to see if trickling was occurring. On occasion, a stage level recorder was placed in the tank to monitor performance. When a system was found to be trickling at the time of inspection, air was blown beneath the bell to recharge it.

In the second phase of the field study, 32 systems were inspected on a weekly basis for three weeks to obtain a broader picture of the scope of the problem. Upon arriving at the site, the liquid level in the siphon tank was measured from a reference point; 30 to 40 liters of water were added to the siphon tank; the liquid level was measured just after adding the water and again ten to fifteen minutes later. If the last two measurements were the same, the siphon was judged not to be trickling. If it was trickling, it was recharged by blowing air beneath the bell. Also, when possible, observations down the vent pipe were made to determine if water was trickling from the siphon.

Laboratory Study: In an attempt to simulate siphon malfunction, a 7.5 cm diameter siphon was mounted in a 61 cm by 61 cm tank with a clear plexiglass side. The conditions studied in the lab were: 1) simulating rapid and very slow STE flows into siphon chamber using tap water, 2) restricting the discharge rate of the siphon, and 3) deoxygenating the tap water and letting the system set for several days to simulate non-use periods within the home.

Results and Discussion

Field Study 1: Table 1 gives the characteristics and results of the initial field study. There were seven 7.5 cm diameter and three 10 cm diameter siphons inspected. All of them were installed in a 1,900 liter

tank, with a length of 1.8 m and width of 0.9 m. The number of people in each residence served ranged from one to five people. The elevation difference between the siphon and soil absorption field ranged from 1.0 to 6 meters, while the distance between the siphon and the soil absorption system ranged from 18 to 100 meters. All of the siphons dosed into pressure distribution networks consisting of small diameter PVC pipe and small diameter holes.

During the initial visit to the sites, seven out of the 10 siphons were malfunctioning. Only at Sites 1 and 7 have the siphons operated satisfactorily throughout the study period. At Site 2 the siphon had a history of malfunctioning. At the time of the first visit, it was found to be trickling. The siphon was charged with air and a stage level recorder placed on it. For the next five weeks it appeared to work satisfactorily until it returned to trickling. It was recharged again and continued to work for the duration of the study.

At Site 3, effluent was observed flowing over the vent pipe. By measurement it was determined that the top of the pipe was just below the high water level for the siphon. After the vent was extended five weeks later, the siphon worked without malfunctioning for the remainder of the study.

The siphon at Site 4 was trickling at the time of the first visit. After adding water and recharging, an air leak at the joint of the auxiliary vent and bell was observed. A week later it was repaired and never malfunctioned again. The siphon at Site 5 never performed satisfactorily for any length of time. Stage level recorder readings showed that it would function properly for several cycles, but then begin to trickle. Later, without any assistance it would begin to cycle properly again.

The 10 cm diameter siphon at Site 6 had a history of problems. About three months prior to the study, the vent pipe had been extended and the auxiliary vent had been shortened slightly. On the initial visit, effluent was observed flowing over the top of the vent pipe even though it was approximately 2-3 cm above the design high water level. It was recharged and appeared to work properly for a week. The vent pipe was extended further, but the system continued to malfunction.

At Site 8, which was added to the study later, the siphon worked properly for two months before it started to trickle. It was recharged and a stage level recorder showed that it would start to trickle and then start siphoning again properly without assistance, similar to Site 5. At Site 9, the siphon trickled for seven weeks before it was recharged. After recharging, it worked properly for the duration of the study.

At Site 10, the 10 cm diameter siphon functioned improperly since it was installed in September 1982. During installation it was tested and appeared to be working properly. However, 18 months later it was discovered that the effluent was flowing over the vent pipe. The siphon was activated by blowing air beneath the bell. It discharged about 10 cm of water from the tank before stopping above the low water level. Further evaluation suggested that most of the holes in the distribution network were plugged. The effluent slowly seeped away and the siphon continued to trickle. In June 1984, an attempt was made to unplug the holes and an extension was put on the vent pipe. Water was added to the tank twice and in both cases, the siphon appeared to be working properly. Examination of the stage level recorder a week later showed that the siphon started to trickle almost immediately. When activated again, flow rate was very slow, indicating holes were still plugged. In September, another attempt was made to unplug the holes in the distribution system. Also, the top of the tank was removed, and the siphon was taken apart, inspected and reassembled.

Table 1. Siphon Characteristics and Performance for Phase I of the Field Study

System No. of People	System ^a		System ^b		System ^c	
	Age (yr)	Size (cm)	Age (yr)	Size (cm)	Age (yr)	Size (cm)
1	23	10	1.2	90	Wd	W
2	5	22	7.5	1.0	20	W
3	2	2	7.5	2.0	30	W
4	2	9	7.5	1.2	18	W
5	2	9	7.5	1.2	20	W
6	2	11	10	6.0	100	W
7	4	13	7.5	1.0	18	W
8	4	20	7.5	3.0	70	W
9	2	22	7.5	2.0	90	W
10	3	24	10	1.0	19	W

Age of system as of July 1983. Diameter (size) of siphon, elevation and distance from siphon to soil absorption system. Visits 1-10 were weekly from 7/28 - 9/29. Visit 11 was on December 1. Visits 12-13 were approximately one week apart, from June 8-September 5.

W - Siphon is working properly.
 T - Siphon was trickling.
 I - Level recorder showed it was working, trickling, and then working again.
 R - Replaced siphon.
 * - Represents when siphon was recharged by blowing air beneath bell.
 e - Nobody at home.
 † - Most holes in distribution network plugged.

The outside pipe of the auxiliary vent was extended by 8 cm to within 2 cm of the bell lip. Observation one week later showed it to be trickling.

Field Study-Phase 2: All but three of the 32 sites visited served residences (Table 2). All of the siphons were dosed into pressure distribution networks with most of the siphons being 7.5 cm in diameter. The age of the systems ranged from 0.3 to 6 years, with 2 to 7 people served per household. On the first visit, six siphons were observed to be trickling and three were found inoperable because the pressure distribution networks were apparently plugged. The six trickling units were restarted.

Table 2. Siphon Performance for Phase 2 of the Field Study.

Systems ^a No. of People	Age (yr)	Size ^b (cm)	System ^c		1984		
			Elev. (m)	Dist. (d)	Week 1	Week 2	Week 3
1	2	7.5	M	S	W	T	W
2	3	7.5	S	M	W	W	W
3	4	7.5	M	M	W	W	W
4	2	7.5	M	M	W	W	W
5	6	7.5	S	L	W	W	W
6	5	7.5	M	M	W	W	W
7	6	10.0	M	M	W	W	W
8	4	7.5	L	M	W	W	W
9	4	7.5	M	M	W	W	W
10	7	7.5	M	M	W	W	W
11	-	15.25	S	M	W	W	W
12	4	7.5	M	L	W	W	W
13	3	7.5	L	M	W	W	W
14	2	7.5	M	M	T	W	T
15	2	10.0	M	M	W	T	T
16	2	7.5	M	M	T	W	W
17	3	12.7	M	M	W	W	W
18	3	7.5	S	M	T	W	W
19	7	10.0	M	M	T	T	W
20	4	7.5	S	M	W	W	W
21	3	7.5	M	M	W	W	W
22	4	7.5	S	M	T	W	W
23	2	7.5	M	M	W	W	W
24	4	7.5	M	M	W	W	W
25	3	10.0	M	M	W	T	W
26	2	7.5	M	M	W	W	W
27	4	7.5	M	M	W	W	W
28	4	7.5	M	M	W	W	W
29	1	2.5	7.5	M	M	P	T
30	3	7.5	M	M	T	W	P
31	5	2	7.5	S	P	P	P
32	3	7.5	S	M	P	P	P

^aAll systems served residences except Sites 7, 11, and 13, which were recreational type units.
^bSize of siphon; tanks were all 1893 L except Systems 11, 17, and 24, which were 11,355, 7570, 3785 L respectively.
^cElevation from siphon outlet to soil absorption system; L < 1m, M = 1 - 5m, S > 5 meters.
^dDistance from siphon to soil absorption system: S < 30m, M = 30 - 100m, L > 100m.
^eAll siphons dosed into pressure network distribution systems.
^fNot visited.

During the second inspection, four systems were found to be trickling. Of these four, only one had been trickling the week before. Of the 23 systems checked the third week, three were found to be trickling and one appeared to have a plugged distribution network which occurred after the second visit. Of those three which trickled, only one had been trickling the week before. During this study, 13 of these siphons, or 41%, were found to be malfunctioning at one time or another. No correlation of malfunctions with other factors was apparent.

At Site 7, the system consists of alternating siphons which have functioned properly. However, in a large system serving a small community, one of the alternating siphons had a chronic trickling problem. No air leaks or other causes of trickling were found. It was taken apart, inspected and put back together. No obvious problem could be found, but it started working properly again. At another site, it was very difficult to get one of the siphons to operate properly, even though both were alternating when field tested prior to the siphon being connected to the distribution system.

Laboratory Phase: The rate at which the water was added to the siphon tank did not appear to affect its performance. Water was added rapidly and also at such a rate that it would take a week to fill the siphon tank. In both cases, the siphon would activate at the design drawdown level. In both series of tests, the discharge pipe was restricted to reduce the discharge rate from the full bore discharge rate of 4.7 L/s to approximately 1 L/s. This action did not affect siphon performance.

When the siphon chamber was filled to within several inches of its high water level and the water was deoxygenated, the siphon would trickle eight out of ten times after being held for five to six days, thus indicating that siphons sitting idle for a few days may start to trickle. However, this hypothesis has not been proven in the field. In the field, two siphons were left sitting idle for eight to ten days with no apparent effect on performance when the SIE was added again. The liquid level in one was about 5 cm below the high water level and the other one was about 5 cm above the bell bottom. Further field testing needs to be done to prove or disprove this hypothesis.

The laboratory siphon chamber was left sitting for about four months with tap water up to within about 2 cm of the high water level. Upon adding water, it started to trickle, even though it was performing satisfactorily previously. Cousin (1973) also found siphons became water-logged after about a month of being idle.

Summary and Recommendations

A number of siphons receiving septic tank effluent for residences were observed in the field to determine how well they were performing. A laboratory study was undertaken to determine the causes of malfunction.

The belief by many that siphons do not need attention is false. Siphons will start to trickle for no apparent reason. If unchecked, the advantage of dosing is lost and if used to pressurize a pressure distribution network, a trickling siphon can lead to plugging of the network perforations. Therefore, to avoid this problem, the homeowner should observe the siphon performance periodically. One approach which has been used successfully is to install a float in the siphon chamber (Figure 3)(Parker, 1983). If the float moves up slowly and recedes approximately the draw depth over a short period of time, then it is performing satisfactorily. If the float remains at the same level or moves up and slowly recedes some, then the siphon is probably trickling and requires maintenance. It can be recharged by blowing air beneath the bell.

indicate if both are working. Some type of monitoring should be mandatory on large systems which use alternating siphons.

Installers must understand the operational principles of siphons and must use better care in installation. The siphon trap must be primed with water and it must be cycled after installation. The installer should return to the site and observe the siphon performance after the system has been in operation for a period of time.

Siphons and the vent pipe should be located beneath the tank riser for ease of observation and maintenance. Observations down the vent pipe is critical for detecting malfunction.

Siphons will do the necessary tasks required of them. However, like any other piece of equipment, they will malfunction on occasion and require some maintenance. Thus, some method must be used to detect the malfunction. Alarms are required for pumps. Floats should be required on siphons. The homeowner must be aware that inattention to siphon performance may be costly in the future if the distribution network plugs.

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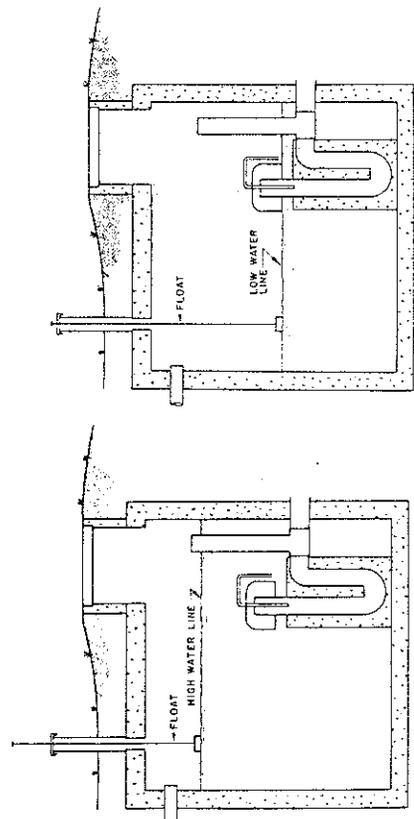


Figure 3. Schematic of siphon tank showing float location for high water level and for low water level for single siphon tanks.

On occasion, alternating siphons will also malfunction, with one receiving all of the effluent. However, a float within the tank will not detect this malfunction. One approach is to install floats in the overflow pipe which are connected to an event recorder or mechanical counters (Figure 4). However, the floats must be far enough into the vent pipe to come in contact with the discharging effluent. In some systems, the effluent will not surge up into the vent pipe. Periodic observation of the recorder will

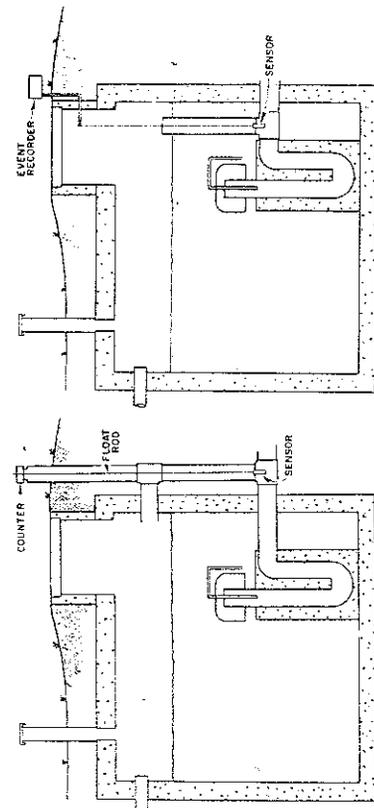


Figure 4. Schematic of siphon tank with alternating siphons showing possible methods for detecting if siphons are alternating. Left figure shows sensor secured in overflow pipe connected to an event recorder placed outside system. Right figures show schematic with float secured to overflow pipe connected to mechanical counter.