Shallow Pressurized Dispersal Systems

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Introduction to Shallow Pressurized Dispersal Systems: Background, Design, Installation, and Maintenance

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Executive Summary

Shallow pressurized dispersal of highly treated effluent allows for higher hydraulic loading rates (HLR) than are possible with conventional treatment and dispersal methods. That's because the risk of soil clogging due to excessive biomat buildup can be eliminated by using pretreatment to remove most of the organic material, followed by uniform dispersal of the highly treated effluent in the biologically-active, well-oxygenated shallow soil layers. This can be achieved with the use of a Shallow Pressurized Dispersal System (SPDS).

A Shallow Pressurized Dispersal System (SPDS), in conjunction with the high level of pretreatment provided by an advanced secondary treatment system that uses a packed bed media filter, such as the AdvanTex® Treatment System, offers other important advantages. Putting the main treatment burden on the pretreatment unit allows the full treatment potential of the soil to be realized, allowing the soil to most effectively remove any residual wastewater constituents, including pathogens, nutrients (nitrogen and phosphorus), and organic constituents that are of increasing concern (pharmaceuticals and personal care products). Therefore, pretreatment followed by an SPDS can minimize the risk of contaminating groundwater or surface waters and maximize long-term effectiveness, reliability, and sustainability of onsite/decentralized systems.

Important SPDS design principles include the following:

- Organic loading to the soil must be greatly reduced by pretreatment. For example, the AdvanTex Treatment System accomplishes this by consistently and reliably producing high quality effluent (median $CBOD_5$ and TSS concentrations of 10 mg/L or better) when operated according to the manufacturer's recommendations.
- The bottom of SPDS infiltration channels must be located in the biologically-active shallow soil mantle where oxygen can easily penetrate. Channel bottoms are typically placed 10-12 inches (255-305 mm) or less below final grade.
- Pressurized dispersal must be used to uniformly spread the pretreated effluent throughout the soil absorption system.
- Unsaturated, well-oxygenated (aerobic) soil conditions must be maintained by applying effluent in small, frequent doses.

NOTE: *The application of treated wastewater to SPDS at higher hydraulic loading rates than conventional dispersal methods depends on strict observance of all the above-listed design principles.*

Not all aerobic treatment technologies are capable of consistently and reliably producing effluent of high enough quality to support long-term infiltration of wastewater in SPDS at higher hydraulic loading rates. The pretreatment unit should always be one that has been demonstrated (through independent third-party field-testing) to consistently produce effluent of very high quality. The risk of forming a clogging biomat in an SPDS is significantly higher for pretreatment technologies that do not consistently produce effluent with median $CBOD_5$ and TSS of 10 mg/L or better.

Not all secondary treatment systems are equally suitable for SPDSs. For example, typical plug-flow suspended growth aerobic processes designed for small-scale residential use often lack safeguards necessary to assure that effluent wastewater is consistently treated to a level of quality sufficient to support the increased hydraulic loading rates that may be allowed for SPDS. Plug-flow suspended growth processes are more prone to biological upsets unless they are constantly monitored and maintained by a properly trained and qualified operator— this level of oversight is generally not practical for a small-scale residential system. Due to potentially high variability of performance with such treatment systems and the previously identified requirements, an advanced secondary treatment system that uses a packed bed media filter, such as the AdvanTex System, operated according to the manufacturer's recommendations, is the only acceptable method of pretreatment.

SPDSs are simple in design and easy to construct. Essentially, the soil absorption system consists of pressurized distribution laterals made of small-diameter PVC pipe with appropriately spaced orifices, laid in a shallow trench, and covered with a suitable material (such as PVC half-pipe or Infiltrator® low-profile chambers) to support the overlying soil. Inspection ports allow visual inspection of the channel bottoms, and cleanouts are provided at lateral ends to facilitate flushing and cleaning should that ever become necessary.

In contrast with drip irrigation systems (another shallow dispersal method), SPDSs are passively operated, need less maintenance (although, by nature of their design, they are considerably easier to maintain), and are less sensitive to upsets.

Introduction to Shallow Pressurized Dispersal Systems

SPDSs are used to treat, disperse, or reuse onsite wastewater in a manner that takes the greatest advantage of the treatment potential of the biologically active shallow soil where 98% of soil microbes and 40% of plant roots are concentrated. SPDS systems disperse high-quality pretreated wastewater to gravelless infiltration channels located in the shallow, biologically active soil layers, typically about 10-14 inches (255-355 mm) below the ground surface. In an SPDS, pretreated wastewater is distributed evenly throughout the length of the channel by pressurized dosing. The wastewater is also evenly distributed over time by using controlled dosing methods (application of wastewater in small, intermittent, regular doses of uniform size) from the packed bed media filter to maintain unsaturated, aerobic conditions that are the most conducive to further treatment of the applied wastewater by soil microorganisms.

Typical SPDS infiltration channels are illustrated in Figures 1a and 1b. The infiltration channel consists of small-diameter PVC pressure distribution pipe with regularly spaced orifices to allow even distribution across the infiltrative surface, laid in a shallow excavation and covered with a larger-diameter channel cover. The channel cover is assembled from sections of PVC half-pipe (Figure 1a) or from Infiltrator® low-profile chamber sections (Figure 1b). In addition to providing rigid support for the overlying soil, the channel cover helps protect the pressurized distribution lines from potential mechanical damage, such as unauthorized digging or traffic in the drainfield area.

A common practice is to use 12-inch (300-mm) wide channels excavated to 10 inches (255 mm) below final grade (as shown in Figure 1a), installed on 3-foot (1-m) centers with 2 feet (0.6 m) of separation from sidewall to sidewall. However, some variation in channel width, depth, and spacing may be allowed depending on local regulations. For example, 6-inch (150 mm) wide channels covered with 6-inch (150-mm) diameter half-pipe may be considered as an alternative in some situations.

In the past, onsite domestic wastewater treatment methods have depended primarily on the deeper soil to assimilate much of the organic material and suspended solids from relatively poor-quality septic tank effluent. Conventional drainfield trench bottoms are typically placed more than 16 inches (400 mm) below the ground surface — below the most biologically active soil zone — where oxygen cannot easily penetrate and the potential for further treatment is minimal.

Conventional septic systems are very limited in their ability to remove organic material and suspended particles — measured as 5-day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) and Total Suspended Solids (TSS) — from domestic wastewater. Consequently, conventional septic systems place a tremendous burden on the drainfield to process, treat, and infiltrate the applied wastewater. The ability of the drainfield to continue processing, treating, and infiltrating wastewater depends on a number of factors, including soil conditions, the wastewater application rate, application method, and the quality of the applied effluent. Depending upon these and other factors, the ability of the drainfield to effectively treat and infiltrate wastewater may deteriorate with time, potentially resulting in clogging and drainfield failure.

The full potential of the soil to remove residual contaminants and pathogens and to continue infiltrating wastewater can be best realized by using advanced treatment of septic tank effluent coupled with dispersal in the shallow soil mantle — this is the concept behind SPDSs. With advanced treatment, the primary burden of treating the wastewater is shifted from the soil to an advanced treatment unit, allowing shallow-soil microorganisms to more effectively treat any residual contaminants and pathogens. Once bulk organic material and nitrogen have been removed by advanced secondary treatment, the shallow soil mantle can be most effectively used to remove residual organic constituents of concern, such as pharmaceuticals and personal care products (Tchobanoglous and Leverenz, 2008), and to treat remaining nitrogen.

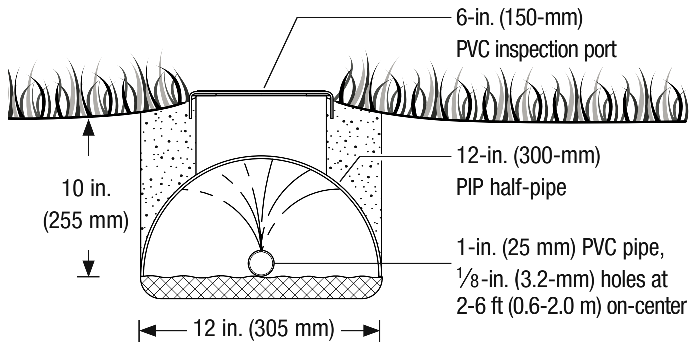


Figure 1a. SPDS with PVC half pipe

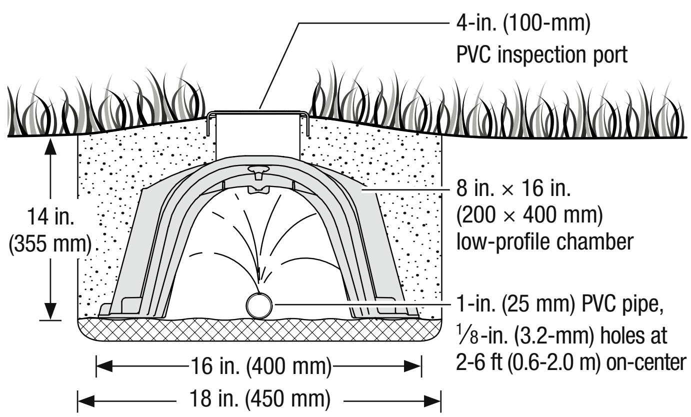
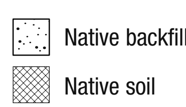


Figure 1b. SPDS with low-profile chamber



Figures 1a and 1b.
Cross-sections of typical below-ground-level SPDS designs

It is well established that soil has the potential to remove significant amounts of nitrogen (Chen and Harkin, 1998; Degen et al., 1991; Tucholke et al., 2007; Smith et al., 2008). The results of a study investigating nitrogen removal in shallow pressurized dispersal systems in Rhode Island showed that the shallow soil removed from 33 to 73% of the nitrogen remaining in applied secondary treated effluent (Holden et al., 2004).

The paked bed media filter used upstream of an SPDS should be one with the demonstrated ability (demonstrated through independent third-party field testing) to consistently and reliably reduce $CBOD_5$ and TSS levels to less than 10 mg/L, reduce Total Nitrogen (TN) to about 20 mg/L or less, and reduce pathogen levels by several orders of magnitude. Because effluent treated to this level contains virtually no organic material, the potential for a clogging biomat to form at the soil infiltrative surface is eliminated. Orenco Systems®, Inc.'s textile packed bed filters — AdvanTex Wastewater Treatment Systems — have undergone rigorous third-party field-testing, demonstrating that when operated according to the manufacturer's instructions they consistently produce effluent with median $cBOD_5$ and TSS concentrations below 10 mg/L in actual field use. This field-testing includes testing conducted for the state of Pennsylvania's On-lot Technology Verification Program (with a final report and evaluation issued by NSF International), and testing conducted for the state of Virginia's performance testing and evaluation program.

With only high-quality effluent being applied to the shallow soil mantle, hydraulic loading (the Long Term Acceptance Rate, or LTAR) is limited only by the infiltrative capacity of the soil. Research has documented that higher soil loading rates can be allowed when SPDS are used in conjunction with advanced secondary treatment (McCarthy et al., 2001; Sievers, 1998; Roy and Dubé, 1995; Tyler and Converse, 1989).

Relying too much on soil to remove organic material and suspended solids from poor-quality effluent applied below the biologically active soil zone can have serious negative consequences. These consequences include greater release of nutrients (nitrogen and phosphorus) to surface waters — potentially harming environmentally sensitive areas—and contamination of water supplies by pathogens and constituents of concern (including pharmaceuticals and personal care products).

There is growing recognition that a better approach than deep disposal trenches is needed. Tchobanoglous and Leverenz (2008) have made the following observation:

> While the use of the soil [as a primary means of removing] cBOD and TSS was acceptable in the past, it is not appropriate for the 21st century. With all of the other constituents now found in septic tank effluent (e.g., pharmaceutically active substances, cleaning agents, etc.) *the very extensive and valuable treatment capacity of the soil should be used for these constituents along with nitrogen and phosphorus*, and not for BOD and TSS which can be treated easily using one of the [advanced] treatment processes described ... (Tchobanoglous and Leverenz, 2008, p. 26, emphasis added)

Instead, those authors advocate a strategy for optimizing the removal of residual constituents. These are the same principles incorporated into the SPDS concept.

> Based on the results of ongoing research into the treatment mechanisms in the soil mantle, certain operational principles can be identified including (1) application of pretreated wastewater in the upper soil mantle, (2) pressure dosing of the applied wastewater, (3) maintaining aerobic conditions, and (4) controlling the hold-up time of the applied wastewater [by intermittent dosing]. (Tchobanoglous and Leverenz, 2008, p. 27)

The same authors emphasize the importance of pressure distribution and timed-dosing with SPDSs.

> Dispersal systems should be designed to maximize bacterial activity, plant uptake, and constituent residence times in the biologically active upper soil mantle under aerobic conditions. The importance of aerobic conditions cannot be overstressed . . . Aerobic conditions can be maintained by the application of small doses of wastewater over a wide area so that the oxygen demands of the applied wastewater will not exceed the available oxygen resources of the soil. (Tchobanoglous and Leverenz, 2008, p. 28)

SPDSs offer an innovative approach to overcoming the potential problems associated with past onsite system techniques.

> The good news for onsite systems is that . . . with effective treatment . . . for the removal of BOD and TSS before the wastewater is applied to the soil mantle, the soil can be used to remove essentially all of the trace constituents found in domestic wastewater along with any residual BOD and TSS . . . *In fact, greater removals can be achieved using the soil mantle as compared to treatment in conventional wastewater treatment plants without advanced treatment.* [Emphasis added.] (Tchobanoglous and Leverenz, 2008, p. 27)

Shallow pressurized dispersal systems are used in a large number of U.S. states and Canadian provinces. A number of states and provinces have adopted specific regulations or guidance for SPDSs. Several examples, including Oregon, British Columbia, and Rhode Island are summarized in the "Regulatory Examples" section of this document.

Benefits of Shallow Pressurized Dispersal Systems

Clogging is an all-too-common cause of conventional drainfield failure, resulting from an excessive buildup of biological mat (also known as "biomat" or "clogging mat"). Excessive biomat indicates anaerobic conditions. Biomat is an impermeable layer that forms over time on the infiltrative surface of trenches. It is characterized as a black gooey material consisting mostly of wastewater solids, mineral precipitates, and microorganisms, in a "slime" of bacterially produced polysaccharides and polyuronides (Kaplan). The slime is produced by certain types of bacteria, in particular anaerobic bacteria, as a protective coating. Its "sticky" nature helps the bacteria adhere to surfaces. The extent of biomat formation depends largely upon how well the soil is aerated and the amount of organic material in the wastewater applied to the soil treatment area ("organic loading").

Under particular circumstances the biomat may serve some useful functions, provided it does not restrict infiltration to the point of drainfield clogging. In a conventional drainfield that has relatively fast-draining soils, biomat can help by detaining wastewater in the trench, decomposing some biodegradable materials, and helping to filter out pathogens and parasites. This allows some treatment to occur before the water penetrates into the permeable soil and rapidly disperses, reducing the potential for contamination of groundwater or nearby surface waters. But the potential usefulness of biomat is often outweighed by the risk of clogging. A failed drainfield can be difficult or impossible to recover, and replacement is often the only option.

In practice, there is almost no way to reliably control and manage biomat formation in a gravity-fed soil absorption system receiving septic tank effluent, or to predict how long before biomat forms evenly over the trench bottom and sidewalls, if ever. Also, in some cases large pores or holes may develop in the soil and infiltrative surface that may or may not be plugged by the clogging mat, allowing water to escape through preferential flow paths with little or no treatment. Because of these uncertainties, relying on biomat in a conventional drainfield trench to accomplish the necessary BOD, TSS, and pathogen removal can be risky and doing so can have potentially serious and undesirable consequences.

Research has shown that development of a clogging mat is highly correlated with loading of BOD and TSS to the drainfield (Siegrist and Boyle, 1987). The reason is explained by Tyler and Converse (1994):

> Organic materials, measured as biological oxygen demand (BOD) and suspended solids (SS) in wastewater [are] substrate for microorganisms. The more organic substrate provided by the wastewater, the more cells and associated fibers and slimes are produced. Cells of microorganisms have been shown to physically fill the pores in the soil reducing the porosity and hydraulic conductivity . . .

The same authors concluded that, " . . . very highly pretreated wastewater effluents could be applied at higher loading rates than septic tank effluent and possibly at rates equal to the soil saturated hydraulic conductivity." (Tyler and Converse, 1989, cited in Tyler and Converse 1994.)

The risk of clogging is eliminated with SPDSs. The detention, filtration, and relatively poor treatment functions of the biomat are replaced and exceeded by a highly efficient advanced treatment system using aerobic treatment principles. Three features of SPDSs prevent biomat development:

1) Greatly reduced organic loading to the soil. (For example, the AdvanTex Treatment System generally removes more than 95% of the organic matter and solids contained in typical septic tank effluent when operated according to the manufacturer's recommendations.)

2) Application of high-quality effluent to the well-aerated and biologically active shallow soil zone, typically 10 inches (255 mm) below the ground surface.

3) Maintenance of aerobic soil conditions by uniform application of wastewater throughout the shallow drainfield using pressure distribution and controlled dosing. This avoids prolonged periods of soil saturation and maximizes soil aeration, which discourages biomat formation.

Beyond simply inhibiting biomat formation, SPDSs take advantage of the full potential for treatment available in the soil because only pretreated, high-quality wastewater is applied to the shallow soil layers in which most of the microorganisms and plant roots are concentrated. More than 98% of all living organisms that reside in the soil are located in the top 16 inches (400 mm) below the ground surface. (See Figure 2a.) In addition, more than 40% of plant roots are concentrated in the upper 12 inches (300 mm) of the soil. (See Figure 2b.)

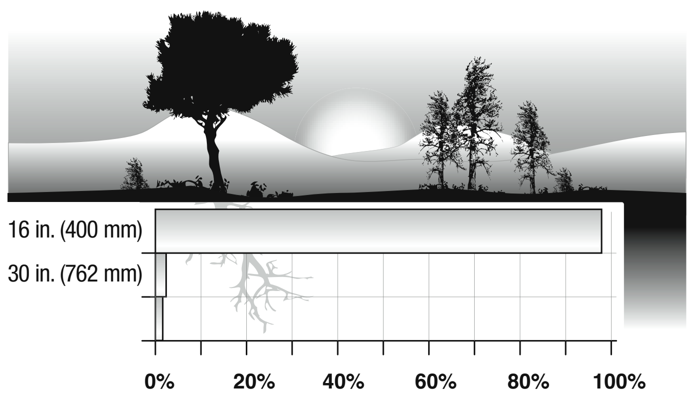


Figure 2a. Distribution of microorganisms in soil column

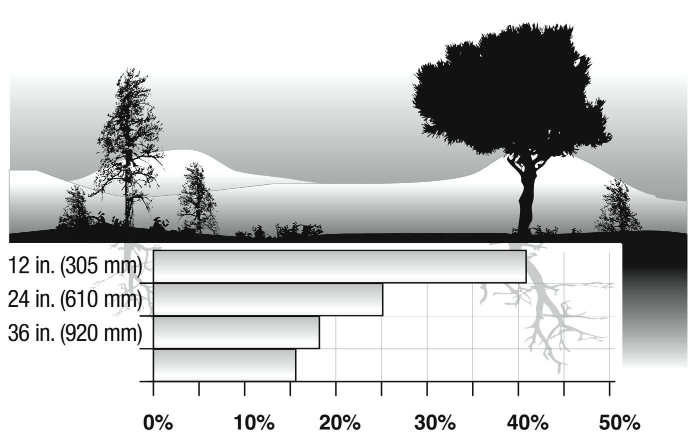


Figure 2b. Distribution of plant roots in soil column

The plant roots help foster an active microbial environment by conditioning the soil, promoting plant/microbe associations, and improving aeration. This increase in microbial activity also helps enhance soil structure and improve infiltration. Plants in shallow soil also maintain soil carbon levels, which can be useful when optimum nitrogen removal is desired.

In a 1988 study, Stewart and Reneau reported nitrogen removal of approximately 90% when septic tank effluent was dosed to a shallow drainfield using pressurized distribution, in soil with a seasonally fluctuating high water table. Similarly, Wolf et al. (1998) reported 79% removal of septic tank effluent nitrogen in a shallow drainfield loaded at 17.89 Lpd/m^2. These results illustrate the exceptional nitrogen-removal potential of shallow soil. Nitrogen loading, more specifically nitrogen in the nitrate-N form, is becoming more of a regulatory concern throughout the country. The typical concentration of total nitrogen in residential strength wastewater is in the range of 60 to 90 mg/L (Tchobanoglous and Leverenz, 2008).

Third-party field- and bench-testing has demonstrated the effectiveness of AdvanTex Treatment Systems in reducing total nitrogen by 60 to 70%. This is achieved through biological nitrogen reduction (nitrification and denitrification processes) whereby TKN and ammonia are converted to nitrate and then nitrate is converted to nitrogen gas.

The AdvanTex System typically produces effluent with a total nitrogen concentration of 15 to 20 mg/L when operated according to the manufacturer's recommendations (mostly in the form of nitrate-N). By loading this treated effluent into the shallow zone of the soil, nitrate-N can be reduced even further.

SPDSs offer advantages with respect to removing other contaminants from wastewater. Soil microbes (bacteria and fungi) are effective at breaking down organic material such as pharmaceuticals and personal care products. Dispersing high-quality effluent in the biologically active shallow soil zone can help assure maximum removal of these organic contaminants.

Therefore, SPDSs are a solution to help address growing public concerns about contamination of drinking water supplies by pharmaceuticals and personal care products. SPDSs also offer an effective means of removing pathogens from wastewater. "Another advantage of lightly dosing the soil mantle is that the removal of pathogens is enhanced." (Tchobanoglous and Leverenz, 2008)

Provided that highly treated effluent is applied, SPDSs are the ideal subsurface dispersal method. They are passively operated, low-maintenance systems that have a number of advantages over drip irrigation (another type of shallow dispersal method).

The shallow channels used in SPDSs reduce installation costs. SPDSs are simple in design and easy to construct. An SPDS can be installed within a few hours, and mechanized excavation equipment isn't necessarily required. The shallow, narrow channels can be dug with a shovel, if needed, to minimize site impact in sensitive areas or places where mechanized excavation equipment can't reach. These channels are easy to integrate into the existing landscape by installing them along contour lines as well as weaving them around trees and shrubs. This practically eliminates the need to alter the native landscape or remove existing trees and vegetation to install an SPDS.

Packed Bed Media Filters for SPDS

Following pretreatment by a packed bed media filter (one that consistently and reliably produces effluent with median $CBOD_5$ and TSS concentrations of 10 mg/L or better), the high quality effluent may be applied to an SPDS using controlled dosing. When only highly treated effluent is applied to the shallow soil for further treatment, coupled with high dosing frequencies, the potential for removing residual contaminants and pathogens is maximized, sustainability at relatively high HLR is maximized, and long-term concerns for clogging are eliminated.

When properly designed and installed, and with regular maintenance at prescribed intervals, packed bed media filters operate consistently and reliably with a minimum of effort by a trained service provider. Additionally, packed bed media filters are passively aerated. They are more sustainable than suspended growth aerobic treatment units, as packed bed media filters do not depend on air blower motors that are prone to mechanical breakdown nor do they demand the large amounts of electricity to operate that suspended growth treatment units require.

Long-term soil acceptance rates are highly dependent on effluent quality (Tyler and Converse, 1994). SPDSs can be expected to infiltrate treated wastewater at higher long-term loading rates only if the applied effluent is consistently of very high quality. Not all secondary treatment systems are equally suited for this purpose. Plug-flow (gravity-in/gravity-out) suspended growth processes, such as traditional aerobic treatment units, are more prone to biological upsets that may result in unacceptable rates of solids transfer to the soil dispersal system. Without a proportionately higher level of monitoring and maintenance and suitable safeguards in place, the performance of such systems can be highly variable and more unpredictable; consequently, they pose a greater risk in situations where drainfield size is reduced. Many state and local authorities have published the results of field surveys with data indicating that suspended growth aerobic treatment units often cannot be relied on for consistent, satisfactory performance. The reports can be obtained by contacting the agencies involved in conducting the studies.

Suspended growth processes operate according to activated sludge treatment principles. Achieving consistently high performance with an activated sludge treatment approach requires a relatively high level of monitoring, maintenance, operator oversight, and typically the inclusion of a mechanical filtering process, such as multimedia filters or other mechanical filtering processes, to protect against the excessive carryover of solids. Providing the necessary operator oversight (municipal plants require personnel on-call 24 hours per day) and process controls can be practical for larger-scale operations such as commercial facilities and municipal treatment plants, but is generally not practical for individual residences.

In contrast to packed bed media filters, in which treatment is accomplished by microorganisms growing on a solid, unsaturated media surface, suspended growth processes depend on the activity of microorganisms in a liquid suspension. They require active aeration using air blower motors and diffusers in order to maintain not only the oxygen levels necessary to promote biological growth and activity, but also to enable sufficient mixing to ensure complete substrate and microbial contact. (The complete mixing issue is often ignored in residential applications.) If a power outage occurs, if the blower is turned off to save electricity, or if the air-lines become clogged or damaged, insufficient oxygen is delivered and therefore inadequately treated or untreated sewage is discharged to the drainfield in the short time that it takes active aerobic microbes to consume all the available free oxygen (DO) and drive the system into an anaerobic (septic) condition. This risk is not acceptable for drainfields of reduced size.

With large-scale activated-sludge plants, the food-to-microorganism ratio is closely monitored and precisely adjusted by modulating the sludge return rate. This is not the case with residential-scale suspended growth treatment units, for which the food-to-microorganism ratio is not precisely controlled. As a consequence, performance is often erratic and frequent sludge pumping is necessary. Residential-scale suspended growth units are often plug-flow treatment units lacking mechanical filtration and fail-safe features to prevent discharge of untreated or partially treated sewage to the soil absorption area in the event of a power loss or other major equipment malfunction. It is because of these and other aforementioned concerns that a packed bed media filter, such as an AdvanTex Treatment System, is the only appropriate choice preceding an SPDS.

System Component Overview

Figure 3 highlights components used in a typical Orenco configuration for Shallow Pressurized Dispersal Systems.

❶ AdvanTex Treatment System*: pretreats effluent prior to dispersal in the shallow infiltration channels. AdvanTex Treatment Systems have been demonstrated under actual field conditions to consistently produce high-quality effluent (median $CBOD_5$ and TSS of 10 mg/L or less) and are ideal for this application.

❷ Discharge Pump System: stores and pumps pressurized wastewater from the AdvanTex Treatment System to the shallow dispersal system. Either a pump tank or pump basin can be used as the pump vessel.

❸ Transport Line: carries treated wastewater from the discharge pump system to the dispersal manifold.

❹ Manifold: distributes flow from the transport line to the laterals. The manifold allows even dispersal of effluent among the laterals, even when installed on a slope.

❺ Lateral: disperses treated wastewater by controlled dosing for uniform application throughout the infiltration channel.

❻ Channel cover: supports the overlying soil and protects the lateral piping, helping to facilitate aeration and assure even dispersal of treated wastewater.

❼ Inspection Port: allows visual inspection of the bottom of the channel.

❽ Cleanout: provides access at the end of the lateral to facilitate flushing or cleaning, if required.

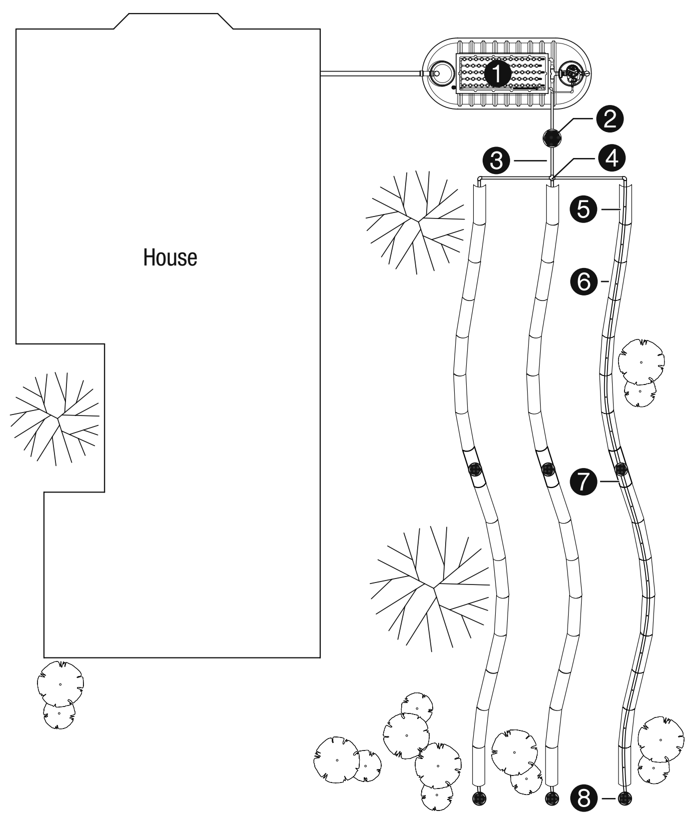


Figure 3. SPDS component overview (illustration not to scale)

** AX20 Treatment System shown*

Designing an SPDS

Before a Shallow Pressurized Dispersal System is installed, certain design criteria must be considered.

Effluent Quality

SPDSs should only be used in conjunction with a packed bed media filter that has been demonstrated under actual field conditions to consistently produce high-quality effluent (median $CBOD_5$ and TSS levels of 10 mg/L or less). The packed bed media filter should be capable of achieving this level of treatment immediately following startup. If the treatment system is unable to meet this level of effluent quality, the higher organic and hydraulic loading rates can cause biomat formation that can reduce the effectiveness of shallow installation.

Area Selection

Not all sites may be suitable for shallow pressurized dispersal. The placement of the SPDS should be selected carefully. It should not be located in a swale or where surface water has the potential for accumulating during wet periods. SPDSs can be installed on steep slopes as long as the channel is installed to the minimum depth required as measured on the downslope sidewall.

Soil Loading Rate Determination

When high-quality effluent is applied to the soil, the long term acceptance rate is limited only by the infiltrative capacity of the soil. Research has documented that higher soil loading rates can be allowed when SPDSs are used in conjunction with advanced secondary treatment (McCarthy et al., 2001; Sievers, 1998; Roy and Dubé, 1995; Tyler and Converse, 1989).

A soil morphological evaluation for the proposed dispersal area should be performed by a local professional to determine soil characteristics (i.e. texture, structure, color, etc.) and depth to groundwater or a limiting layer (i.e., bedrock, fragipan, claypan, etc.).

In addition to the soil evaluation, an infiltration test should be performed using the Infiltration Test Kit as described in the attached document, Orenco Infiltration Test Kit (NIN-TST-SET-1). This test can be used to determine the infiltrative rate of the soil when it is loaded with clean water. The advanced treatment system produces a very high quality effluent, preventing the build-up of a substantial biomat in the soil that could reduce infiltrative capacity over time. Therefore, the loading rate determined through this infiltration test using clean water very closely resembles the Long Term Acceptance Rate (LTAR) of the soil. It is recommended that a conservative safety factor of two be applied when determining the actual hydraulic loading rate. This is applied by taking the LTAR determined by the test and dividing by two.

Infiltration Channel Design

Infiltration Channels: The infiltration channel is typically 12 inches (305 mm) wide by 10-14 inches (255-355 mm) deep — as measured from the downslope sidewall — and incorporates a manifold, pressurized distribution laterals, and half-pipe or low-profile chambers. (See Figures 1a and 1b.) However, smaller channel widths down to 6 inches (150 mm) have been proven effective.

The infiltration channels must be level from end to end and across their width. SPDS channels are typically spaced on 3-foot (1 m) centers with 2 feet (0.6 m) of undisturbed earth between the channel sidewalls.

Care should be taken to make sure that the bottom of the infiltration channel is not too deeply buried or covered by excessive backfill. To enhance air penetration and biological treatment in the soil, the infiltration channel bottom should be about 10-14 inches (255-305 mm) or less below the ground surface.

Manifolds and Laterals: Manifolds and transport lines are typically the same size. The lateral lines are typically 1-in. (25-mm) diameter of Class 200 pipe or other pipe of suitable grade. Actual pipe diameters should be determined using Orenco's PumpSelect™ program to ensure that head losses are not too high and that the differential in flow between the first and last orifice in each lateral does not exceed the maximum allowed tolerances.

Orifices of ⅛-inch (3.17-mm) diameter should be drilled in the lateral lines at the 12 o'clock position with at least 2-foot (0.6 m) center-to-center spacing. Using the correct size drill bit is critical and orifices should be drilled using a drill press or guide instead of "freehand" in the field. A 1⁄64-in. difference in hole size can increase the minimum flow required by up to 27% to achieve an equivalent residual head. In areas where freezing is a concern, at least one orifice at the distal end of each lateral should be drilled in the down position to allow for draining of the lateral network.

A minimum of 2 feet (0.6 m) of residual head at the distal orifice should be used for sizing the pump to ensure equal distribution.

(*NOTE: This recommendation is a guideline that applies only to pressure distribution systems receiving high-quality effluent with an expected median $CBOD_5$ and Total Suspended Solids concentrations of 10 mg/L or less.*)

There should be a minimum of one 150-mm diameter inspection port per lateral. At the end of each lateral, a sweep ell (or two 45° elbows) and a ball valve with a threaded plug should be installed to allow flushing of the lateral during maintenance visits.

Channel Covers: To cover the laterals, the channel cover is typically made from sections of 12-in. (300-mm) diameter plastic irrigation pipe (PIP) rated at a minimum of 43 psi (296 kPa) and cut in half longitudinally or assembled from commercially available low-profile plastic chambers. Alternatively, 6-inch (150-mm) diameter half-pipe may be used where 6-inch (150-mm) wide infiltration channels are an option.

For SPDSs using PVC half-pipe chambers, installation instructions are provided on page 15 of this document. For SPDSs using Infiltrator® Quick4 Equalizer Low Profile Chambers, please use Infiltrator's installation instructions — available for download from their website.

Installations on Sloping Sites: Maintaining equal distribution on a sloping site is more difficult than on a level one for several reasons: the uneven residual pressure at the lateral orifices, uneven distribution of effluent during the start of a dose cycle, and draining of effluent to the lower lines. Various methods can be used to overcome these difficulties:

- using an automatic distributing valve to dose zones that are at differ ent elevations
- using different sized orifices to control the squirt height in laterals of different elevation
- adjusting the squirt height through an orifice disk assembly at the beginning of each lateral line.

When infiltration channels are installed on a slope, the water in the uphill laterals will drain down to the lowest channel following each dose, thereby loading the lowest channel with more water and defeating the purpose of equal distribution. To prevent this from occurring, the transport line should be plumbed to the manifold at the lowest lateral and check valves should be installed in the manifold between each lateral. (See Figure 4.)

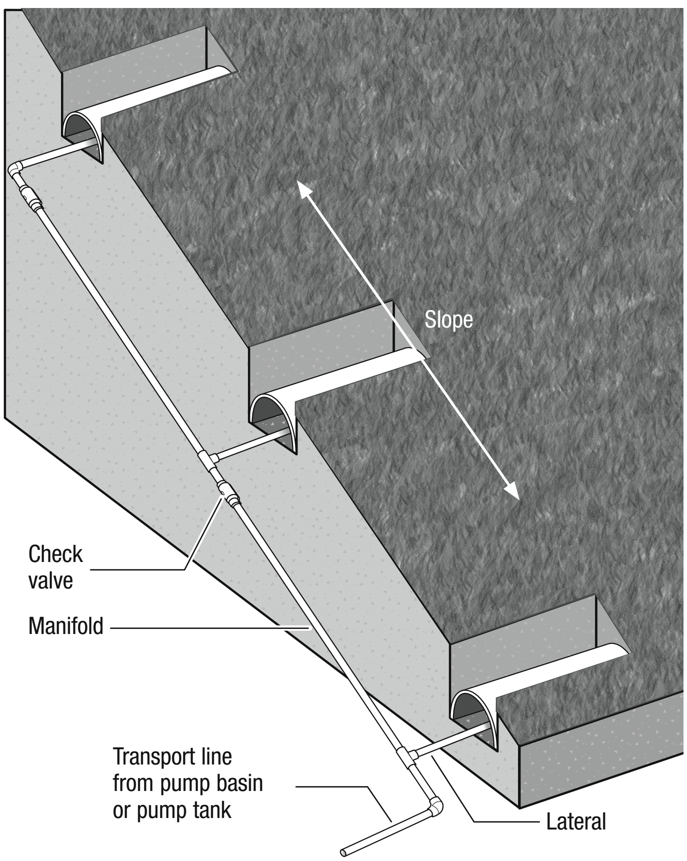


Figure 4.
Cross-section, SPDS installed on slope

At surface-level or above surface-level installations: Where necessary to meet minimum vertical separation requirements between the natural soil surface and high seasonal groundwater table or limiting layer, it may be possible to install an SPDS with the infiltrative surface closer to the original ground surface elevation, at the original ground elevation (Figure 5a), or even above the original grade over a base of imported fill material (Figure 5b). There are additional installation requirements associated with at-grade or above grade channels that are necessary for best results:

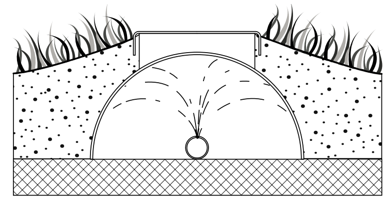


Figure 5a. SPDS installed at original surface elevation

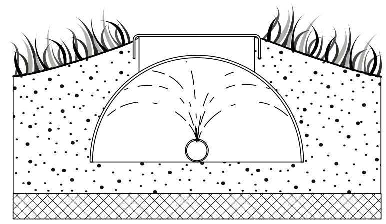


Figure 5b. SPDS installed above original surface elevation

Imported fill material

Native soil

Figures 5a and 5b. Surface-level and above surface-level installations of SPDSs

- The soil cover (or “cap”) should be the same textural class or one class finer than the natural topsoil.
- The dispersal area should be scarified to destroy the vegetative mat.
- The SPDS should be installed with a 9-foot (3-m) minimum separation between the edge of the fill and the nearest channel cover in all directions.
- Fill should be applied and worked in for a mixed boundary layer between the fill and the native soil. Fill material should be evenly graded to a final minimum depth of 10 inches (255 mm) over the channel covers. The cap should be of sufficient depth to stabilize the completed installation, support vegetative growth, and maintain a barrier against human or animal contact.

Discharge Pump System Design

The discharge pump system for an SPDS can pump from either a pump basin (Figure 6a) or a pump tank (Figure 6b).The discharge pump system consists of the following components:

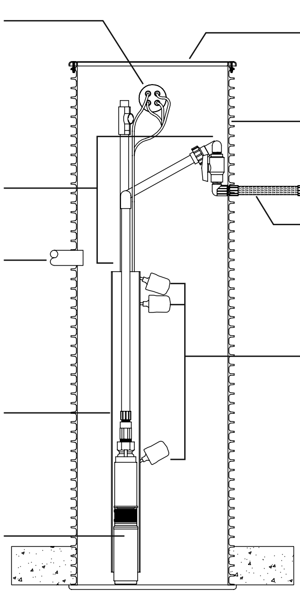


Figure 6a. Pump basin

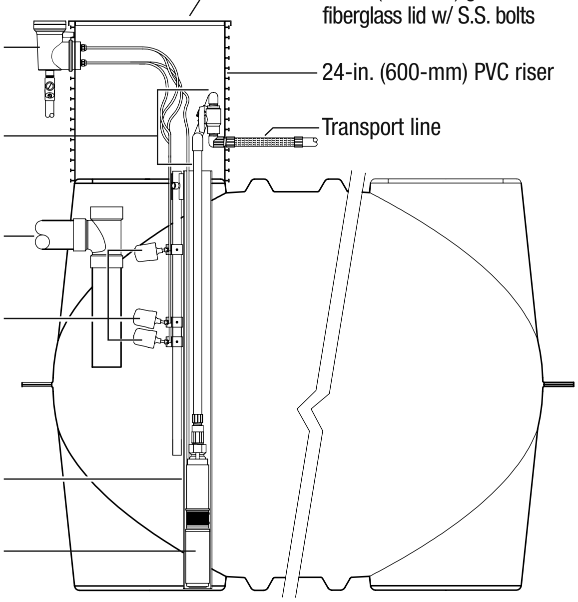


Figure 6b. Pump tank

Figure 6a and 6b. Pump discharge options

- Pump Vessel: A watertight 24-inch (600-mm) diameter pump basin or locally available concrete or fiberglass tank. All piping should be rated for the pressures it will be subjected to and be Schedule 40 PVC or equivalent.
- 4-inch (100-mm) Turbine Effluent Pump: A 100-mm diameter submersible turbine effluent pump should be used to dose an SPDS. Pumps of this type perform reliably through the frequent on/off cycling (for small frequent doses) that is required for dosing an SPDS. These pumps also provide increased scouring velocity under higher head conditions. (Ball, 1995)
- Flow Inducer: A cylindrical shaft placed within the pump vessel that houses the pump and is designed to help direct the liquid around the pump motor during pumping to keep the motor cool.
- Float Assembly: Float switches mounted on a float stem with collars for secure, easily adjustable mounting. The float assembly signals the liquid level positions to trigger alarms and control the pump.
- Discharge Assembly: An assembly that includes all the necessary piping (pipe, fittings, etc.) to convey effluent from a pump to the outside of a riser or pump basin.
- Transport Line: Piping used to transport effluent from the pump vessel to the discharge manifold. It should be installed at a constant ascending or descending grade from the pump vessel to the manifold. The size of the transport line is typically 1 inch (25 mm) or larger in diameter (nominal size).
- Control Panel: The control panel houses the electromechanical or digital components that control the pump and the preceding treatment system.

A discharge pump system is necessary in order to pressurize the SPDS to equally distribute the treated effluent and to control dosing. When designing a pressurized system, it's necessary to know the flow rate (Q_t) and total dynamic head (TDH) at which the pump needs to operate. Plotting the head versus flow rate for a particular system on a graph yields a system curve. When a system curve is plotted on the same graph and scale as a pump curve, the approximate operating point of the pump will be where the system curve intersects the pump curve.

A system curve can be drawn by plotting the TDH produced by the system at various desired flow rates. TDH can be calculated as the summation of the static lift, piping headlosses, and desired residual head. The use of the Hazen-Williams Equation, the empirical discharge assembly headloss equations, and the orifice equation allow fairly accurate TDH calculations. Widely available computerized pump selection software, such as Orenco's PumpSelect™ program, makes plotting of system curves quick and easy. For more information on Orenco's PumpSelect software, contact Orenco.

For example, consider a typical four-bedroom home with the following design parameters: (Calculations for this example in SI units are provided in Appendix A of this Technical Manual.)

Elevation of the tank liquid level = 100 ft
Elevation of the laterals = 130 ft
Static lift = 30 ft (130 - 100)
Total lateral line length, = 150 ft (three laterals, 50fteach, determined based on soil and site evaluation)
Drainfield area = 350 ft^2
Orifice spacing = 2 ft (25 per lateral)
Pump discharge assembly size = 1in.
Transport line, manifold line, and lateral line pipe size = 1 in.
Transport line (Schedule 40) length = 125 ft
Hazen-Williams coefficient = 150 (for PVC pipe)

Determine the pump flow rate and total dynamic head (TDH) as follows:

(A) The discharge rate for each orifice in a lateral (Q_o) is computed using the orifice equation.

$$Q_o = 12.4\, d^2 \sqrt{h}$$

Where:

d = diameter of orifice in millimeters (typically 0.125 in.)
h = meters of pressure head at the orifice (a minimum of 2 ft is required)

So:

$$Q_o = 12.4\,(0.125)^2 \sqrt{2} = 0.27 \text{ gpm/orifice}$$

(B) Nominal flow into each lateral (Q_l) is calculated by multiplying the number of orifices (n) by the discharge rate of each orifice.

$$Q_l = (n)(Q_o)$$

So:

$$Q_l = (25 \text{ orifices/lateral})(0.27 \text{ gpm/orifice}) = 6.75 \text{ gpm/lateral}$$

(C) Total flow for all laterals is calculated by multiplying the number of laterals by the nominal discharge rate to each lateral.

$$Q_t = 3\,(6.75 \text{ gpm/lateral}) = 20.3 \text{ gpm}$$

(D) TDH is calculated by adding all the head losses throughout the system.

$$TDH = H_s + H_{hv} + H_f + H_m + H_l + H_r$$

Where:

H_s = static loss (difference in height between the tank liquid level and the highest lateral)
H_m = manifold headloss (typically ranges from 0 to 2 ft, average 1 ft)
H_l = lateral line headloss (typically ranges from 0 to 2 ft, average 1 ft)
H_r = residual head pressure (squirt height)

Discharge assembly headloss (H_{hv}) is a function of line diameter and flow. The example values below represent discharge assemblies that include a check valve:

H_{hv} (1 in.) = $0.070Q^2$
H_{hv} (1¼ in.) = $0.007Q^2$
H_{hv} (1½ in.) = $0.003Q^2$
H_{hv} (2 in) = $0.002Q^2$

H_f = transport line headloss using a converted form of the Hazen-Williams Equation:

$$H_f = (10.5)(L)\left(\frac{Q}{C}\right)^{1.85} (D)^{-4.87}$$

Where:

H_f is head loss in meters; L is the length of pipe in meters; Q is the flow rate in L/sec; C is the Hazen-Williams coefficient; and D is the inside pipe diameter in millimeters.

So:

$$TDH = (130 - 100) + 0.070Q^2 + \left[(10.5)(L)\left(\frac{Q}{C}\right)^{1.85} (D)^{-4.87} \right] + 1 + 1 + 2$$
$$= 30 + 28.8 + 25.7 + 1 + 1 + 2$$
$$= 88.5 \text{ ft}$$

After going through the preceding calculations, we determine that the pump selected for this example needs to be able to produce a flow rate of at least 20.3 gpm at a total dynamic head of 88.5 feet. Figure 7 shows the system curve plotted in comparison to pump curves for a variety of different pumps. The figure shows that with the system curve used in this example, Pump A would operate at just slightly more than the required 20 gpm — the circled point where the system curve intersects the Pump A curve. To be conservative, Pump B, with an expected operating point of 24 gpm, would be a more appropriate choice.

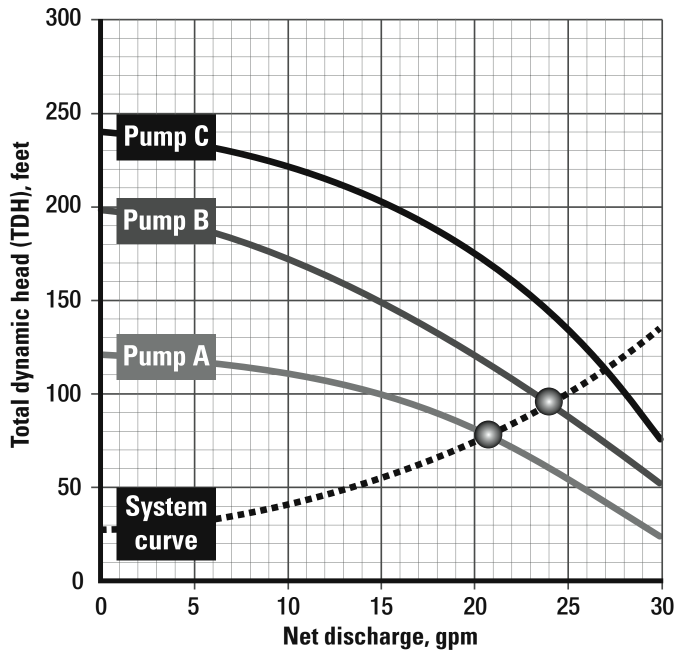


Figure 7. Sample system curve

Dosing

Using small frequent doses is the key to creating unsaturated aerobic conditions in the SPDS, thereby maximizing infiltrative capacity and preventing short-circuiting or preferential flow. Controlled dosing also enhances the treatment of residual contaminants, including organics and nitrogen, by spreading wastewater over a larger soil area and by controlling "holdup time" in the soil (Tchobanoglous and Leverenz, 2008, page 28). When dosing is not controlled, soil interstices may be filled with water, allowing contaminants to migrate long distances without coming in contact with soil particles; by contrast, when the amount of applied water is limited and the soil remains unsaturated, water migrates by capillary action and there is greater contact between wastewater and the surface of soil particles where biological transformations occur. Controlled dosing evens out the flow discharged to the dispersal field both spatially and over time. Effluent from a dosing tank is discharged in small, uniform doses over the course of the day instead of in concentrated slugs during peak times of system use, typically morning and evening. Another benefit of controlled dosing is that discharge pump event counters and elapsed time meters can help the operator detect unintended and undesirable water inflow from leaky tanks, leaky plumbing fixtures, etc. In addition to allowing detection of unintended inflows, it also protects the drainfield from being hydraulically overloaded, which can lead to failure.

Controlled dosing allows a specific amount of treated wastewater to be distributed evenly throughout the day. This objective is normally achieved using a timer, located in the control panel, to control the discharge pump on/off cycles. Two different approaches to controlled dosing are common. One approach is to control the discharge pump directly, using a timer rather than floats. The alternative approach, which is equally effective, may be used when the preceding treatment system is an intermittent or recirculating packed bed filter with timer-controlled dosing and built-in surge capacity — in this case, timed dosing to the filter sets the timed dosing regime for the discharge pump. Thus, the filter-dosing timer indirectly controls discharge pump cycle timing, which effectively accomplishes timed dosing.

For a timer-controlled discharge pump, it is recommended that the timer be set to deliver 12-24 doses to the soil absorption system daily. (In cold-weather applications, if the transport line and/or manifold and laterals are designed to drain following each dose, the pump "on" time must be sufficient to refill any drained lines, as well as deliver the required dose volume to the soil absorption system.)

The following examples show how controlled dosing can be achieved either by directly controlling the discharge pump by using a timer (Example 1) or by controlling the discharge pump indirectly through timed filter-dosing (Example 2).

Example 1, direct control of the discharge pump by timer

Use the same parameters from the sample four-bedroom home with the following additional assumptions:

200 gpd design flow
18 doses per day

The volume pumped with each dose cycle (V_p) can be calculated using this simple formula:

$$V_p = (D \div N) + (V_{rf})$$

Where:

D = actual flow (gal./day)
N = number of doses per day (in the recommended range of 12-24)
V_{rf} = refill volume (volume necessary to refill any drained lines)

For this example, assume that neither the transport line, manifold, or lateral lines are designed to drain following a dose. The volume pumped per dose is:

$$V_p = (200 \div 18) = 11.1 \text{ gallons}$$

The timer settings ("On" and "off" time) can then be calculated by the following simple formulas:

$$\text{On time (min.)} = V_p \div Q_d$$
$$\text{Off time (min.)} = (1440 \div N) - \text{(On time)}$$

Where:

Q_d = pump flow rate (L/sec)
N = number of doses per day (in the recommended range of 12-24)

For this example, the timer settings can now be calculated:

On time = 11.1 gal. ÷ 24 gpm = 30 sec
Off time = (1440 ÷ 18) - 0.5 = 79.5 min

Example 2, indirect control of the discharge pump by timed filter-dosing

A 30-gpm recirculation pump is used to dose an AdvanTex Treatment System. The normal recirculation pump timer is typically set for an "on" time of 0.3 minutes (or 20 seconds) and an "off" time of 19.7 minutes per cycle. Therefore, a dose of approximately 10 gallons is applied to the AdvanTex Treatment System every 20 minutes. Assuming that the recirculating splitter valve (RSV) is seated, 100% of this 10-gallon dose flows to the discharge vessel every 20 minutes. If the discharge vessel floats are set to deliver a 15-gallon dose (for a shallow drainfield of 150 lineal feet, covering a 300 ft^2 area), 0.04 gal./dose per square foot of drainfield area, or 0.1 gal./dose per square foot of channel surface area. The dispersal area will be dosed at approximately 30-minute intervals. When the RSV is not seated, all filtrate is returned to the primary compartment of the processing tank, the discharge pump is at rest, and the dispersal area is not dosed.

Of course this dosing pattern is dependent upon the discharge floats being set at the proper height to ensure a small dose is delivered — i.e., 10-5 gallons. This is easily accomplished by knowing the gallons per inch of the discharge vessel and setting the float "on" and "off" (activation/deactivation) points the necessary distance apart to achieve the desired dose volume.

Telemetry Requirements

The treatment system should be controlled by a telemetry monitoring system that alerts the service provider about changes in system operation and/or increased flow caused by leaking toilets, infiltration, etc, that could cause hydraulic overloading of the dispersal field.

Cold Weather Considerations

Small frequent dosing to the drainfield helps keep the lines from freezing, even in very cold climates. Where freezing is a concern, further protection can be provided by covering the transport line with appropriate insulation (such as Dow Blueboard) or by burying the transport line deeper where possible. Where necessary to protect them from freezing, the transport line, manifold, and lateral lines can be installed so that they completely drain following each dose. This can be accomplished by drilling one of the orifices in each lateral in the downward position and by utilizing a drainback-style hose and valve assembly in the pump tank. A constant slope with no dips or swales must be maintained in the transport line to ensure complete drainage.

Infiltration Test Kit Setup and Testing

This section explains how to set up an Orenco® Infiltration Test Kit and perform a test to determine the infiltrative capacity of soil before installing an SPDS. Once the infiltrative capacity of the soil is determined, the information can be used to select an appropriate hydraulic loading rate for sizing the dispersal system. An SPDS must be dosed with small volumes of effluent: just enough to cover the bottom of the infiltration channel to a depth of ¼ to ½ inch (6 to 13 mm). Small doses prevent saturated flow, so that the occurrence of preferential flow paths is eliminated and conditions in the dispersal area remain aerobic. The dose frequency depends on the daily volume to be dispersed and the acceptable loading rate in gallons per square foot per day (or liters per square meter per day). The loading rate, in turn, is limited by the soil's infiltrative capacity and may also be limited by local regulations.

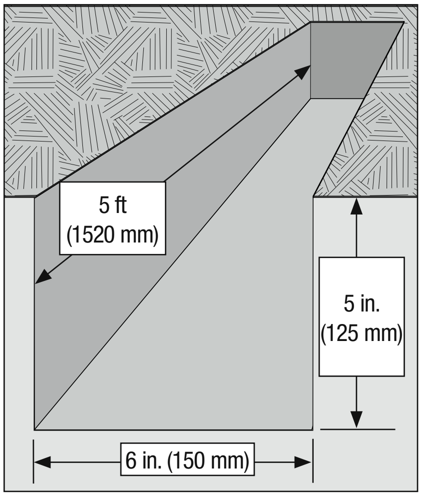


Figure 8. Dig infiltration test channel (Step 2)

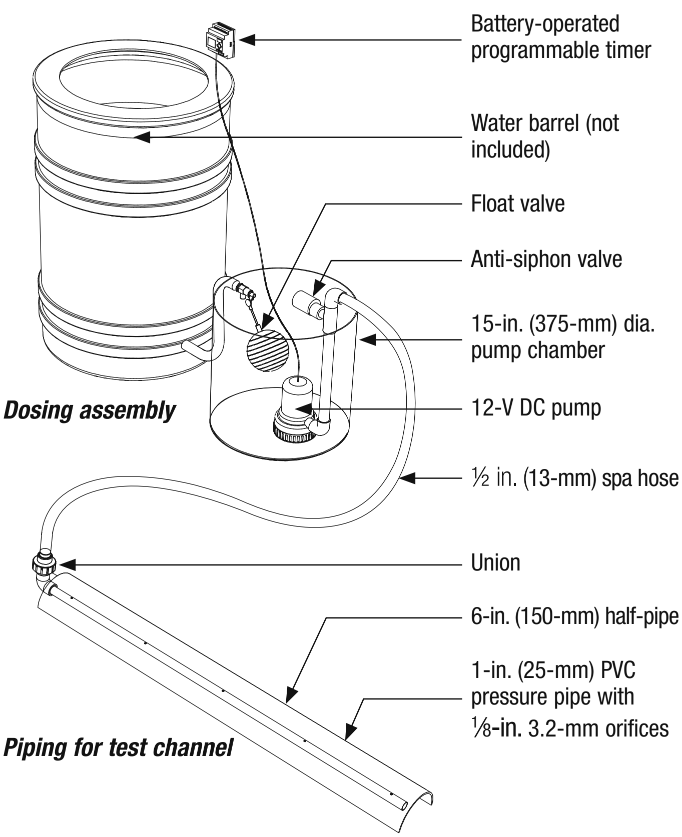


Figure 9. Infiltration test kit (specific components may vary between kits.)

The Orenco Infiltration Test Kit helps to determine the infiltrative capacity of the soil and, therefore, the correct loading rate and dose frequency for the SPDS. Clean household water is used with the test kit because it provides a valid measurement of the soil's infiltrative capacity when an SPDS is dosed with the high-quality effluent produced by an AdvanTex® Treatment System (median effluent $CBOD_5$ and TSS concentration of 10 mg/L or better), operated according to the manufacturer's recommendations.

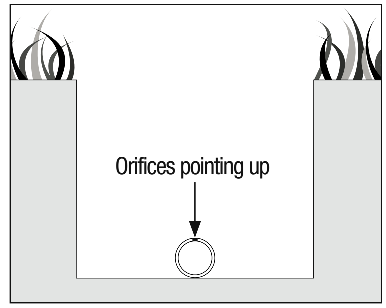


Figure 10. Place pressure pipe

Step 1: Check Control Panel Battery

Check the control panel battery; make sure it is fully charged for the test.

Step 2: Dig Infiltration Test Channel

Dig a level test channel 6 in. wide × 5 in. deep × 5 ft long (150 mm × 125 mm × 1520 mm) as shown in Figure 8. Avoid smearing the channel surfaces and be sure the channel floor is level.

Step 3: Set Up Test Kit

Set up the test equipment as shown in Figure 9. If possible, set the bottom of the water barrel at a higher elevation than the top of the pump chamber.

Step 4: Place Pressure Pipe

Place the 1-in. (25-mm) PVC pipe in the bottom of the channel, orifices pointing up, as shown in Figure 10.

Step 5: Calculate Dosing Parameters

Use the following calculations to determine the pump timer settings needed in order to run the infiltration test. These calculations are based on the anticipated infiltration rate of the soil. Calculations for dosing parameters in SI units are provided in Appendix A of this Technical Manual.

Step 5a: Determine the 24-hour daily applied volume (V_{daily}) at the anticipated infiltration rate of the soil. For example, if the loading rate to be tested is 5 gal./ft²/day, then given the test channel bottom dimensions of 0.5 ft × 5 ft = 2.5 ft²:

$$V_{daily} = 5 \text{ gal./ft}^2\text{/day} \times 2.5 \text{ ft}^2 = 12.5 \text{ gpd}$$

Step 5b: Determine the volume of water per dose. Timer settings should be selected to deliver just enough water to cover the bottom of the infiltration test channel to a depth of ¼ to ½ inches. For conducting the test, the dose volume (V_{dose}) is calculated, based on the specified test channel dimensions, to deliver ½ inch of water to the infiltration channel with each dose:

$$V_{dose} = (0.5 \text{ in} \div 12 \text{ in./ft}) \times 5 \text{ ft} \times 0.5 \text{ ft} \times 7.48 \text{ gal./ft}^3 = 0.78 \text{ gal./dose}$$

Step 5c: Determine the pump flow rate (Q) in gallons per minute. Fill the pump chamber, and then measure and record the water level in the chamber to the nearest $^1/_{16}$ in. (or millimeter for calculations using SI measurements). Turn the "AUTO/OFF/MAN" switch on the pump to "MAN" and, using a watch or timer to track run time, allow the pump to run for 60 seconds. Make sure that water doesn't flow into the pump chamber while the water is being pumped down. Measure the water level again, and then determine the change in water level.

The 15-inch (375-mm) diameter pump chamber has a capacity of 0.76 gal./in. (0.113 L/mm. To determine the pump flow rate, multiply the water level change by the pump chamber capacity. For example, if the water level drops by 2.75 inches (70 mm) in 60 seconds, the pump flow rate is:

$$Q = (2.75 \text{ in.} \times 0.76 \text{ gal./in.}) / (60 \text{ sec}) = 2.09 \text{ gal./min}$$

Step 5d: Determine the total pump run time over a 24-hour day:

$$T_{daily} = (V_{daily} \div Q)$$

Continuing with the example:

$$T_{daily} = (12.5 \text{ gal./day} \div 2.09 \text{ gal./min}) = 360 \text{ sec/day or } 6 \text{ min/day}$$

Step 5e: Determine the number of doses per day (N):

$$N = V_{daily}/V_{dose}$$

Continuing with the example, if the daily applied volume (V_{daily}) = 12.5 gal./day, and the dose volume (V_{dose}) delivered to the infiltration test channel will be 0.78 gal./dose, then:

$$N = 12.5 \text{ gal.day} \div 0.78 \text{ gal./dose} = 16 \text{ doses/day.}$$

Step 5f: Determine the pump run time per dose, in seconds:

$$T_{dose} = T_{daily} \div N$$

Continuing with the example:

$$T_{dose} = 360 \text{ sec/day} \div 16 \text{ doses/day} = 23 \text{ sec/dose}$$

Step 5g: Determine the pump off interval (T_{off}) between doses, in minutes:

$$T_{off} = (1440 \text{ min/day} - T_{daily} \text{ min/day}) \div N$$

Continuing with the example:

$$T_{off} = (1440 \text{ min/day} - 6 \text{ min/day}) \div 16 \text{ doses/day} = 89.6 \text{ minutes/dose (round off to 90 minutes)}$$

After completing these calculations, set the pump timer as described in Step 6 and verify the actual water acceptance rate of the soil by conducting the infiltration test described in Step 7. If the test indicates that the actual acceptance rate is lower than the rate tested, recalculate the dosing parameters using a lower anticipated infiltration rate and repeat the test as necessary.

***NOTE:** Be sure to maintain the water supply to the pump during the test.*

Step 6: Set Pump Timer

Set the programmable pump timer using the T_{dose} and T_{off} times determined in Steps 5f and 5g.

Continuing with the example in Steps 5f and 5g, the timer settings would be 90 minutes off and 23 seconds on.

Step 7: Run Infiltration Test

Step 7a: Place the 6-inch (150-mm) half-pipe over the pressure pipe and activate the programmed pumping. Be sure to maintain the water supply to the pump during the test.

Step 7b: Allow the infiltration test to run for a minimum of 24 hours. Be sure the water supply to the pump is maintained during the infiltration test. (See Figure 11)

Step 7c: If, after a day or more of dosing at a given rate, no continuous ponding occurs, that loading rate can be considered acceptable for the soil. We recommend, however, that a conservative safety factor of two be applied when selecting the actual hydraulic loading rate for designing the SPDS.

***NOTE:** For sites where groundwater mounding is a concern, wider than typical channel spacing may be necessary.*

Figure 11. Run infiltration test

SPDS Installation and Maintenance

Installing the SPDS

There are two typical configurations for SPDS channels. (See Figure 12.) One consists of perforated laterals laid in a 12-inch (300-mm) wide infiltration channel, covered with sections of plastic half-pipe and shallowly buried in native soil. The other uses a 18-inch (460-mm) infiltration channel and 16-inch (400-mm) Infiltrator® low-profile chamber sections.

Check your design plans against the Orenco® SPDS kit to be sure you have the correct parts in the correct quantities for the installation. In addition to the SPDS kit, make sure you have the following tools and supplies:

- Laser level or other leveling device
- Rotary tiller, shovel, or other excavation tools
- Leaf rake or garden claw
- Landscape staples (if half-pipe is being curved)
- Miscellaneous fittings (if needed)
- Appropriate fill material (if native fill cannot be used)

Additionally, study the system plans and read the installation instructions thoroughly before installing the SPDS.

Step 1: Dig Infiltration Channels

Step 1a: Check your system plans for the correct infiltration channel depth for your system, as well as the distance between the channels. Your system plans should include the correct depth and separation for the infiltration channels, based on the type of soil present and the depth to groundwater or a limiting layer.

Step 1b: Dig the channels. In most soils, the channels can be dug with a rotary tiller and a shovel. When using PVC half-pipe channel covers, the channels are typically about 12 inches (300 mm) wide, but narrower channels may be used where allowed by local regulations. When using Infiltrator® low-profile chambers, channels are 18 inches (460 mm) wide to accommodate the 16-inch (400-mm) wide chamber sections. As noted above, channels can be straight, or they can be curved to fit terrain and avoid vegetation, but they must be set on level grade. (See Figure 13.)

Step 1c: When removing loose soil from the channels, take care not to smear the soil along the walls and bed of the channel.

Step 2: Lay Lateral Piping

Step 2a: Remove the plugs from the ends of the perforated lateral pipes, and lay the piping along the center of the channel with the holes facing straight up. Connect the sections with couplings. Once the pipes are laid out, glue all the joints with PVC primer and cement, making sure the holes in the pipe are facing straight up. If curving lines, additional elbows may be necessary. Landscape staples can also be used to curve the pipe and maintain its position in the channel. (See Figure 14.)

Step 2b: At the end of each lateral, install a sweep ell (or two 45° elbows) and a ball valve with a threaded plug. (See Figure 15.)

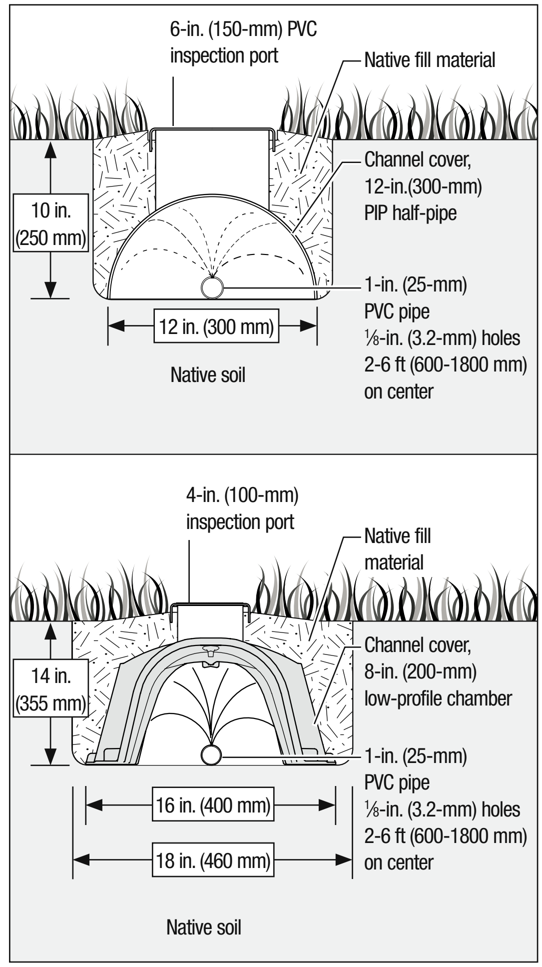


Figure 12. Typical SPDS cross sections showing dimensions and materials

Figure 13. Channels can be excavated to accommodate landscaping features

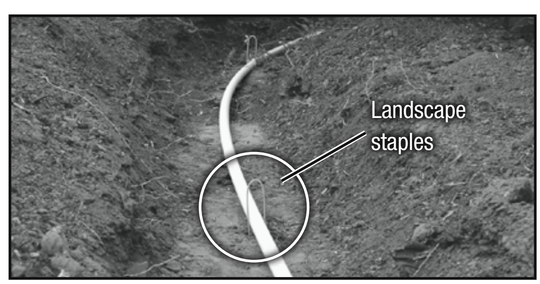


Figure 14. Landscape staples can be used to maintain lateral pipe position

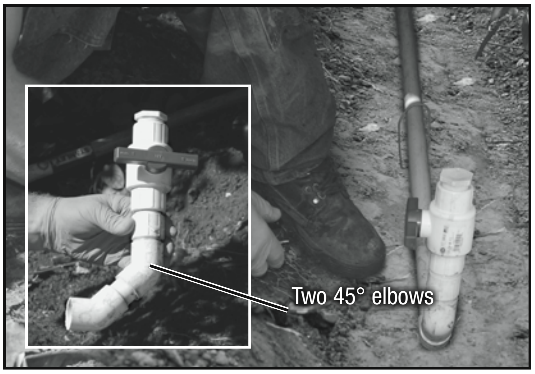


Figure 15. Install a sweep ell (or two 45° elbows) and a ball valve with a threaded plug

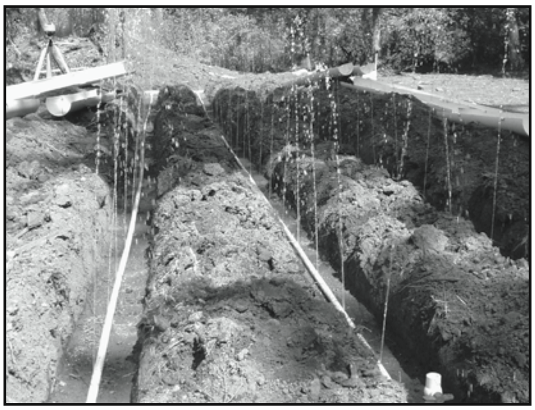


Figure 16. Measure squirt height

Figure 17. Cover the lateral pipe with half-pipe or low-profile chamber material

Step 3: Test System and Lay Half-Pipes over Laterals

Step 3a: With the pump running in the manual position, individually open the ball valve at the end of each lateral, one at a time, for 5 or 10 seconds to flush out any construction debris from the manifold piping. Be sure all lateral valves are completely closed after flushing is complete.

Step 3b: With the pump still running manually, measure the squirt height with a tape measure. (See Figure 16.) The squirt height should measure approximately 3-6 feet (0.6-1.5 m). Windy conditions will cause the squirt heights to measure less. For more accurate squirt height measurements, attach a piece of clear PVC pipe to the end of the lateral. Record the squirt height measurement at start-up and before and after servicing.

Step 3c: Lay the half-pipe (or Infiltrator® low-profile chamber) sections over the laterals, overlapping the section ends by about 2 ½ inches (60 mm). (See Figure 17.) For covering curving laterals, half-pipe section ends can be cut at an angle and overlapped to match the curve of the lateral. Install one inspection port halfway along each lateral

Step 3d: Install the valve box over the ball valves at the end of each lateral.

Step 4: Backfill with Native Soil

Step 4a: Backfill the excavation with caution. Do not compact the soil around the half-pipe or chamber.

Step 4b: Native material is acceptable if there are no large or sharp rocks that may damage the pipe walls. If native material is not usable, backfill with sand or pea gravel, or use an imported material that is approved by your local regulator.

Maintaining the SPDS

SPDSs require very little maintenance but should be inspected at least annually, at the same time the AdvanTex Treatment System is being inspected and maintained.

Step 1: Check Inspection Ports

Check each of the inspection ports (one per line) to see whether ponding is occurring in the infiltration channels.

Step 2: Verify Squirt Height

Verify the squirt height at the end of each lateral.

Step 3: Flush Laterals if Necessary

Provided that the effluent applied to the SPDS meets the recommended high level of quality (median $CBOD_5$ and TSS of 10 mg/L or less), it should not be necessary to flush the lateral lines when performing routine maintenance. However, if the observed squirt height has deteriorated significantly, the lateral lines may need to be flushed.

NOTE: *In this case, the AdvanTex® Treatment System should be checked for proper operation.*

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The following works were referenced in the development of this paper.

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Regulatory Examples

The following are examples of the rules and guidance for SPDSs adopted by various regulatory jurisdictions.

1) Oregon, USA
   a) Dispersal system size reductions (infiltrative surface) are given for advanced treatment and shallow narrow drainfields.
   b) Separation distance allowed from a temporary water table:
      i) <12% slope, no separation distance is required
      ii) >12% slope, 6-in. separation distance is required
   c) Separation distance allowed from a permanent water table:
      i) Soil Group A (Sand, Loamy Sand, Sandy Loam): 24 in.
      ii) Soil Group B (Loam, Silt Loam, Sandy Clay Loam, Clay Loam):18 in.
      iii) Soil Group C (Silty Clay Loam, Silty Clay, Sandy Clay, Clay): 12 in.
   d) 4-bedroom home example:
      i) 450 gpd design flow
      ii) Soil Group A: 4.28 gpd/ft^2
      iii) Soil Group B: 3.33 gpd/ft^2
      iv) Soil Group C: 3.0 gpd/ft^2
      v) Permeable saprolite or fractured bedrock: 3.0 gpd/ft^2
      vi) Vertisols (high shrink-swell clays): Not allowed
2) British Columbia, Canada
   a) Infiltration channel design is very similar to what is allowed in Oregon. A whole section on Shallow Narrow Drainfields is included in Best Practices Manual. Support pipes placed under the half-pipe are recommended to address the perception that the half-pipe would cut into the soil.

b) Increased loading rates are allowed based upon effluent quality and LTAR. Appendix G of the Best Practices Manual includes a formula for sizing the drainfield.

3) Rhode Island, USA

a) Infiltration channel design is very close to what is allowed in Oregon: 8- to 12-in. depth and 12-in. width. However, a 5-ft center-to-center infiltration channel spacing is required vs. Oregon's allowance of 3-ft center-to-center spacing.

b) An increase in hydraulic loading rate (infiltrative surface) is allowed when being dosed with wastewater below 30 mg/L BOD and TSS. Loading rates depend on soil texture, structure, and consistence and vary from 2.3 to 3.7 gpd/ft^2.

Appendix A: Calculations in SI Units

Discharge Pump System Design Example, SI Units

Sample design parameters for a four-bedroom home:

Elevation of the tank liquid level = 30 m
Elevation of the laterals = 40 m
Static lift = 10 m (40 - 30)
Total lateral line length, = 45 m (three laterals, 15 m each, determined based on soil and site evaluation)
Drainfield area = 35 m^2
Orifice spacing = 0.6 m (25 per lateral)
Pump discharge assembly size = 25 mm
Transport line, manifold line, and lateral line pipe size = 25 mm
Transport line (Schedule 40) length = 40 m
Hazen-Williams coefficient = 150 (for PVC pipe)

Determine the pump flow rate and total dynamic head (TDH) as follows:

(A) The discharge rate for each orifice in a lateral (Q_o) is computed using the orifice equation.

$$Q_o = 0.00220\ d^2 \sqrt{h}$$

Where:
d = diameter of orifice in millimeters (typically 3.2)
h = meters of pressure head at the orifice (a minimum of 0.6 m is required)

So:

$$Q_o = 0.0220\ (3.2)^2 \sqrt{0.6}$$
$$= 0.018 \text{ L/sec/orifice}$$

(B) Nominal flow into each lateral (Q_l) is calculated by multiplying the number of orifices (n) by the discharge rate of each orifice.

$$Q_l = (n)(Q_o)$$

So:

$$Q_l = (25 \text{ orifices/lateral})(0.018 \text{ L/sec/orifice})$$
$$= 0.450 \text{ L/sec/lateral}$$

(C) Total flow for all laterals is calculated by multiplying the number of laterals by the nominal discharge rate to each lateral.

$$Q_t = 3\ (0.450 \text{ L/sec/lateral}) = 1.35 \text{ L/sec}$$

(D) TDH is calculated by adding all the head losses throughout the system.

$$TDH = H_s + H_{hv} + H_f + H_m + H_l + H_r$$

Where:
H_s = static loss (difference in height between the tank liquid level and the highest lateral)
H_m = manifold headloss (ranges from 0 to 0.5 m)
H_l = lateral line headloss (ranges from 0 to 0.5 m)
H_r = residual head pressure (squirt height)

Discharge assembly headloss (H_{hv}) is a function of line diameter and flow. The example values below represent discharge assemblies that include a check valve:

H_{hv} (25 mm) = $5.38Q^2$
H_{hv} (32 mm) = $0.538Q^2$
H_{hv} (40 mm) = $0.230Q^2$
H_{hv} (50 mm) = $0.154Q^2$

H_f = transport line headloss using a converted form of the Hazen-Williams Equation:

$$H_f = (1.2 \times 10^{10})(L)\left(\frac{Q}{C}\right)^{1.85} (D)^{-4.87}$$

Where:
H_f is head loss in meters; L is the length of pipe in meters; Q is the flow rate in L/sec; C is the Hazen-Williams coefficient; and D is the inside pipe diameter in millimeters.

So:

$$TDH = (40 - 30) + 5.38Q^2 + \left[(1.2 \times 10^{10})(L)\left(\frac{Q}{C}\right)^{1.85} (D)^{-4.87}\right] + 0.25 + 0.25 + 0.6$$
$$= 10 + 9.09 + 8.45 + 0.25 + 0.25 + 0.6$$
$$= 28.7 \text{ m}$$

Dosing Examples, SI Units

Example 1, direct control of the discharge pump by timer

Use the same parameters from the sample four-bedroom home with the following additional assumptions:

750 L/day design flow
18 doses per day

The volume pumped with each dose cycle (V_p) can be calculated using this simple formula:

$$V_p = (D \div N) + (V_{rf})$$

Where:
D = actual flow (L/day)
N = number of doses per day (in the recommended range of 12-24)
V_{rf} = refill volume (volume necessary to refill any drained lines)

For this example, assume that neither the transport line, manifold, or lateral lines are designed to drain following a dose. The volume pumped per dose is:

$$V_p = (750 \div 18)$$
$$= 42.7 \text{ liters}$$

The timer settings ("On" and "off" time) can then be calculated by the following simple formulas:

On time (min.) = $V_p \div Q_d$
Off time (min.) = $(1440 \div N)$ - (On time)

Where:
Q_d = pump flow rate (L/sec)
N = number of doses per day (in the recommended range of 12-24)

For this example, the timer settings can now be calculated:

On time = 42.7 L ÷ 1.6 L/sec = 30 sec
Off time = (1440 ÷ 18) - 0.5 = 79.5 min

Example 2, indirect control of the discharge pump by timed filter-dosing

A 1.9-L/sec recirculation pump is used to dose an AdvanTex Treatment System. The normal recirculation pump timer is typically set for an "on" time of 0.3 minutes (or 20 seconds) and an "off" time of 19.7 minutes per cycle. Therefore, a dose of approximately 37.9 liters is applied to the AdvanTex Treatment System every 20 minutes. Assuming that the recirculating splitter valve (RSV) is seated, 100% of this 37.9-liter dose flows to the discharge vessel every 20 minutes. If the discharge vessel floats are set to deliver a 56.8-liter dose (for a shallow drainfield of 45.75 m, covering a 32.5 m^2 area), this corresponds to a hydraulic loading rate of 1.75 L/dose per square meter of drainfield area, or 4.1 L/dose per square meter of channel surface area. The dispersal area will be dosed at approximately 30-minute intervals. When the RSV is not seated, all filtrate is returned to the primary compartment of the processing tank, the discharge pump is at rest, and the dispersal area is not dosed.

Infiltrator Test Kit Pump Timer Setting Examples, SI Units

Step 5a: Determine the 24-hour daily applied volume (V_{daily}) at the anticipated infiltration rate of the soil. For example, if the loading rate to be tested is 200 L/m^2/day, then given the test channel bottom dimensions of 150 mm × 1520 mm = 0.225 m^2:

$$V_{daily} = 200\ \text{L/m}^2\text{/day} \times 0.225\ \text{m}^2 = 45\ \text{L/day}$$

Step 5b: Determine the volume of water per dose. Timer settings should be selected to deliver just enough water to cover the bottom of the infiltration test channel to a depth of 5 to 15 mm. For conducting the test, the dose volume (V_{dose}) is calculated, based on the specified test channel dimensions, to deliver 10 mm of water to the infiltration channel with each dose:

$$V_{dose} = (10\ \text{mm}) \times 1520\ \text{mm} \times 150\ \text{mm} = 2.3\ \text{L/dose}$$

Step 5c: Determine the pump flow rate (Q) in L/sec. Fill the pump chamber, and then measure and record the water level in the chamber to the nearest mm. Turn the “AUTO/OFF/MAN” switch on the pump to “MAN” and, using a watch or timer to track run time, allow the pump to run for 60 seconds. Make sure that water doesn’t flow into the pump chamber while the water is being pumped down. Measure the water level again, and then determine the change in water level.

The 375-mm diameter pump chamber has a capacity of 0.113 L/mm. To determine the pump flow rate, multiply the water level change by the pump chamber capacity. For example, if the water level drops by 70 mm in sixty seconds, the pump flow rate is:

$$Q = (70\ \text{mm} \times 0.113\ \text{L/mm}) / (60\ \text{sec}) = 0.132\ \text{L/sec}$$

Step 5d: Determine the total pump run time over a 24-hour day:

$$T_{daily} = (V_{daily} \div Q)$$

Continuing with the example:

$$T_{daily} = (45\ \text{L/day} \div 0.132\ \text{L/sec}) = 341\ \text{sec/day or } 6\ \text{min/day}$$

Step 5e: Determine the number of doses per day (N):

$$N = V_{daily}/V_{dose}$$

Continuing with the example, if the daily applied volume (V_{daily}) = 46 L/day, and the dose volume (V_{dose}) delivered to the infiltration test channel will be 3.0 L/dose, then:

$$N = 45\ \text{L/day} \div 2.3\ \text{L/dose} = 20\ \text{doses/day.}$$

Step 5f: Determine the pump run time per dose, in seconds:

$$T_{dose} = T_{daily} \div N$$

Continuing with the example:

$$T_{dose} = 341\ \text{sec/day} \div 20\ \text{doses/day} = 17\ \text{sec/dose}$$

Step 5g: Determine the pump off interval (T_{off}) between doses, in minutes:

$$T_{off} = (1440\ \text{min/day} - T_{daily}\ \text{min/day}) \div N$$

Continuing with the example:

$$T_{off} = (1440\ \text{min/day} - 6\ \text{min/day}) \div 20\ \text{doses/day} = 71.7\ \text{minutes/dose (round off to 70 minutes)}$$