

SIPHONS FOR ON-SITE SYSTEMS
LAB AND FIELD EVALUATION

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by

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ABSTRACT

Siphons are commonly used to pressurize on-site distribution systems downgrade of the tank. Because of their design, it was believed that they would perform adequately without observation or maintenance. Problems have occurred and trickling siphons have been observed in the field. Observations in the field and experimentation in the lab suggest improper installation is a major factor in siphon malfunction, but siphons can malfunction for no apparent reason and if not corrected, will reduce the life of the distribution system. Siphon tanks should be equipped with some type of monitoring device to enable the homeowner to periodically check on its operation.

INTRODUCTION

Siphons in some shape or form have been around for many years and recently have become popular for use in mounds and in-ground pressure distribution networks for on-site disposal of sewage. Because of the siphons design simplicity (no moving parts) and lower cost, they have replaced pumps on sites where the effluent moves downhill.

Siphon Operation

A typical cross section of a dosing tank and siphon assembly is shown to identify the various components (Fig. 1). The trap must be filled with water initially after installation.

The size of the bell controls the amount of effluent dosed per discharge; the larger the bell the larger the discharge. The auxillary vent pipe controls how much air is trapped in the bell and also allows for proper venting of the bell after the siphon has discharged. The vent pipe allows air trapped in the discharge pipe to escape, preventing air locking and disruption of the siphon action. This vent also provides an overflow if the siphon should become plugged.

As the effluent level begins to rise in the tank, it reaches the auxillary vent opening, effecting a seal and trapping the proper volume of air in the bell to maintain balance with the water in the trap (Fig. 2A). As the

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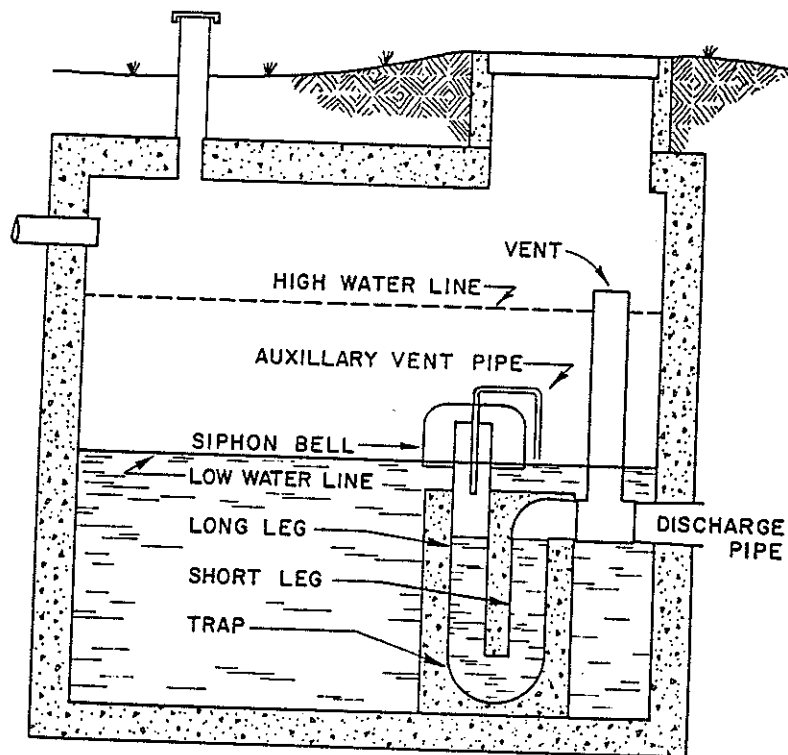


Fig. 1 Typical Cross Section of a Dosing Chamber Containing a Siphon. This Figure Shows Most Beneficial Placement of Tank Opening in Relation to Siphon and Vent Pipe for Operational Observation

effluent continues to rise, the air under the bell is compressed and begins to force the water from the trap into the discharge pipe. When the long leg of the trap is completely filled with air, a small rise in the effluent level of the tank causes air to escape into the short leg, disrupting the equilibrium and causing the siphon to activate. The level of effluent in the tank drops until the bottom of the bell is reached, sucking air and breaking the siphon action, at which point the cycle starts over.

For larger systems, two or more siphons of the same size can be placed in the same tank to provide greater flexibility by discharging into separate distribution systems. As in a single siphon, the traps must be initially filled with water (Fig. 2). The stages of operation are the same as for a single siphon and due to slight variation one of the siphons will activate (Siphon A in Fig. 2). When the siphon action is broken, the first trap will be re-filled, but the other trap, having been partially emptied, will have less water in its trap (Siphon B in Fig. 2). This second siphon will then discharge during the next cycle because of the smaller plug of water in its trap.

Because the siphon operates on hydraulic principles and contains no moving parts, it was assumed that it would perform maintenance free for the life of the system. However, a number of plugged distribution systems were brought to our attention and it was discovered that the siphons were not working properly. This prompted a survey of seven siphons, five of which were found to be trickling.

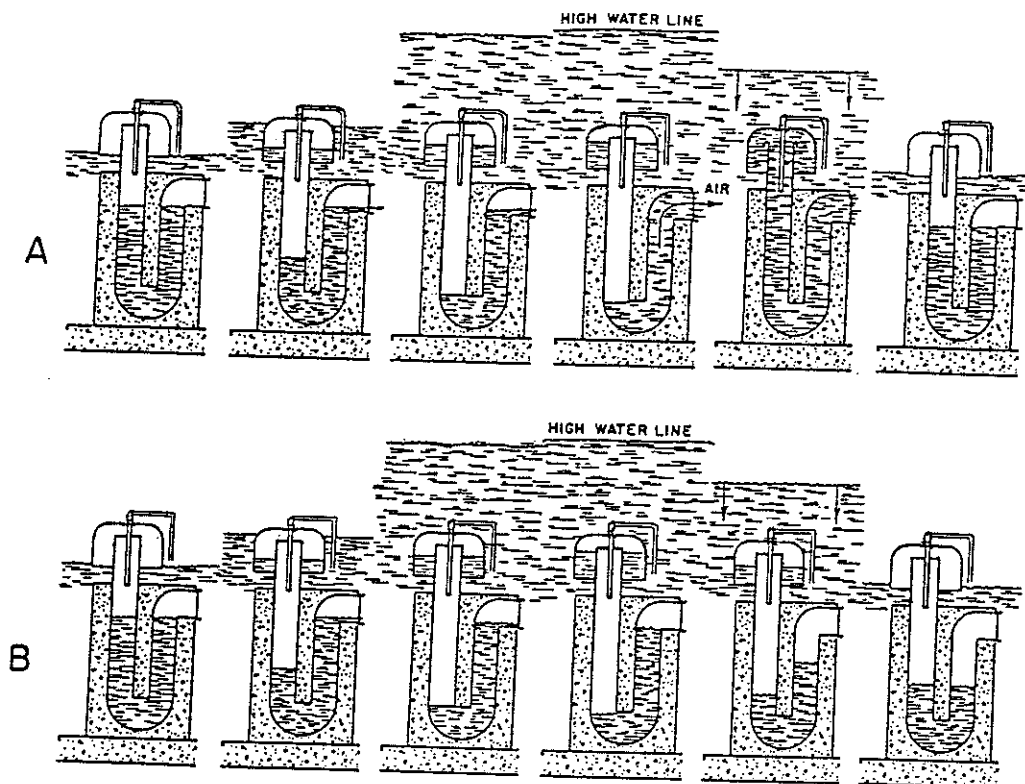


Fig. 2 Schematic of Siphon Showing Effluent Location in Trap in Relation to Liquid Level in Tank (A). Effluent Location of Alternating Siphons, Siphon A Activating (A&B).

Trickling occurs when an insufficient amount of air is trapped or held under the bell. This volume of air, when compressed, allows the water rising in the bell to reach the trap inlet, or the water level in the tank to reach the overflow pipe, before the water in the long leg of the trap can be forced out. A siphon can remain in this state indefinitely if not rebalanced by recharging it with air. Cousin (1973) found 75-80% of the siphons surveyed in Canada to be trickling. Various inquiries to installers and homeowners revealed a growing problem. The purpose of this study was to evaluate field performance of siphons and to simulate field conditions in the laboratory and evaluate the principle of operation when siphons are connected to pressure distribution systems.

LABORATORY PHASE

In the laboratory, two 3 in. (7.5 cm) siphons were examined under various conditions to try and locate possible problems. One of the siphons was fitted with observation windows so that internal fluid levels could be observed during operation. This siphon was placed inside a 2 ft. (61 cm) square tank with one plexiglass side. The other siphon was placed in an actual dosing tank and connected to a typical full size pressure distribution system.

The siphons were subject to a variety of flow rates cycling from once every ten minutes to one dose per week. Operation was not effected by flow rate. It was noted that the level of discharge did, on occasion, fluctuate 0.5 in.

(1.27 cm) to 0.75 in. (1.95 cm) above and below the design level, respectively. A dimension which is set during installation is the distance between the bottom of the bell and the trap inlet. This dimension was varied 1.5 in. (3.81 cm) above and below the design level, with no significant effect on operation; however, the high water level was effected. As the distance between the two is decreased, the high water level increases proportionately, which may cause a problem with the effluent overtopping the overflow pipe.

Auxillary vent pipe dimensions were also varied. With the external auxillary vent (EAV) opening held constant at the height prescribed by the manufacturer, the internal auxillary vent (IAV) dimension was varied from 0 to 12 in. (0 to 30 cm), at which point the IAV opening became submerged in the water in the long leg of the trap. With the IAV pipe opening above the bottom of the bell, the siphon will not vent adequately and will begin to trickle. With the IAV extending one inch or more below the top of the discharge pipe, the bell has trouble venting itself and will begin to trickle. This allows about four inches where the IAV opening can be positioned. This dimension was not given on the manufacturer's installation sheet, but supposedly piping of correct length is included with the siphon package.

With the IAV now held constant within the range of proper operation, the position of the EAV opening was varied from even with the bottom of the bell to 3.5 in. (8.9 cm) above the bell bottom. The siphon operated properly when the EAV opening was in the range of 0.75 in. (1.91 cm) to 3.25 in. (8.26 cm). With the opening from 0 to 0.5 in. (1.17 cm) above the bell bottom, the bell could not intake sufficient air to balance with the water in the trap. From 0.5 in. (1.27 cm) to 0.75 in. (1.91 cm) the EAV opening was near the surface during venting where scum or debris may cause plugging as venting by the EAV only occurs after the siphon action is broken at the bottom of the bell. At a distance greater than 3.25 in. (8.26 cm) insufficient air is trapped in the bell and trickling occurs. At 1.75 in. (4.4 cm) from the bottom of the bell the siphon activated at its design discharge of 13 in. (33.0 cm), which is the dimension given on the installation sheet for this particular model. The location of the opening above or below 1.75 in. (4.4 cm) caused the discharge level to move up or down respectively. The EAV piping is usually supplied by the manufacturer with dimensions included.

EPA Design Manual (1980) and others have indicated that plugging of the auxillary vent piping is a major cause of siphon malfunction. When tested in the lab, a completely plugged auxillary vent did cause the siphon to trickle due to inadequate venting of the bell. However, the siphon continued to operate properly with up to 92% of the auxillary vent pipe plugged. Above 92% blockage the siphon would operate erratically with a large variance in discharge levels and eventual trickling.

When the full-scale model was put into operation it ran for three week without any problems, at which point it started to trickle. Further investigation revealed a very tiny stream of air bubbles escaping from the connection between the bell and the auxillary vent pipe. The air bubbles were so small that it would be almost impossible to detect them in a field situation. After the bell was recharged with air, the leak seemed to seal itself and the siphon has operated properly for the past two months. This does indicate that a single factor or combination of factors can cause a siphon to trickle, and once this happens, the siphon will usually continue to trickle until it is manually reset. If the system continues to trickle, the advantage of dosing the

distribution system is lost (Bouma et al., 1974), and the small diameter holes in the distribution system may plug.

Prolonged inactivity of the system appears to effect its performance. The tank was filled to within an inch of discharge, the water deoxygenated, and allowed to sit for a period of time. After six days the siphon started to trickle. Adequate testing has not been done in the field to substantiate this experiment, but siphons have been shown to become waterlogged after sitting idle for one month with ordinary tap water (Cousin, 1973), which was verified in our lab. This indicates that a siphon should be checked if it sits idle for an extended period of time. Also, testing with tap water may not accurately simulate actual operation.

FIELD STUDY

The field study consisted of monitoring a number of actual systems throughout southern Wisconsin. At each site a series of measurements were taken to relate siphon specifications with operation (Fig. 3). When available, sufficient water was added to activate the siphon and determine proper operation. If sufficient water was not accessible, a 10 gal. (38 L) container of water was emptied into the tank and this new level was recorded. After 15 minutes the level was again measured and compared to the previous reading. If the two readings were the same, the siphon was considered to be working. If the vent pipe was located beneath the tank opening, it was possible to directly determine if the system was trickling by watching for a significant amount of effluent flowing out to the distribution system. When a siphon was found to be trickling, air was blown under the bell with a "J"-shaped tube to recharge it.

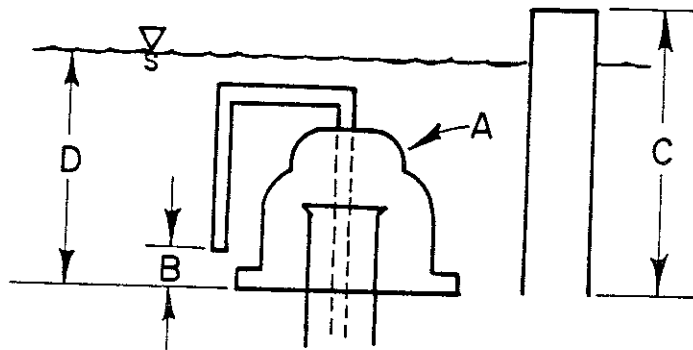


Fig. 3 Schematic Showing Measurements Taken at Each Site with Distances Measured from Bell Bottom
A) Size of the bell
B) Distance to the Auxillary Vent Opening
C) Distance to Vent Opening
D) Distance to Water

In Phase 1 of the study, ten systems were monitored and corrective measures were applied when possible. The study was conducted in 1983-84 with a

follow-up one year later (Table 1). Converse et al. (1985) reported on the first two years.

Siphons 1 and 7 have worked properly for the duration of the study. Site 2 was reported to have had a plugged distribution system which was cleared before the study began. The system was initially trickling, the bell was recharged and a stage level recorder placed on it. On the seventh visit the system was again found to be trickling and was again recharged. No other corrective measures were taken and the site was still functioning properly in August of 1985.

At Site 3 the vent pipe was found to be too short and, once extended, has worked properly since. An air leak was found in the joint between the auxiliary vent pipe and bell of Site 4. After repairs were made, the system seemed to be working. However, upon inspection in August of 1985, the effluent was found to be running over the vent pipe. Since the design discharge level was very close to the vent height, this system could probably be corrected by extending the vent pipe several inches to allow for fluctuations in discharge levels.

Operation of the siphon at Site 5 was very inconsistent. A stage level recorder showed that the siphon would start to trickle and then go back into operation with no outside assistance. In the spring of 1985 the distribution system was found to be plugged with ice and the siphon trickling. The bell was then checked for leaks and placed back into operation. However, a stage level recorder showed the siphon continued to trickle for two weeks and inspection showed the bell was reinstalled incorrectly. The siphon was then replaced with a new one and has been working properly since. In the laboratory the trap was pressurized to check for any leaks, but none were found. The reason for this system's erratic behavior has not been identified.

Sites 6 and 10 did not function properly for the duration of the study. Both systems worked properly when tap water was run into the tank at a rapid rate, but a recorder placed on these units shows that during normal operation the siphons began to trickle immediately. At Site 10 a new siphon was installed and the cover of the tank arranged so that the vent pipe could be observed directly. The system is now working properly. The old trap was pressurized to check for leaks, but none were found. The siphon bell at Site 6 is in the process of being replaced. These faulty siphons will later be tested in the lab.

The siphon at Site 8 worked properly for nine weeks, then was found to be trickling. It was reset and a stage level recorder showed it activated once, started to trickle and then started working properly. When observed in August of 1985, the siphon was again found to be trickling. A check of the auxiliary vent pipe dimensions is necessary to determine the possible cause of the problem. The siphon at Site 9 was found to be trickling and once reset, has been working properly as of August 1985.

Because of the number of problems encountered with the siphons studied in the first phase, a larger number of siphons were looked at in 1984. Thirty-two additional systems were added to the study to get a better understanding of possible problems. The results of this phase are recorded in Table 2. In

Table 1. Siphon Performance for Phase 1 of the Field Study

System ^a	1983b										1984c														1985																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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^aSee Converse et al. (1985) for siphon characteristics.

Visits 1-10 were weekly from 7/28 - 9/29. Visit 11 was on December 1. CVisit 1 was on August 28. CVisit 2 was on August 29. CVisit 3 was on August 30. CVisit 4 was on August 31. CVisit 5 was on September 1. CVisit 6 was on September 2. CVisit 7 was on September 3. CVisit 8 was on September 4. CVisit 9 was on September 5. CVisit 10 was on September 6. CVisit 11 was on September 7. CVisit 12 was on September 8. CVisit 13 was on September 9. CVisit 14 was on September 10. CVisit 15 was on September 11. CVisit 16 was on September 12. CVisit 17 was on September 13. CVisit 18 was on September 14. CVisit 19 was on September 15. CVisit 20 was on September 16. CVisit 21 was on September 17. CVisit 22 was on September 18. CVisit 23 was on September 19. CVisit 24 was on September 20. CVisit 25 was on September 21. CVisit 26 was on September 22. CVisit 27 was on September 23. CVisit 28 was on September 24. CVisit 29 was on September 25. CVisit 30 was on September 26. CVisit 31 was on September 27. CVisit 32 was on September 28. CVisit 33 was on September 29. CVisit 34 was on September 30. CVisit 35 was on October 1. CVisit 36 was on October 2. CVisit 37 was on October 3. CVisit 38 was on October 4. CVisit 39 was on October 5. CVisit 40 was on October 6. CVisit 41 was on October 7. CVisit 42 was on October 8. CVisit 43 was on October 9. CVisit 44 was on October 10. CVisit 45 was on October 11. CVisit 46 was on October 12. CVisit 47 was on October 13. CVisit 48 was on October 14. CVisit 49 was on October 15. CVisit 50 was on October 16. CVisit 51 was on October 17. CVisit 52 was on October 18. CVisit 53 was on October 19. CVisit 54 was on October 20. CVisit 55 was on October 21. CVisit 56 was on October 22. CVisit 57 was on October 23. CVisit 58 was on October 24. CVisit 59 was on October 25. CVisit 60 was on October 26. CVisit 61 was on October 27. CVisit 62 was on October 28. CVisit 63 was on October 29. CVisit 64 was on October 30. CVisit 65 was on November 1. CVisit 66 was on November 2. CVisit 67 was on November 3. CVisit 68 was on November 4. CVisit 69 was on November 5. CVisit 70 was on November 6. CVisit 71 was on November 7. CVisit 72 was on November 8. CVisit 73 was on November 9. CVisit 74 was on November 10. CVisit 75 was on November 11. CVisit 76 was on November 12. CVisit 77 was on November 13. CVisit 78 was on November 14. CVisit 79 was on November 15. CVisit 80 was on November 16. CVisit 81 was on November 17. CVisit 82 was on November 18. CVisit 83 was on November 19. CVisit 84 was on November 20. CVisit 85 was on November 21. CVisit 86 was on November 22. CVisit 87 was on November 23. CVisit 88 was on November 24. CVisit 89 was on November 25. CVisit 90 was on November 26. CVisit 91 was on November 27. CVisit 92 was on November 28. CVisit 93 was on November 29. CVisit 94 was on November 30. CVisit 95 was on December 1. CVisit 96 was on December 2. CVisit 97 was on December 3. CVisit 98 was on December 4. CVisit 99 was on December 5. CVisit 100 was on December 6. CVisit 101 was on December 7. CVisit 102 was on December 8. CVisit 103 was on December 9. CVisit 104 was on December 10. CVisit 105 was on December 11. CVisit 106 was on December 12. CVisit 107 was on December 13. CVisit 108 was on December 14. CVisit 109 was on December 15. CVisit 110 was on December 16. CVisit 111 was on December 17. CVisit 112 was on December 18. CVisit 113 was on December 19. CVisit 114 was on December 20. CVisit 115 was on December 21. CVisit 116 was on December 22. CVisit 117 was on December 23. CVisit 118 was on December 24. CVisit 119 was on December 25. CVisit 120 was on December 26. CVisit 121 was on December 27. CVisit 122 was on December 28. CVisit 123 was on December 29. CVisit 124 was on December 30. CVisit 125 was on December 31.

visits 1-10 were weekly from 7/28 - 9/29. Visit 11 was on December 1. Visit 1 was on April 28; Visits 2-13 were approximately one week apart, from June 8 - September 5.

dW - Siphon is working properly.

T - Siphon was trickling.

I - Level recorder showed it was working, trickling then working again.
R - Remained stationary.

R - Repaired siphon.

* - Represents when siphon was recharged by blowing air beneath bell.
nobody at home.

Most holes in distribution network plugged.

1984, 11 of the 32 sites, or 34% of the siphons, were found to be trickling at one time or another. No corrective measures other than recharging the bells with air were applied. In August of 1985, only 4 of the 32 siphons, or 12.5%, were trickling. Six of the systems having problems in 1984 were working properly when observed one year later. At Site 31 the distribution system was cleaned several times and the EAV opening was adjusted to 1.75 in. (4.4 cm) from the bell bottom by the installer in May, 1985.

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

System ^a	1984			1985	System ^a	1984			1985
	Week 1	Week 2	Week 3			Week 1	Week 2	Week 3	
1 ^b	W	T	W	T	17	W	-	-	W
2	W	W	-	W	18	T	W	W	W
3	W	W	W	W	19	T	T	-	W
4	W	W	W	W	20	W	W	W	W
5	W	W	W	W	21	W	W	W	W
6	W	W	W	W	22	T	W	W	W
7	W	W	-	W	23	W	W	W	W
8	W	W	W	W	24	W	W	W	W
9	W	W	W	W	25	W	T	-	Tp
10	W	W	-	W	26	W	W	W	W
11	W	W	W	W	27	W	W	W	W
12	W	W	W	W	28	W	W	T	W
13	W	W	W	W	29	Wp	Tp	-	Wp
14	T	W	T	T	30	T	W	Wp	Wp
15	W	T	T	W	31	Wp	Wp	Wp	Wp
16	T	W	W	T	32	Wp	Tp	Wp	Wp

^aAll systems served residences except Sites 7, 11, and 17, which were recreational type units. (See Converse et al. for system characteristics.

^bW - Siphon working

T - Siphon trickling

Wp, Tp - Distribution system is plugged

(-) Site not visited

In 1985, of the four sites with plugged distribution systems, three had siphons which discharged properly when the tanks were filled. One system with a history of plugging has its siphon 3 in. (7.6 cm) from the floor of the tank, with no additional depth for settling solids.

System 16 was trickling over the overflow pipe and the overflow height was determined to be very close to the design discharge level. The problem could possibly be remedied by extending the overflow pipe a few inches. The other failing systems require a closer examination of the vent piping. Of the 29 siphons measured, 21, or 72%, were found to have incorrect dimensions for their EAV piping with measurements varying from 1/2 in. (1.27 cm) above bell bottom to 2 1/8 in. (5.4 cm) above bell bottom.

The one alternating system (Site 7) contained in this survey appeared to be working properly, but it is very difficult to determine if it was alternating. Another alternating system inspected was found to have only one siphon functioning. The length of the auxillary vent pipe was adjusted on the siphons according to manufacturer's instructions. The system was monitored for several weeks, but the siphons were still not alternating. In August of 1985 two new bells were installed at the site and the siphons have been alternating.

SUMMARY AND RECOMMENDATIONS

Siphon performance in on-site waste systems was evaluated and some of the problems with these systems have been identified.

One of the biggest problems with siphons is improper installation by contractors who do not understand the proper operation of siphons, and manufacturers who do not give adequate step by step clear installation instructions. Many of the problems found were due to improper installation which, when corrected, allowed the siphons to function properly. Manufacturers should include specific dimensions for both the internal and external auxillary vent pipes so that installers can check the piping during installation. A periodic inspection of siphons is necessary to insure proper operation.

Siphons can begin to trickle for no apparent reason, and if not corrected, can cause plugging of the distribution system. The homeowner must be told that they should be checked periodically. An inexpensive and simple method of monitoring the system is with a float device (Figure 4a). The float will move up slowly with the tank level and then quickly move down during the discharge. If the float oscillates in the center of travel, the siphon should be reported for maintenance.

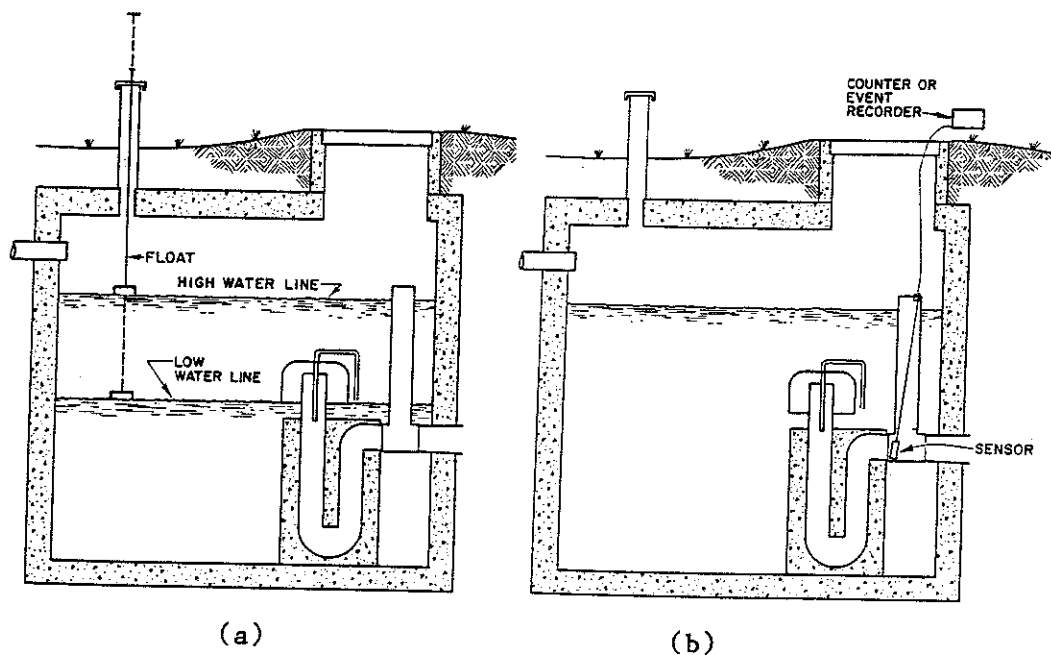


Fig. 4 Schematic of Siphon Tank Showing Possible Monitoring Devices for: a) Single siphon b) Alternating siphon

A monitoring device should be required for alternating systems to prevent overloading if one siphon should malfunction. A float system will not work on an alternating system, but a recorder system such as shown in Figure 4b will work satisfactorily.

The tank should be set up in such a way as to locate the opening above the siphon and overflow pipe. This greatly facilitates observation of siphon performance.

The siphon should be elevated from the floor of the tank to provide space for settling of any solids which may make their way into the tank.

The siphon can perform the operation it is intended for if it is properly installed and periodically checked. Its design simplicity and low cost have a great advantage over a pump, but like a pump, the siphon should be monitored for malfunctions and repaired as soon as possible.

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