SPLIT BED RECIRCULATING SAND FILTER SYSTEM COMPONENT MANUAL FOR PRIVATE ONSITE WASTEWATER TREATMENT SYSTEMS

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I. INTRODUCTION AND SPECIFICATIONS

This Private Onsite Wastewater Treatment System (POWTS) component manual provides design, construction, inspection, operation, and maintenance specifications for a split bed recirculating sand filter system component. However, these items must accompany a properly prepared and reviewed plan acceptable to the governing unit to help provide a system that can be installed and function properly. Violations of this manual constitute a violation of chs. Comm 83 and 84, Wis. Adm. Code. The split bed recirculating sand filter system component must receive influent flows and loads less than or equal to those specified in Table 1.

When designed, installed, operated and maintained in accordance with the provisions of this manual, the split bed recirculating sand filter system provides high quality treatment of domestic wastewater. Effluent quality from this process will typically average ≤ 10 mg/L for BOD_5, ≤ 10 mg/L for TSS, ≤ 20 mg/L for total nitrogen, and ≤ 10,000 cfu/100 ml for fecal coliform when wastewater characteristics are within the ranges specified in Tables 1 to 3.

Note: Detailed plans and specifications must be developed, and submitted for review and approval by the governing unit having authority over the plan for the installation. Also a Sanitary Permit must be obtained from the department or governmental unit having jurisdiction. See Section X for more details.

Table 1
INFLUENT FLOWS AND LOADS

SEPTIC/RECIRCULATION TANK	
Design wastewater flow (DWF)	≤ 2250 gal/day
Monthly average value of Fat, Oil and Grease (FOG)	≤ 30 mg/L
Monthly average value of five day Biochemical Oxygen Demand (BOD_5)	≤ 300 mg/L
Monthly average value of Total Suspended Solids (TSS)	≤ 400 mg/L
Monthly average of Total Nitrogen (TN)	≤ 180 mg/L

Table 1 **INFLUENT FLOWS AND LOADS** (continued)		
Design wastewater flow (DWF) from one and two-family dwellings	≤ 150 gal/day/bedroom	
Design wastewater flow (DWF) from public facilities	≥ 150% of estimated wastewater flow in accordance with Table 4 of this manual or s. Comm 83.43 (6), Wis. Adm. Code	
Forward flow	= Design wastewater flow (DWF)	
FILTER BED DOSE TANK		
Wastewater particle size	≤ 1/8 inch	
FILTER BED		
Design filter bed flow ratio	2:1	
Loading rate based on DWF	Recirculation side 8.0 gpd/ft^2	Effluent side 5.5 gpd/ft^2
Area per spray head	≤ Manufacturer's specifications	
Difference in flow between any two spray heads	≤ 5 %	
Dose frequency	48 to 144 times per day (Every 10 – 30 minutes)	
Volume of a single dose	DWF x recirculation rate ÷ dose frequency	

<table>
<tr><th colspan="4">Table 2
SIZE</th></tr>
<tr><th colspan="4">SEPTIC/RECIRCULATION TANK</th></tr>
<tr><td rowspan="2">Volume when DWF is:</td><td colspan="3">Multiplier used to calculate volume of tank</td></tr>
<tr><td>Septic/recirculation tank with no primary septic tank preceding</td><td>Primary septic tank preceding septic/recirculation tank</td><td>Septic/recirculation tank with primary septic tank preceding</td></tr>
<tr><td>≤ 300 gpd</td><td>4.2</td><td>2.5</td><td>1.0</td></tr>
<tr><td>> 300 and ≤ 450 gpd</td><td>3.7</td><td>2.0</td><td>1.0</td></tr>
<tr><td>> 450 and ≤ 900 gpd</td><td>3.2</td><td>1.5</td><td>1.0</td></tr>
<tr><td>> 900 and ≤ 1500 gpd</td><td>2.7</td><td>1.3</td><td>1.0</td></tr>
<tr><td>> 1500 gpd</td><td>2.2</td><td>1.0</td><td>1.0</td></tr>
<tr><th colspan="4">FILTER BED DOSE TANK</th></tr>
<tr><td colspan="2">Permanent liquid depth</td><td colspan="2">≥ One inch + pump off level</td></tr>
<tr><td colspan="2">Working Volume when DWF is:</td><td colspan="2">Volume</td></tr>
<tr><td colspan="2">≤ 300 gpd</td><td colspan="2">≥ DWF x 0.75</td></tr>
<tr><td colspan="2">> 300 and ≤ 450 gpd</td><td colspan="2">≥ DWF x 0.70</td></tr>
<tr><td colspan="2">> 450 and ≤ 600 gpd</td><td colspan="2">≥ DWF x 0.65</td></tr>
<tr><td colspan="2">> 600 and ≤ 750 gpd</td><td colspan="2">≥ DWF x 0.60</td></tr>
<tr><td colspan="2">> 750 and ≤ 900 gpd</td><td colspan="2">≥ DWF x 0.55</td></tr>
<tr><td colspan="2">> 900 and ≤ 1500 gpd</td><td colspan="2">≥ DWF x 0.50</td></tr>
<tr><td colspan="2">> 1500 gpd</td><td colspan="2">≥ DWF x 0.45</td></tr>
<tr><td colspan="2">Emergency volume</td><td>With simplex pump
≥ DWF</td><td>With duplex pumps
≥ 1/6 DWF</td></tr>
<tr><td colspan="2">Recirculation Ratio</td><td colspan="2">3.5:1</td></tr>
<tr><th colspan="4">FILTER BED</th></tr>
<tr><td>Area of filter bed</td><td colspan="2">Recirculation side:
2/3DWF ÷ 8.0 gpd/ft²</td><td>Effluent side:
1/3DWF ÷ 5.5 gpd/ft²</td></tr>
<tr><td colspan="2">Depth of filter bed container</td><td colspan="2">≥ 44 inches</td></tr>
</table>

Table 3 OTHER SPECIFICATIONS	
Piping material	Meet requirements of s. Comm 84.30 (2), Wis. Adm. Code for its intended use
Tanks	Meets requirements of s. Comm 84.25, Wis. Adm. Code
Liner (recirculation container)	≥ 30 Mil. PVC or ≥ 45 Mil. EPDM
Pipe size of underdrain	≥ 3 inch diameter
Underdrain aggregate material	- Meets ASTM Standard C33 for coarse aggregate - Be washed to remove fine material - Be ¾ to 1-1/2 inch in size with < 1% passing ¾" sieve - Have hardness value of ≥ 3 on Moh's Scale of Hardness
Pea gravel	- Meets ASTM Standard C33 for coarse aggregate - Be washed to remove fine material - Be 1/4 to 1/2 inch in size with < 1% passing 1/4" sieve - Have hardness value of ≥ 3 on Moh's Scale of Hardness
Barrier material	- Be of material that will not degrade - Consist of approximately 95% open area and capaible of providing a free passage of water - Be capaible of preventing prentitration of an air hose during cleaning of the filter media - Be equivalent to Enkamat 7010 or Tensar TM3000

Table 3 **OTHER SPECIFICATIONS** (continued)	
Filtration media for recirculation side	- Effective size of 2 to 6 mm - Uniformity coefficient of < 2.0 - Free of fines with < 1% by weight passing #30 sieve - Have hardness value of ≥ 3 on Moh's Scale of Hardness
Filtration media for effluent side	- Effective size of 1 to 2.5 mm - Uniformity coefficient of < 1.5 - Free of fines with < 1% by weight passing #50 sieve - Have hardness value of ≥ 3 on Moh's Scale of Hardness
Depth of underdrain aggregate	≥ 6 inches
Depth of filter media	≥ 24 inches
Head pressure on spray head	≥ 2.5 feet
Installation inspection	In accordance with ch. Comm 83 Wis. Adm. Code
Management	In accordance with ch. Comm 83 Wis. Adm. Code

II. DEFINITIONS

Definitions unique to this manual are included in this section. Other definitions that may apply to this manual are located in ch. Comm 81 of the Wis. Adm. Code or the terms use the standard dictionary definition.

- "Design filter bed flow ratio" means the ratio of flow onto the recirculation side of the filter bed to the flow onto the effluent side of the filter bed.
- "Effluent by-pass valve" means a valve installed in the drain line from the effluent side of the filter bed that opens when water level in the filter bed dosing tank drops to a preset level, allowing drainage from the effluent side of the filter bed to discharge into the filter bed dosing tank instead of flowing to the final effluent tank or dispersal field.

- "Effluent side" means the portion of the filter bed from which drainage is routed to the final effluent tank or dispersal field, except when the effluent by-pass valve is open, in which case this flow is routed into the filter bed dosing tank.

- "Emergency storage" means the volume available within a tank or chamber to contain a defined amount of water above the high water alarm level.

- "Filter bed" means the layers of media over which influent wastewater from the filter bed dosing tank is distributed and through which it is filtered. The filter bed is composed of a recirculation side and an effluent side.

- "Filter bed dosing tank" is a tank or chamber containing the pump system that doses effluent from the septic/recirculation tank onto the filter bed. A filter bed dosing pump system is installed in this tank or chamber. This tank or chamber contains sufficient volume to provide a liquid level depth, a working volume, and an emergency storage volume.

- "Final effluent tank" means a tank or chamber that receives flow from the effluent side of the filter and stores it for dosing into a dispersal field. An effluent pump system to pressure dose the dispersal field is installed in the final effluent tank or chamber. This tank or chamber contains sufficient volume to provide a liquid level depth, the volume of a dose to the dispersal field, and an emergency storage volume.

- FOG means the concentration of fats, oils and grease in the raw wastewater flowing into the treatment system.

- "Forward flow" means the design daily wastewater flow rate for the system.

- "HRT" means hydraulic retention time, which is the tank or chamber volume divided by the forward flow rate running through it, expressed in hours or days.

- "Hydraulic loading rate" means the forward flow divided by the filter bed area.

- "Permanent liquid depth" means a water depth the system is designed to ensure remains in a pump chamber to provide cooling and protection against running dry for the pump(s).

- "Recirculation loop" means the flow path of effluent from the recirculation side of the filter bed, routing this effluent through the septic/recirculation tank.

- "Recirculation ratio" means the ratio of the total flow onto the filter bed to the forward flow rate = (recirculation flow + forward flow)/forward flow.

- "Recirculation side" means the portion of the filter bed from which drainage is routed through the recirculation loop.

- "Sand filter" means the generic concept of porous media filtration identified by this term, without regard to whether the media employed in the filter bed is sand or some other material.

- "Septic/recirculation tank" means a primary or secondary septic tank or chamber through which both forward flow and flow through the recirculation loop are routed, for the purpose of mixing these flows to accomplish denitrification.

- "Working volume" means the depth range in the filter bed dosing tank between the depth at which the effluent by-pass valve opens and the high water alarm is tripped. Water level remains within this depth range during normal operation. This volume is set to provide sufficient equalization volume to assure that water level remains below the alarm level during normal operation.

III. DESCRIPTION AND PRINCIPLE OF OPERATION

The split bed recirculating filter system is a refinement of the split bed recirculating sand filter process that was developed as described in reference 2. The split bed recirculating filter system is engineered to provide improved nitrogen removal and to optimize performance and reliability of the split bed recirculating sand filter process.

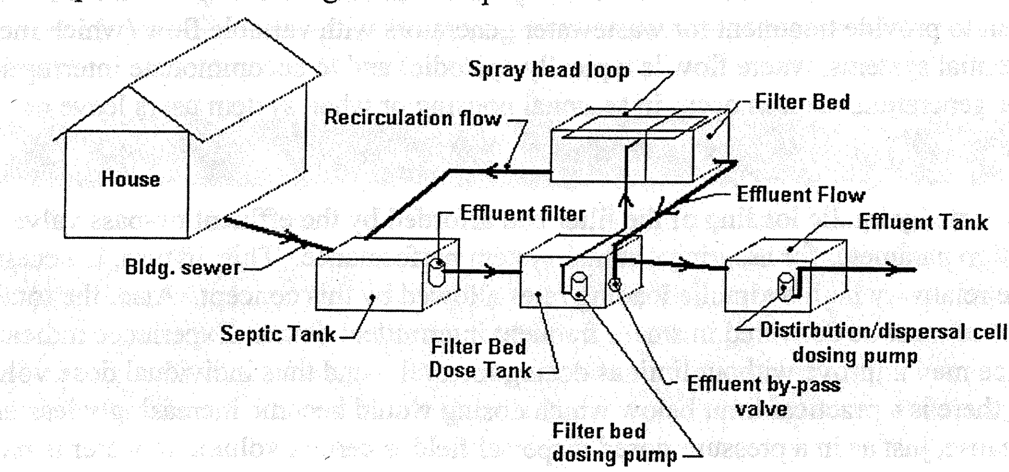

Figure 1 – Flow path

The process is illustrated in Figure 1. Flow from the wastewater source enters a septic tank, where it is mixed with recirculation flow. (Note: Especially for larger systems with multiple generators located remote from the treatment center, it may be more efficient to install a primary septic tank, followed by a septic/recirculation tank at the treatment center.) Effluent from the septic/recirculation tank flows into the filter bed dosing tank, where a pump system intermittently doses wastewater onto a split sand filter bed.

As wastewater percolates through the filter bed, it is treated by physical filtration and biological processes. The filter bed is a rich and diverse ecosystem, containing many trophic levels of organisms. That, plus the very large surface area provided by the filtration media—creating very long mean cell residence times—renders the sand filtration process highly stable and resistant to process upsets. The major mode of failure is clogging of the filter bed, a condition which builds up very slowly and is readily observable, allowing ample time for maintenance to be performed before the condition reaches a point where it would compromise treatment performance.

Wastewater dosed onto the recirculation side of the filter bed drains through the recirculation loop to the septic/recirculation tank. Wastewater dosed onto the effluent side of the filter bed drains to the dispersal field in accordance with the approved design, unless the effluent by-pass valve is open.

The effluent by-pass valve is a device that opens when the water level in the filter bed dosing tank drops to a pre-set minimum operating depth. When the effluent by-pass valve is open, drainage from the effluent side of the filter bed returns to the filter bed dosing tank instead of flowing on to the final effluent tank. When this happens, all of the wastewater dosed onto the filter bed returns to the filter bed dosing tank, some of it indirectly through the recirculation loop and some of it directly through the effluent by-pass valve. This arrangement assures that the filter bed dosing tank can never run out of water, so the filter bed dosing pump system can always load the filter bed with the same amount of water on the same schedule every day, regardless of how little forward flow enters the system. That allows the split bed recirculating filter system to provide treatment for wastewater generators with variable flow (which includes most residential systems, where flow is typically episodic) and to accommodate interruptions in wastewater generation, such as occur in seasonal housing or when system users leave on vacation.

The steady state hydraulic loading of the filter bed afforded by the effluent by-pass valve is a critical design parameter for assuring optimal system performance. This, in turn, is necessary to support the relatively high hydraulic loading rates allowed by this concept. Also, the total hydraulic load must be delivered in small, frequent intermittent doses. Experience indicates that performance may improve without limit as dosing interval—and thus individual dose volume—decreases, there is a practical limit below which dosing would become increasingly less uniform. This is because, just as in a pressure-dosed dispersal field, a certain volume of water is required simply to fill the feed pipe system. A range of 10 to 30-minute dosing intervals is recommended.

Another critical factor is uniform distribution of wastewater over the filter bed, which is accomplished with a spray distribution system. This assures that the entire bed volume is available to provide treatment and prevents "short-circuiting" due to point-loading of part of the bed. Spray distribution also "pre-aerates" the wastewater as it is being applied to the filter bed, further enhancing treatment efficiency.

The split bed recirculating filter system typically reduces total nitrogen content of the wastewater in the range of 60-90%. Removal percentage generally increases with increasing nitrogen concentration in the influent. As noted previously, effluent total nitrogen concentration of <20 mg/L is typically achieved.

The nitrogen in the wastewater from the septic tank is in the ammonium form and the remainder is organic nitrogen. The sand filtration process typically transforms most of the ammonium nitrogen into nitrate nitrogen, a process called nitrification that is accomplished by aerobic bacteria living in the filter bed. Most of the organic nitrogen is mineralized (transformed into ammonium nitrogen) in the filter bed as well, and most of this "new" ammonium is also nitrified. Then nitrogen is removed from the wastewater permanently by the denitrification process. When the nitrified effluent is introduced into an anaerobic environment containing sufficient food for them, denitrifying bacteria will utilize nitrate as a substrate, transforming the nitrogen into the gaseous form N_2. This bubbles off into the atmosphere, which is about 80% nitrogen gas. So the denitrifying sand filter process is a simple, non-polluting method of reducing total nitrogen content in wastewater system effluent.

Since effluent from the recirculation side of the filter bed flows back to the septic/recirculation tank, drainage from the recirculation side of the filter bed does not have to be of extremely high quality. As long as a high degree of nitrification is accomplished, the level of treatment is not critical—30 mg/L of BOD_5 will do just as well as 10 mg/L. Therefore, the recirculation side of the filter bed can be loaded more heavily than the effluent side, which decreases the total bed area requirement. To minimize clogging potential at the higher hydraulic loading rate, a coarser media is used in the recirculation side of the filter bed.

Though finer than the media in the recirculation side, media in the effluent side is still fairly coarse. The relatively high hydraulic loading rate and the very frequent doses require that the filter bed must drain fairly quickly so that air will be drawn into the pore spaces around media grains between doses.

IV. DESIGN

A. Size- Sizing of the split bed recirculating sand filter system must be in accordance with this manual. The means of pressurizing the distribution network must provide equal distribution of influent over the distribution cell. A pressurized distribution network sized using the charts contained in this manual and methods delineated in either Small Scale Waste Management Project publication 9.6, entitled "Design of Pressure Distribution Networks for Septic Tank – Soil Absorption System" or Dept. of Commerce publication SBD-10573-P, entitled "Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems" is acceptable.

B. Split Bed Recirculating Sand Filter System Component Design – Detailed plans and specifications must be developed for review and approval by the governing unit having authority over the plan for the installation. A Sanitary Permit must also be obtained from the department or governmental unit having jurisdiction.

   Design of the split bed recirculating sand filter system component is based on the estimated wastewater flow. It must be sized such that it can accept the daily wastewater flow at a rate that will provide treatment.

Design of the split bed recirculating sand filter system includes four steps, which are: (A) calculating the design wastewater flow, (B) sizing of the primary septic tank or compartment or septic/recirculation tank, (C) design of the filter bed dose tank or compartment, and (D) design of split filter bed component.

Step A. Design wastewater flow

One and two-family dwellings. The infiltrative surface size for one and two-family dwelling application is determined by calculating the designed wastewater flow (DWF). To calculate DWF use formula 1.

Formula 1
DWF = 150 gallons/bedroom/day

Public facilities. Infiltrative surface size for a public facility application is determined by calculating the DWF using formula 2. Public facility estimated daily wastewater flows are listed in Table 4. Facilities that are not listed in Table 4 are not included in this manual. Many commercial facilities have high BOD_5, TSS and FOG (fats, oil and grease), which must be pretreated in order to bring their values down to an acceptable range before entering into the split bed recirculating sand filter system component described in this manual.

Formula 2
DWF = 1.5 x Sum of each wastewater flow per source per day (from Table 4)

Table 4 Public Facility Wastewater Flows		
Source	**Unit**	**Estimated Wastewater Flow (gpd)**
Apartment or Condominium	Bedroom	100
Assembly hall (no kitchen)	Person (10 sq. ft./person)	1.3
Bar or cocktail lounge (no meals served)	Patron (10 sq. ft./patron)	4
Bar or cocktail lounge* (w/meals - all paper service)	Patron (10 sq. ft./patron)	8
Beauty salon	Station	90
Bowling alley	Bowling lane	80
Bowling alley (with bar)	Bowling lane	150
Camp, day and night	Person	25
Camp, day use only (no meals served)	Person	10
Campground or Camping Resort	Space, with sewer connection and/or service building	30
Campground sanitary dump station	Camping unit or RV served	25
Catch basin	Basin	65
Church (no kitchen)	Person	2
Church* (with kitchen)	Person	5
Dance hall	Person (10 sq. ft./person)	2
Day care facility (no meals prepared)	Child	12
Day care facility* (with meal preparation)	Child	16
Dining hall* (kitchen waste only without dishwasher and/or food waste grinder)	Meal served	2
Dining hall* (toilet and kitchen waste without dishwasher and/or food waste grinder)	Meal served	5
Dining hall* (toilet and kitchen waste with dishwasher and/or food waste grinder)	Meal served	7
Drive-in restaurant* (all paper service with inside seating)	Patron seating space	10
Drive-in restaurant* (all paper service without inside seating)	Vehicle space	10
Drive-in theater	Vehicle space	3
Employees (total all shifts)	Employee	13
Floor drain (not discharging to catch basin)	Drain	25
Gas station / convenience store	Patron (minimum 500 patrons)	3
Gas station (with service bay) Patron Service bay	 Patron Service bay	 3 50
Hospital*	Bed space	135
Hotel, motel or tourist rooming house	Room	65
Medical office building Doctors, nurses, medical staff Office personnel Patients	 Person Person Person	 50 13 6.5
Migrant labor camp (central bathhouse)	Employee	20
Mobile Home (Manufactured home) (served by its own POWTS)	Bedroom	100
Mobile home park	Mobile home site	200

* = May be high strength waste

Table 4
Public Facility Wastewater Flows
(continued)

Source	Unit	Estimated Wastewater Flow (gpd)
Nursing, Rest Home, Community Based Residential Facility	Bed space	65
Outdoor sport facilities (toilet waste only)	Patron	3.5
Parks (toilets waste only)	Patron (75 patrons/acre)	3.5
Parks (toilets and showers)	Patron (75 patrons/acre)	6.5
Public shower facility	Shower taken	10
Restaurant*, 24-hr. (dishwasher and/or food waste grinder only)	Patron seating space	4
Restaurant*, 24-hr. (kitchen waste only without dishwasher and/or food waste grinder)	Patron seating space	12
Restaurant, 24-hr. (toilet waste)	Patron seating space	28
Restaurant*, 24-hr. (toilet and kitchen waste without dishwasher and/or food waste grinder)	Patron seating space	40
Restaurant*, 24-hr. (toilet and kitchen waste with dishwasher and/or food waste grinder)	Patron seating space	44
Restaurant* (dishwasher and/or food waste grinder only)	Patron seating space	2
Restaurant* (kitchen waste only without dishwasher and/or food waste grinder)	Patron seating space	6
Restaurant (toilet waste)	Patron seating space	14
Restaurant* (toilet and kitchen waste without dishwasher and/or food waste grinder)	Patron seating space	20
Restaurant* (toilet and kitchen waste with dishwasher and/or food waste grinder)	Patron seating space	22
Retail store	Patron (70% of total retail area ÷ 30 sq. ft. per patron)	1
School* (with meals and showers)	Classroom (25 students/classroom)	500
School* (with meals or showers)	Classroom (25 students/classroom)	400
School (without meals or showers)	Classroom (25 students/classroom)	300
Self-service laundry (toilet waste only)	Clothes washer	33
Self-service laundry (with only residential clothes washers)	Clothes washer	200
Swimming pool bathhouse	Patron	6.5

* = May be high strength waste

Step B. Sizing of the Primary Septic Tank or Compartment and Septic/Recirculation Tank This section determines the required liquid volume of the primary septic tank or compartment, if utilized, preceding the septic/recirculation tank and the septic/recirculation tank that has or does not have a primary septic tank or compartment preceding it.

1. Determine the minimum liquid volume of the primary septic tank or compartment.

   The minimum liquid volume of the primary septic tank or compartment is equal to the design wastewater flow times the multiplier specified in Table 2.

   Minimum liquid volume of primary septic tank or chamber = DWF x Multiplier used to calculate volume of tank specified in Table 2.

2. Determine the minimum liquid volume of the septic/recirculation tank following the primary septic tank or compartment, if applicable.

   The minimum liquid volume of the septic/recirculation tank is equal to the design wastewater flow times the multiplier specified in Table 2, which is 1. Therefore the liquid capacity equals the design wastewater flow.

   Minimum liquid volume of septic/recirculation tank = DWF

3. Determine the minimum liquid volume of the septic/recirculation tank that does not have a primary septic tank or compartment preceding it, if applicable.

   The minimum liquid volume of the septic/recirculation tank is equal to the design wastewater flow times the multiplier specified in Table 2.

   Minimum liquid volume of septic/recirculation tank = DWF x Multiplier used to calculate volume of tank specified in Table 2.

Step C. Design of the Filter Bed Dose Tank or Chamber – This section determines the required liquid volume and depth of the filter bed dose tank or chamber as well as the operation elevation of the by-pass valve, high water alarm and low level emergency pump cut off. Figure 2 shows a cross section of a filter bed dose tank for a split bed recirculating sand filter.

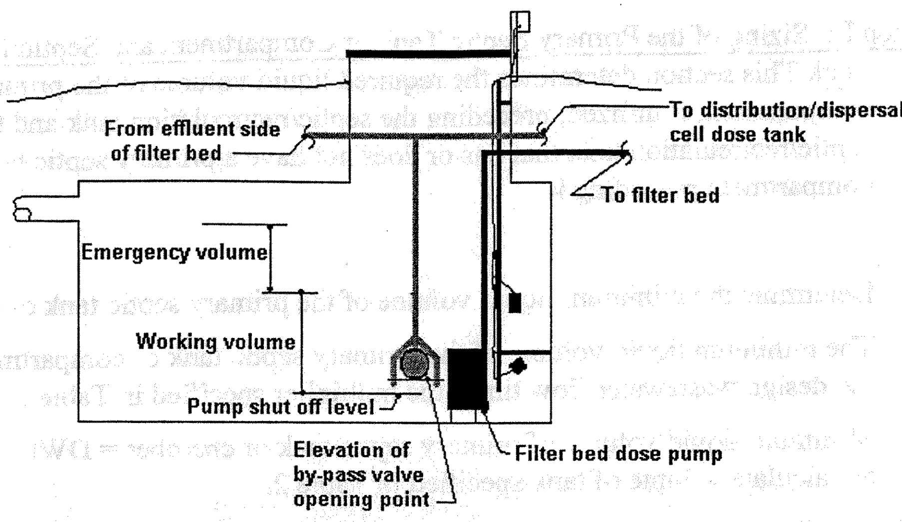

Figure 2 – Cross section of filter bed dose tank

1. Determine the minimum liquid volume of the filter bed dose tank or compartment.

   The minimum liquid volume of the filter bed dose tank or compartment is equal to the volume required for permanent liquid depth plus the working volume plus the emergency volume.

   a. Minimum liquid volume of the filter bed dose tank or compartment for the permanent liquid depth = Distance from tank bottom to low level shut off plus one inch x gallons per inch of the tank depth.

      Permanent liquid depth = (1 inch + pump off level) ÷ gal/in of tank

   b. Minimum liquid volume of the filter bed dose tank or chamber for the working volume is equal to the design wastewater flow times the multiplier specified in Table 2.

      Working volume = DWF x multiplier specified in Table 2.

   c. Minimum liquid volume of filter bed dose tank or chamber for the emergency volume is equal to the design wastewater flow when simplex pump is employed or 1/6 of the design wastewater flow when duplex pumps are employed.

      Emergency volume for simplex pump = DWF

      Emergency volume for duplex pumps = DWF ÷ 6

2. Determine the required elevation of the inlet invert of the filter bed dose tank or chamber.

   The minimum elevation of the inlet invert is determined by dividing the sum of the required volumes of the permanent liquid depth, working volume, and emergency volume by the gallons per inch value of the tank.

Elevation of inlet invert = permanent liquid depth volume + working volume + emergency volume ÷ gallons per inch of tank.

3. Determine the elevation of the opening point of the by-pass valve.

   The minimum elevation of the opening point of the by-pass valve is equal to the minimum liquid level required by the pump manufacturer of the filter bed pump plus at least one inch.

   Elevation of opening point of the by-pass valve = Minimum liquid level for pump + ≥ 1"

<u>Step D. Design of the Split Bed Recirculating Sand Filter Component</u> - This section determines the required surface areas of the two sides of the filter bed as well as the dimensions for the complete filter bed component. Figure 3 shows a cross section of filter bed that can be used in accordance with this manual. Figure 4 shows a plan view of a filter bed that can be used in accordance with this manual.

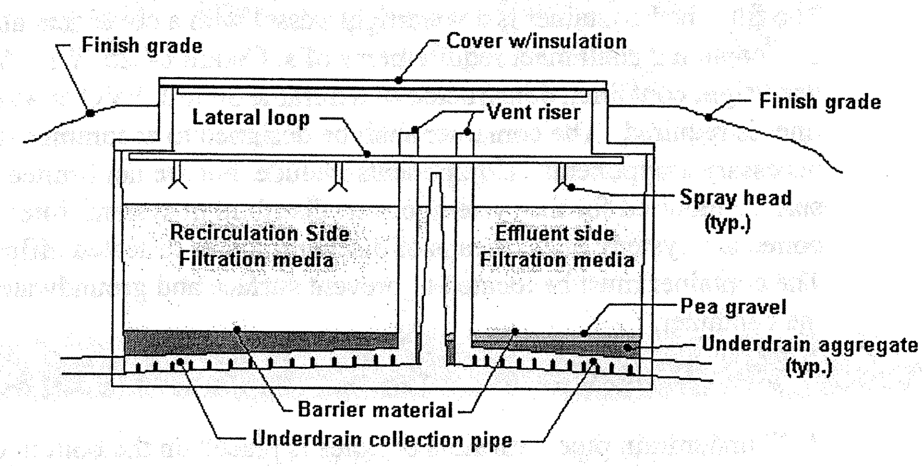

Fig. 3 – Filter bed in a tank

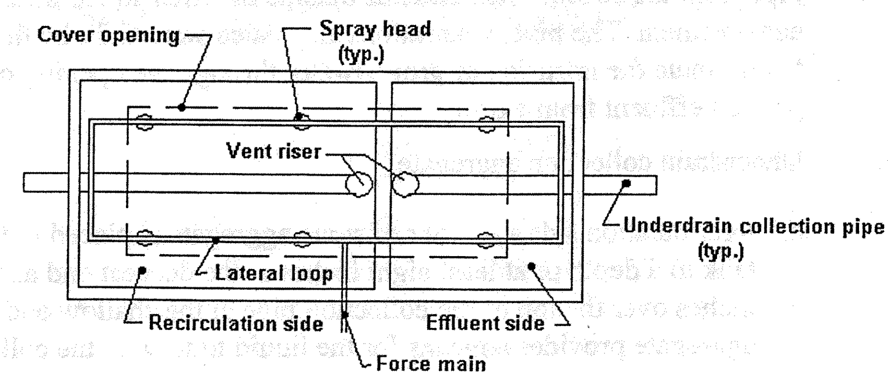

Fig. 4 – Plan view of filter bed in a tank

1. Determine the infiltrative surface area required for the recirculation side of the filter bed.

   The infiltrative surface area for the recirculation side of the filter bed is calculated by dividing twice the design wastewater flow by 3 then dividing by a design loading rate of 8.0 gpd/ft^2

   Distribution cell area = 2 x DWF ÷ 3 ÷ DLR of 8.0 gpd/ft^2

2. Determine the infiltrative surface area required for the effluent side of the filter bed.

   The infiltrative surface area for the effluent side of the filter bed is calculated by dividing the design wastewater flow by 3 then dividing by a design loading rate of 5.5 gpd/ft^2

   Distribution cell area = DWF ÷ 3 ÷ DLR of 5.5 gpd/ft^2

3. Filter bed container

   The filter bed container is a watertight vessel with a cover that allows access. The container shall meet requirements of s. Comm 84.25, Wis. Adm. Code or a watertight container, constructed of a durable 30 mil. PVC or 45 mil. EPDM liner is required. The container shall be designed to accommodate all the necessary components. Components include, but are not limited to: infiltrative surface required for the system; cover; distribution system; filter media; collection system; and a means of discharging the collected effluent by gravity. The container must be located to prevent surface and groundwater from entering the container.

4. Filtered effluent collection

   A 3" underdrain pipe with slots or holes is placed on the bottom of each side of the container to collect the effluent from each side individually. The collection pipe from the recirculation side extends outside the filter container to the primary septic tank or septic compartment of the septic/recirculation tank. The collection pipe from the effluent side extends outside the filter to the filter bed dose tank or compartment. The pipe penetrations are sealed watertight by the use of a gasket to eliminate the intrusion of groundwater through the opening or to prevent ponded effluent from exiting.

5. Underdrain collection aggregate

   a. Recirculation side - A layer of stone aggregate is placed in the bottom of the tank to a depth of at least eight inches at the deepest end and at least two inches over the top of the collection pipe at the shallow end. The stone aggregate provides a means for the liquid to flow to the collection pipe.

   b. Effluent side - A layer of stone aggregate is placed in the bottom of the tank to a depth of at least six inches at the deepest end and at least two inches over the top of the collection pipe at the shallow end. The stone aggregate provides a means for the liquid to flow to the collection pipe.

6. Cover over effluent side underdrain collection aggregate

A layer of pea gravel meeting the specifications of Table 3 is placed over the underdrain collection aggregate on the effluent side of the filter bed to a depth of at least two inches. The pea gravel acts as a barrier so the filter media does not migrate into the underdrain stone aggregate and pipe.

7. Barrier material

A barrier material meeting the speicifcations of Table 3 is placed over the pea gravel on the effluent side and over the underdrain collection aggregate on the recirculation side of the filter bed. The barrier acts as a barrier to prevent the mixing of the filter media with the underdrain material during cleaning of the media.

8. Filter media

a. Recirculation side - A two-foot layer of filter media meeting the specifications listed in Table 3 for filtration media for recirculation side is placed on top of the underdrain collection aggregate in the recirculation side of the filter bed to provide filtration and treatment of the wastewater. The top of the filter media is leveled.

b. Effluent side - A two-foot layer of filter media meeting the specifications listed in Table 3 for filtration media for effluent side is placed on top of the pea gravel in the effluent side of the filter bed to provide filtration and treatment of the wastewater. The top of the filter media is leveled.

9. Distribution network

The distribution network spreads the effluent as uniformly as possible over the filter media surface. The network consists of a manifold and laterals. A typical design consists of:

a. Spray heads – Spray heads shall be located downward and at least six inches above the filter media. There are twice as many spray heads in the recirculation side as there are in the effluent side of the filter bed. Spray heads must be accessible from an access opening in the filter bed cover.

b. Laterals – Laterals are supported by use of hangers and are looped together to provide equal distribution. Laterals are pitched in order to provide drainage of the lateral between doses.

c. Force main – Force mains slope back to provide drainage of the force main between doses. The pipe penetration is sealed watertight by the use of a gasket to eliminate the intrusion of groundwater through the opening or to prevent ponded effluent from exiting. The force main is sized using Table 5.

d. Recirculation tank pump - The pump is sized to meet flow the design rate and a lateral pressure of at least two and one-half feet at distal end.

Table 5 Friction Loss (foot/100 feet) in Plastic Pipe[a]						
Flow in	Nominal Pipe Size					
GPM	¾"	1"	1-1/4"	1-1/2"	2"	3"
1						
2						
3	3.24					
4	5.52					
5	8.34					
6	11.68	2.88				
7	15.53	3.83		Velocities in this area		
8	19.89	4.91		are below 2 feet per second		
9	24.73	6.10				
10	30.05	7.41	2.50			
11	35.84	8.84	2.99			
12	42.10	10.39	3.51			
13	48.82	12.04	4.07			
14	56.00	13.81	4.66	1.92		
15	63.62	15.69	5.30	2.18		
16	71.69	17.68	5.97	2.46		
17	80.20	19.78	6.68	2.75		
18		21.99	7.42	3.06		
19		24.30	8.21	3.38		
20		26.72	9.02	3.72		
25		40.38	13.63	5.62	1.39	
30		56.57	19.10	7.87	1.94	
35			25.41	10.46	2.58	
40			32.53	13.40	3.30	
45	Velocities in this area exceed		40.45	16.66	4.11	
50	10 ft per second, which are not		49.15	20.24	4.99	
60	acceptable velocity for this pipe			28.36	7.00	0.97
70	diameter			37.72	9.31	1.29
80					11.91	1.66
90					14.81	2.06
100					18.00	2.50

Note a: Table is based on Hazen – Williams formula: $h = 0.002082L \times (100/C)^{1.85} \times (gpm^{1.85} \div d^{4.8655})$

Where: h = Feet of head L = Length in feet

C = Friction factor from Hazen – Williams (145 for plastic pipe)

gpm = gallons per minute d = Nominal pipe size

10. Vent riser pipes

A vent riser pipe is extended from the upslope end of each underdrain collection pipe to above the spray head lateral to monitor for ponding and/or formation of a clogging mat. The pipes must be secured

11. Discharge of the filtered effluent from the effluent side of the filter bed.

The filtered effluent from the effluent side drains by gravity through the filter bed dose tank or compartment. The filtered effluent drain pipe is installed with a low liquid level by-pass valve to divert all of the effluent into the dose tank or compartment during low or no flow conditions.

12. By-pass valve.

The pipe connecting the by-pass valve to the discharge pipe is installed by the use of a long turn tee fitting. The by-pass valve is set at an elevation that will open the valve during low or no flow conditions to assure the effluent by-pass valve operates very frequently to minimize seizing of the by-pass valve. This elevation is determined in step "E" under "Design of Recirculation tank or Chamber" of this manual.

Figures 5 and 6 show two different by-pass valves. Both of the by-pass valves can be constructed using the proper components or they may be purchased ready to install.

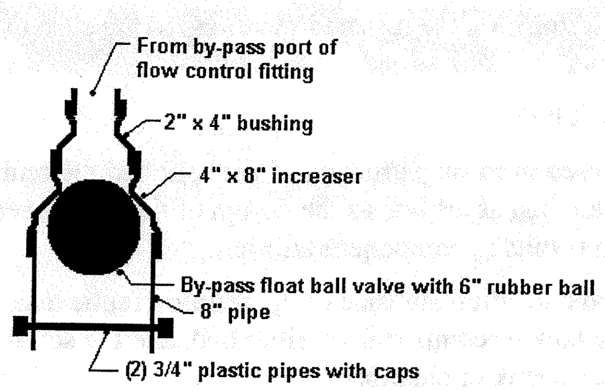

Figure 5 – By-pass valve using float ball

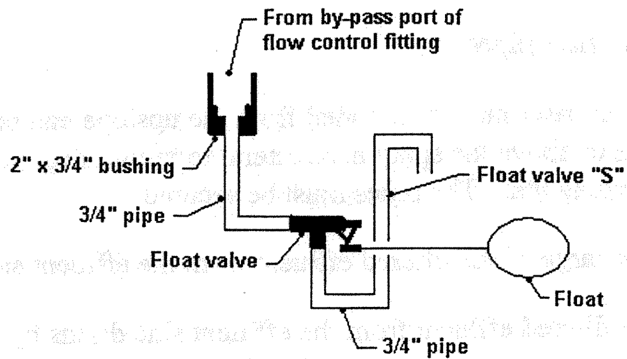

Figure 6 – By-pass valve using float valve

13. Access opening for filter bed

The cover over the filter bed must include an access opening that extends to final grade. The size of the access must be sufficient in size to allow easy access to all spray heads and surface area for maintenance of the filter bed. All surface waters must be diverted away from the filter bed.

14. Control panel

The control panel must be located in an accessible area and be capable performing the required functions of the system, such as timed doses.

V. CONSTRUCTION

Procedures used in the construction of the split bed recirculating sand filter system component are just as critical as the design of the component. A good design with poor construction results in component failure.

A. Lay out the location and size of the primary septic tank, septic/recirculation tank, filter bed dose tank or compartment, filter bed, and the soil distribution/dispersal component and its dose tank or chamber.

B. Determine where the force main from the filter bed dose tank or compartment will connect to the effluent distribution system of the filter bed component. The size of the force main pipe is determined from the pressure distribution design and sizing requirements specified in this manual and sizing methods of either Small Scale Waste Management Project publication 9.6, entitled "Uniform Distribution in Soil Absorption Fields" or Dept. of Commerce publication SBD-10573-P, entitled "Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems" publication.

C. Excavate and install the necessary tanks at the proper elevations and locations. When a watertight container using a durable 30 mil. PVC or 45 mil. EPDM liner is used for the filter bed, the following is required. The liner must be protected from punctures that can be caused by sharp rocks and construction tools. The filter bed can be placed at various elevations in the landscape from placement on the ground surface with soil mounded around it to buried with the top 2" to 6" below original grade surface. It is imperative that surface and ground water not be allowed to enter the filter.

The excavation is made 6" to 12" larger than the filter. Untreated plywood, waferboard or other suitable material is formed into a box to support the liner and allow the liner to be draped over the top. Only sand is placed between the frame and soil to protect the liner after the plywood has decomposed. Approximately 2" of sand is placed in the bottom of the excavation prior to placement of the liner. The top of the liner must be above the seasonal high water table so groundwater does not flow into the filter bed.

When the excavation around the frame is backfilled, it is done with sand that is placed in one foot increments and compacted by use of water or tamping prior to additional sand being placed.

The bottom of each compartment must be pitched towards the end of the compartment where the underdrain collection pipe exists the compartment.

D. Install a three inch diameter underdrain filtered effluent collection pipe with slots or holes by placing it on the bottom each compartment of the filter bed tank and connect them to solid wall pipe prior to exiting the tank. The opening in the tank wall shall be sealed by use of a gasket.

   The piping from the underdrain collection pipe from the filter bed must be pitched at least 1/8 inch per foot.

   Connect the vent riser pipes to the upslope end of the underdrain collection pipes and extend the vent risers up to the proper elevation.

E. Place a layer of stone aggregate meeting the specifications listed in Table 3 in the bottom of each compartment of the filter bed component tank. The depth of the aggregate in the recirculation side must cover the underdrain collection pipe by at least two inches and be at least eight inches deep at the wall by the underdrain collection pipe discharge.

   The depth of the aggregate in the effluent side must cover the underdrain collection pipe by at least two inches and be at least six inches deep at the wall by the underdrain collection pipe discharge.

F. Place a two-inch layer of pea gravel meeting the specifications listed in Table 3 over the stone aggregate on the effluent side.

G. Place barrier material meeing the specifications listed in Table 3 over the pea gravel on the effluent side and over the undrain aggregate on the recirculation side of the filter.

H. Place 24 inches of filter media meeting the specifications listed in Table 3 on top of the pea gravel in the effluent side and on top of the stone aggregate on the recirculation side.

I. Install the pressure distribution network with laterals.

J. Install the primary septic tank or install septic/recirculation tank, whichever one is part of the design.

K. Install the filter bed dose tank.

L. Install the dose tank for the soil distribution/dispersal cell.

M. Install necessary piping and controls as specified in section IV.

N. Test the system to adjust the head pressure to at least 2.5 feet at the distal spray head and filter bed pump run time.

O. Backfill all excavations. Berm soil over filter bed tank, or install other landscaping features as specified on approved plan.

P. Restore and stabilize all disturbed areas.

VI. OPERATION, MAINTENANCE AND PERFORMANCE MONITORING

A. The component owner is responsible for the operation and maintenance of the system. The county, department or POWTS service contractor may make periodic inspections of the components, and effluent levels, etc.

The owner or owner's agent is required to submit appropriate records routinely to the county or other appropriate jurisdiction and/or the department.

B. Design approval and site inspections before, during, and after the construction are accomplished by the county or other appropriate jurisdictions in accordance to Ch. Comm 83 of the Wis. Adm. Code.

C. Other routine and preventative maintenance aspects are:

Routine operations and preventative maintenance activities recommended for a split bed recirculating sand filter system include:

- Observe all effluent filters every 6 months. Clean all effluent filters at least once per year, or more often if required, based upon observation of their condition.
- At the time effluent filter cleaning is executed, monitor the scum layer and sludge depth in all septic tanks and septic/recirculation tanks. Pump these tanks when the clear depth has been reduced to the extent that pumping is required under applicable regulations, as set forth in the management plan.
- Observe dosing cycle every 6 months. If dosing time and/or frequency varies from design values, execute appropriate action to restore design values.
- Observe alarm function every 6 months. If alarm does not work properly, take appropriate action to restore function.
- Observe function of effluent by-pass valve every 6 months. If valve does not open and close as required, take appropriate action to restore function.
- Observe function of dispersal field dosing pump every 6 months. If pump does not function according to design, take appropriate action to restore function.
- Observe general condition of all components in regard to corrosion, structural integrity, groundwater intrusion, etc. If any problems appear, take appropriate action to assure continued proper system function.

- Observe or determine history of odor problems. Take appropriate actions to eliminate any odor problems.
- Observe the condition of the filter bed every 6 months. Observe the spray head operation during a dosing event. Clean or replace any spray heads that are not distributing wastewater as they were designed to. Observe the surfaces of the filter bed during and after a dosing event. If water remains ponded on the surface for more than a minute or two after the end of a dosing event:

(a) Skim surface of bed if it appears that ponding is due to buildup of solids on the bed surface.
(b) If a surface clogging layer is not evident, dig into bed and observe if clogging appears to be deep. This is indicated by a very black color and low porosity due to large quantity of zoogleal mass in media pores.
(c) If clogging does appear to be greater than 6 inches deep, schedule bed cleaning as soon as practical.
(d) If clogging does not appear to be less than or equal to 6 inches deep, break up surface layer of filter bed by raking or tilling. Observe condition of filter bed again within two weeks. If clogging is still occurring, schedule bed cleaning as soon as practical.

The filter bed cleaning procedure is as follows:

- Plug outlet pipe of bed area to be cleaned.
- Flood bed area to be cleaned with clear water (e.g., with a water hose from potable supply) to the maximum level allowed by the containment.
- Using an air compressor with a 1"+/- pipe connected to the end of a hose, agitate the bed by inserting the pipe into it. Mark the pipe so that it is inserted only one foot deep the first two iterations of the process. It may be inserted all the way to the barrier material on all subsequent iterations.
- While the bed is being agitated, suction the water off the surface with a pumper truck hose.
- When all the water covering the bed surface has been pumped out of the containment, refill the containment with clear water and repeat the process.
- Repeat for 5-6 iterations or until agitating the bed no longer floats a significant amount of solids out of the bed.
- Remove plug from outlet line and allow bed to drain completely before restoring it to service.
- If effluent side of bed is being cleaned, pump out and clean dosing tank and final effluent tank. If there is no effluent dosing tank (gravity-dosed dispersal bed is used), remove effluent by-pass valve before removing plug so all drainage from filter bed will flow into dosing tank.

D. USER'S MANUAL

A system user's manual shall be provided to the owner of a split bed recirculating sand filter system upon completion of installation. The manual shall contain the following:

- Diagrams of all system components.
- A site plan showing locations of all system components and connecting piping as installed.
- Specifications or brand and model names of electrical and mechanical components.
- Names and phone numbers of local governmental authority having jurisdiction over system, and manufacturer of system or the management entity to be contacted in the event of a failure.
- Information on the periodic maintenance of the system, such as detailed above.
- Information on water conservation tips to help assure system will not be overloaded.

E. PERFORMANCE MONITORING

Performance monitoring shall be performed on a split bed recirculating sand filter system on the following schedule:

1. 6 months after startup
2. 1 year after startup
3. 18 months after startup
4. 2 years after startup
5. 3 years after startup
6. 4 years after startup
7. Once every 3 years thereafter
8. Between 2 and 4 months after the filter bed has been cleaned, or after it has been raked/tilled if it is determined that cleaning was not warranted.

Performance monitoring shall be in accordance with the approved management plan.

VII. REFERENCES

1. David Venhuizen, 1994. "Demonstration Systems Performance Analysis—Final Report", Town of Washington Wastewater Management Facility Plan.

2. David Venhuizen, 1996. Intermittent Sand Filters – New Frontiers for an Ancient Art".

3. David Venhuizen, 1997. "A Minnesota Regulator's Guide to the Venhuizen Standard Denitrifying Sand Filter Wastewater Reclamation System".

4. David Venhuizen, 1998. “Sand Filter/Drip Irrigation Systems Solve Water Resources Problems”. ASAE Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems, pp. 356-362.

5. David Venhuizen, 1998. “Washington Island Project: Evolution of the Denitrifying Sand Filter Concept”. ASAE Proceedings of the Eighth International Symposium on Individual and Small Community Sewage Systems, pp. 470-479.

VIII. System Design Worksheet

Split Bed Recirculating Sand Filter System

A. Design wastewater flow rate (forward flow) and characteristics

One or Two-family dwelling:

Design flow rate = number of bedrooms x 150 gallons/day

= _______ bedrooms x 150 gallons/day

= ______________ gallons/day

Public facilities:

Design flow rate = number of units x flow rate per unit x 1.5

= ___________ units x __________ gallons/day/unit x 1.5

= _____________ gallons/day

BOD_5 value of raw wastewater: __________ mg/l of BOD_5

B. Primary septic tank

1. Primary septic tank volume = DWF x multiplier specified in Table 2

= _______________ gallons x ______________

= _______________ gallons

2. Manufacturer of primary septic tank: _______________________________________

3. Model primary septic tank: ______________________

C. Septic/recirculation Tank

1. Installation includes wastewater primary septic tank

_____ Yes _____ No

2. Septic/recirculation tank volume = DWF x multiplier specified in Table 2

= _______________ gallons x __________ (multiplier)

= _______________ gallons

D. Filter bed dosing tank

1. Determine permanent liquid depth

Permanent liquid depth = Minimum depth to low-level cutoff switch specified by pump manufacturer + one inch to obtain depth at which effluent valve opens

Permanent liquid depth = ________ inches + 1 inch (10 inch minimum)

= ____ inches

2. Determine working volume

Working volume = DWF x multiplier specified in Table 5

= ____________ gallons x ________ = ____________ gallons

3. Determine emergency storage volume

For simplex pump system, required volume = DWF x 1 day

= ___________ gallons

For duplex pump system, required volume = DWF x 1/6 of a day

= ___________ gpd x 1/6 of a day

= _________ gallons

4. Specify tank providing required dimensions

Selected tank size: ______________ gallons

Manufacturer: ____

Site constructed: __ yes __ no

5. Determine the average gallons per inch of filter bed dose tank

Gallons per inch = liquid capacity of tank (gallons) ÷ liquid depth (inches)

= _____ gallons ÷ _______ inches

= ______ gallons/inch (gal/in)

6. Determine if chosen tank is of proper size

Liquid depth of tank ≥ sum of permanent liquid depth + depth of working volume + depth of emergency volume

a. Liquid depth of tank = _____ inches

b. Permanent liquid depth = _____ inches

c. Liquid depth of working volume = _____ gal (#2) ÷ _____ gal/in (#5) = ____ inches

d. Liquid depth of emergency volume = _____ gal (#3) ÷ ____ gal/in (#5) = ____ inches

$a \geq b + c + d$

_____ inches(a) ≥ ____ inches(b+c+d)

7. Specify depth to effluent by-pass valve entry (must be above top of working volume) = _____

D. Filter bed dosing pump

1. Determine elevation head

From system layout plan and design for dosing tank and filter bed containment,

Elevation head = ______________ feet

2. Determine spray head flow and pressure requirement

Flow per spray head (consult mfg. information or test data) = ____________ gpm

Number of spray heads = __________ heads

Total instantaneous flow rate = ___ spray heads x _____ gpm/spray head = _______ gpm

Pressure required to drive spray head at this flow = __________ feet

3. Determine pipe friction losses

From system layout plan and design for dosing pump system, calculate equivalent lengths of each pipe size used in the feed pipe system and flows in each run of pipe.

Total friction head loss = ____________ feet

4. Determine other losses

Total all other losses – e.g., in-line filter, switching valve (for systems with multiple filter beds fed from one pump system).

Total other losses = ____________ feet

5. Calculate total head requirement

Total head = elevation head + spray head pressure + friction losses + other losses

= __________ + __________ + __________ + __________ = ____________ feet

6. Specify pump

Specify pump that can supply required flow at this total dynamic head:

Manufacturer and model ____

E. Filter bed dosing cycle

1. Specify working recirculation ratio = ________:1

2. Calculate total hydraulic load = forward flow x recirculation ratio

= _____________ gpd x ________ = _______________ gpd

3. Calculate total pump run minutes per day = total hydraulic load ÷ instantaneous flow rate

= ________________ gpd ÷ _____________ gpm = ________________ minutes/day

4. Specify dosing interval = ____________ minutes

5. Calculate number of doses per day = 1440 (minutes/day) ÷ dosing interval in minutes

= 1440 ÷ ___________ minutes = _____________ doses per day

6. Calculate length of dose = total daily pump run time ÷ number of doses per day

= ______________ minutes ÷ ___________ doses = _______________ minutes/dose

7. Adjust length of dose for time it takes to fill feed pipe, since this volume will drain back between doses.

Estimated time to fill feed pipe = pipe volume (gal) ÷ total instantaneous flow rate (gpm)

= _____________ gallons ÷ ____________ gpm = ____________ minutes

8. Add results of (7) to results of (6) to arrive at actual length of dose:

Length of dose = _________ minutes + ___________ minutes = ____________ minutes

9. Specify repeat cycle timer that is capable of providing required dosing interval and dosing time:

Manufacturer and model of timer ____

F. Filter bed area

Recirculation side area = 2/3 DWF ÷ loading rate of 8.0 gpd/ft^2

= 2/3 X ______________ gpd ÷ 8.0 gpd/ft^2 = _______________ ft^2

Effluent side area = 1/3 DWF ÷ loading rate of 5.5 gpd/ft^2

= 1/3 X ______________ gpd ÷ 5.5 gpd/ft^2 = ______________ ft^2

IX. Example System Design Worksheet

Split Bed Recirculating Sand Filter System

A. Design wastewater flow rate (forward flow) and characteristics

One or Two-family dwelling:

Design flow rate = number of bedrooms x 150 gallons/day

= __4__ bedrooms x 150 gallons/day

= __600__ gallons/day

Public facilities:

Design flow rate = number of units x flow rate per unit x 1.5

= ________ units x ________ gallons/day/unit x 1.5

= ________ gallons/day

BOD_5 value of raw wastewater: ________ mg/l of BOD_5

B. Primary septic tank

1. Primary septic tank volume = DWF x multiplier specified in Table 2

= ________ gallons x ________

= ________ gallons

2. Manufacturer of primary septic tank: ________

3. Model primary septic tank: ________

D. Septic/recirculation Tank

1. Installation includes wastewater primary septic tank

_____ Yes __X__ No

2. Septic/recirculation tank volume = DWF x multiplier specified in Table 2

= __600__ gallons x __3.2__ (multiplier)

= __1920__ gallons

D. Filter bed dosing tank

1. Determine permanent liquid depth

Permanent liquid depth = Minimum depth to low-level cutoff switch specified by pump manufacturer + one inch to obtain depth at which effluent valve opens

Permanent liquid depth = __9__ inches + 1 inch (10 inch minimum)

= __10__ inches

2. Determine working volume

Working volume = DWF x multiplier specified in Table 5

= __600__ gallons x __0.65__ = __390__ gallons

3. Determine emergency storage volume

For simplex pump system, required volume = DWF x 1 day

= __600__ gallons

For duplex pump system, required volume = DWF x 1/6 of a day

= __________ gpd x 1/6 of a day

= _________ gallons

4. Specify tank providing required dimensions

Selected tank size: __1250__ gallons

Manufacturer: __Wiscast Tanks__

Site constructed: __ yes __X__ no

5. Determine the average gallons per inch of filter bed dose tank

Gallons per inch = liquid capacity of tank (gallons) ÷ liquid depth (inches)

= __1250__ gallons ÷ __56__ inches

= __22.3__ gallons/inch (gal/in)

6. Determine if chosen tank is of proper size

Liquid depth of tank ≥ sum of permanent liquid depth + depth of working volume + depth of emergency volume

a. Liquid depth of tank = _56_ inches

b. Permanent liquid depth = _11_ inches

c. Liquid depth of working volume = _390_ gal (#2) ÷ _22.3_ gal/in (#5) = _17.5_ inches

d. Liquid depth of emergency volume = _600_ gal (#3) ÷ _22.3_ gal/in (#5) = _27_ inches

$a \geq b + c + d$

_56_ inches(a) ≥ _55.5_ inches(b+c+d)

7. Specify depth to effluent by-pass valve entry (must be above top of working volume) = _30 "_

D. Filter bed dosing pump

1. Determine elevation head

From system layout plan and design for dosing tank and filter bed containment,

Elevation head = _10_ feet

2. Determine spray head flow and pressure requirement

Flow per spray head (consult mfg. information or test data) = _5.3_ gpm

Number of spray heads = _6_ heads

Total instantaneous flow rate = _6_ spray heads x _5.3_ gpm/spray head = _31.8_ gpm

Pressure required to drive spray head at this flow = _2.5_ feet

3. Determine pipe friction losses

From system layout plan and design for dosing pump system, calculate equivalent lengths of each pipe size used in the feed pipe system and flows in each run of pipe.

Total friction head loss = 2.25 feet

4. Determine other losses

Total all other losses – e.g., in-line filter, switching valve (for systems with multiple filter beds fed from one pump system).

Total other losses = 0 feet

5. Calculate total head requirement

Total head = elevation head + spray head pressure + friction losses + other losses

= 10 + 2.5 + 2.25 + 0 = 14.75 feet

6. Specify pump

Specify pump that can supply required flow at this total dynamic head:

Manufacturer and model U-Pump Model OK4

E. Filter bed dosing cycle

1. Specify working recirculation ratio = 3.5 :1

2. Calculate total hydraulic load = forward flow x recirculation ratio

= 600 gpd x 3.5 = 2100 gpd

3. Calculate total pump run minutes per day = total hydraulic load ÷ instantaneous flow rate

= 2100 gpd ÷ 31.8 gpm = 66 minutes/day

4. Specify dosing interval = 15 minutes

5. Calculate number of doses per day = 1440 (minutes/day) ÷ dosing interval in minutes

= 1440 ÷ 15 minutes = 96 doses per day

6. Calculate length of dose = total daily pump run time ÷ number of doses per day

= 33 minutes ÷ 96 doses = 0.34 minutes/dose

7. Adjust length of dose for time it takes to fill feed pipe, since this volume will drain back between doses.

Estimated time to fill feed pipe = pipe volume (gal) ÷ total instantaneous flow rate (gpm)

= 4.2 gallons ÷ 31.8 gpm = 0.13 minutes

8. Add results of (7) to results of (6) to arrive at actual length of dose:

Length of dose = 0.34 minutes + 0.13 minutes = 0.47 minutes

9. Specify repeat cycle timer that is capable of providing required dosing interval and dosing time:

Manufacturer and model of timer Time Right model Flow Timer #1

F. Filter bed area

Recirculation side area = 2/3 DWF ÷ loading rate of 8.0 gpd/ft^2

= 2/3 X 600 gpd ÷ 8.0 gpd/ft^2 = 50 ft^2

Effluent side area = 1/3 DWF ÷ loading rate of 5.5 gpd/ft^2

= 1/3 X 600 gpd ÷ 5.5 gpd/ft^2 = 36.4 ft^2

X. PLAN SUMBITTAL AND INSTALLATION INSPECTION

A. Plan Submittal

In order to install a component correctly, it is important to develop plans that will be used to install the component correctly the first time. The following checklist may be used when preparing plans for review. The checklist is intended to be a general guide. Conformance to the list is not a guarantee of plan approval. Additional information may be needed or requested to address unusual or unique characteristics of a particular project. Contact the reviewing agent for specific plan submittal requirements, which the agency may require that are different than the list included in this manual.

<u>General Submittal Information</u>

- Submittal of additional information requested during plan review or and questions concerning a specific plan must be referenced to the Plan Identification indicator assigned to that plan by the reviewing agency.
- Plans or documents must be permanent copies or originals.

<u>Forms and Fees</u>

- Application form for submittal, provided by reviewing agency along with proper fees set by reviewing agent.
- Onsite verification report signed by the county or appropriate state official.

<u>Documentation</u>

- Architects, engineers or designers must sign, seal and date each page of the submittal or provide an index page, which is signed, sealed and dated.
- Master Plumbers must sign, date and include their license number on each page of the submittal or provide an index page, which is signed, sealed and dated.
- Three completed sets of plans and specifications (clear, permanent and legible); submittals must be on paper measuring at least 8-1/2 by 11 inches.

<u>Plot Plan</u>

- Dimensioned plans or plans drawn to scale (scale indicated on plans) with parcel size or all property boundaries clearly marked.
- Slope directions and percent in component area.
- Benchmark and north arrow.
- Setbacks indicated as per appropriate code.
- Location information; legal description of parcel must be noted.
- Location of any nearby existing component or well.

Plan View

- Dimensions for Recirculating filter media filter distribution cell(s).
- Location of observation pipes.
- Pipe lateral layout, which must include the number of laterals, pipe material, diameter and length; and number, location and size of orifices.
- Manifold/force main locations, with materials, length and diameter of each.

Cross Section of Component

- Lateral elevation, position of observation pipes, dimensions and depths of aggregates and filter media, and type of cover, and depth, if applicable.

Component Sizing

- For one and two-family dwellings, the number of bedrooms must be included.
- For public facilities, the sizing calculations must be included.

Tank and Pump Information

- All construction details for site-constructed tanks.
- Size and manufacturer information for prefabricated tanks.
- Notation of pump or siphon model, pump performance curve, friction loss for force main and calculation for total dynamic head.
- Cross section of tank / chamber to include storage volumes; connections for piping, vents, and electricity; pump "off" setting; dosing cycle and volume; and location of vent and manhole.
- Cross section of two compartments tanks or tanks installed in a series must include information listed above.

Other

- For design flows greater than 1000 gpd, include the manufacturer, model, and location of a metering device, which accurately meters the amount of effluent entering the component.

B. Inspections.

Inspection shall be made in accordance with ch. 145.20,. Wis. Stats and s. Comm 83.26, Wis. Adm. Code. The inspection form on the following two pages may be used. The inspection of the component installation and/or plans is to verify that the component at least conforms to specifications listed in Tables 1-3 of this manual.

GENERAL INFORMATION	
Permit Holders Name:	County:
VRP Elevation:	Sanitary Permit Number:
VRP Description:	Plan ID Number:
Inspector Name & License #:	Parcel Tax Number:
Dates Inspected:	

FILTER BED INFORMATION	Recir. side	Effluent side
Area		
Loading rate		
# of heads		
Influ. BOD_5		

CONTRACTOR INFORMATION	
Plumber Name:	Phone #:
Electrician Name:	Phone #:
Excavator Name:	Phone #:

ELEVATION DATA				
STATION	BS	HI	FS	ELEV
VRP:				
FBFM:				
FBFM End:				
DAFM:				
DAFM End:				
Base of FBDT: Base of DADT:				
FBFM pitch: DAFM pitch:				

SEPTIC/RECIR. TANK INFORMATION	
Manufacturer: Tank Capacity:	Gallons/inch
Capacity of First Compartment:	
Capacity of Second Compartment:	

SEPTIC/RECIR. TANK VAULT	
Inside height:	inches
*Alarm/timer override:	inches
*Timer off:	Inches
*Red. Off/low level alarm:	Inches
Force main Diameter:	Inches
Force main Length:	Feet

* Measured from bottom of tank cover.

PUMP INFORMATION	FBDT	DADT
Manufacturer:		
Model Number:		
Lift:		
Friction Loss:		
System Head:		
As-Built TDH:		
System Demand:		

OPERATIONAL REVIEW		
FBDT floats tested	Yes	No
DADT floats tested	Yes	No
Distribution pipes flushed	Yes	No
As-built TDH below pump curve	Yes	No
Septic tank tested for water tightness	Yes	No
Owner issued operational manual	Yes	No
Residual head at start up		
Programmable timer settings	On	Off

ADMINISTRATIVE REVIEW		
Revision to plans required	Yes	No
Construction directive issued	Yes	No
Construction order issued	Yes	No
Date of directive		
Directive deadline		
Enforcement order date		
Enforcement order deadline		
Date compliance issued		

DADT – Dispersal Area Dose Tank
DAFM – Dispersal Area Force Main
FBDT - Filter Bed Dose Tank
FBFM – Filter Bed Force Main
SEPTIC/RECIR. – Septic/Recirculation
VRP- Vertical Reference Point

DEVIATIONS FROM APPROVED PLANS:

Date Installation Approved ____________ **Inspector Signature** ______________________________________

SINGLE PASS SAND FILTER COMPONENT MANUAL

FOR

PRIVATE ONSITE WASTEWATER TREATMENT SYSTEMS

State of Wisconsin

Department of Commerce

Division of Safety and Buildings

SBD-10595-P (R.6/99)

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ADA Statement

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I. INTRODUCTION AND SPECIFICATIONS

This Private Onsite Wastewater Treatment System (POWTS) component manual provides design, construction, inspection, operation, and maintenance specifications for an single pass sand filter component. However, these items must accompany a properly prepared and reviewed plan acceptable to the governing unit to help provide a system that can be installed and function properly. Violations of this manual constitute a violation of chs. Comm 83 and 84, Wis. Adm. Code. The single pass sand filter component must receive influent flows and loads less than or equal to those specified in Table 1. When designed, installed and maintained in accordance with this manual, the single pass sand filter component provides treatment of domestic wastewater. The effluent from a single pass sand filter typically has monthly average values of ≤ 10 mg/L for BOD_5, ≤ 10 mg/L for TSS, and ≤ 10^4 cfu/100 ml for fecal coliform when inputs are within the range specified in Tables 1 to 3.

Note: Detailed plans and specifications must be developed for review and submitted for review and approval by the governing unit having authority over the plan for the installation. Also a Sanitary Permit must be obtained from the department or governmental unit having jurisdiction. See Section X for more details.

Table 1 INFLUENT FLOWS AND LOADS	
Design wastewater flow (DWF)	≤ 2250 gal/day
Monthly average value of Fats, Oil and Grease (FOG)	≤ 30 mg/L
Monthly average value of five day Biochemical Oxygen Demand (BOD_5)	≤ 220 mg/L
Monthly average value of Total Suspended Solids (TSS)	≤ 150 mg/L
Number of design daily influent doses	Equally spaced throughout 24 hr. period
Discharge from an orifice during a single dose	≤ 0.25 gal
Design Loading Rate (DLR)	≤ 1.25gpd/ft^2

Table 1 **INFLUENT FLOWS AND LOADS** (continued)	
Design wastewater flow (DWF) from one- and two-family dwellings	≥ 150 gal/day/bedroom
Design wastewater flow (DWF) from public facilities	≥ 150% of estimated wastewater flow in accordance with Table 4 of this manual or s. Comm 83.43 (6), Wis. Adm. Code
Wastewater particle size	≤ 1/8 inch
Distribution cell area per orifice	≤ 6 ft^2

Table 2 **SIZE**	
Total distribution cell area	≥ DWF ÷ DLR
Depth of sand	≥ 24 inches
Depth of pea gravel under sand	≥ 6 inches
Depth of stone aggregate above sand	≥ 6 inches
Depth of cover over sand filter fabric and liner	≤ 6 inches of sandy loam or coarser or decorative stone
Depth of cover over sand filter fabric and liner	≥ 2 inches
Surge capacity in tank or chamber for pump used to does single pass sand filter	≥ 2/3 DWF above pump on level and 1/3 DWF above high level alarm
Liner	≥ 30 mil. PVC or ≥ 45 mil. EPDM
Piping material	Meets requirements of s. Comm 84.30 (2), Wis. Adm. Code for its intended use

Table 2 **SIZE** (continued)	
Fabric cover	Geotextile fabric meeting s. Comm 84.30 (6) (g), Wis. Adm. Code
Size of underdrain	≥ 4 inches
Depth of pea gravel above underdrain	≥ 3 inches

Table 3 **OTHER SPECIFICATIONS**	
Amount of stone aggregate around underdrain	≥ 2 inches
Depth of sand bedding	≥ 2 inches under liner
Effluent application	By use of pressure distribution network conforming to sizing requirements contained in this manual and methods delineated in either Small Scale Waste Management Project publication 9.6 or Dept. of Commerce publication SBD-10573-P
Difference in flow between any two orifices in a single lateral	≤ 10%
Difference in flow between any two orifices in the effluent distribution network	15%
Number of observation pipes	≥ Two 4 inch pipes extending from the sand aggregate interface to finished grade
Location of observation pipes	Located at a distance equal to approximately 1/6 the distribution cell length from each end along the center of the filter's width
Head pressure on orifice	≥ 5 feet

Table 3
OTHER SPECIFICATIONS (continued)

Effective size of sand media	D10 > 0.30 mm	
Uniformity Coefficient of sand media	CU < 4.0	
Sand media sieve specifications	Sand Maximum/Minimum Gradation	
	Sieve Size	Percent Passing
	3/8	100
	4	95 – 100
	8	80-100
	16	45 – 85
	30	15 – 60
	50	3 – 15
	100	0 – 4
Stone aggregate sieve specifications	Aggregate Maximum/minimum Gradation (ASTM Standard C33, Size 4, coarse aggregate)	
	Sieve Size	% Passing
	2”	100
	1-1/2”	90-100
	1”	20-55
	¾”	0-15
	3/8”	0 – 5
Stone aggregate hardness specification	> value of 3 on Moh’s Scale of Hardness	

Table 3 **OTHER SPECIFICATIONS** **(continued)**	
Pea gravel sieve specifications	Aggregate Maximum/minimum Gradation (ASTM Standard C33, Size 7, coarse aggregate)
	Sieve Size — % Passing
	3/4" — 100
	½" — 90-100
	3/8" — 40-70
	#4 — 0-15
	#8 — 0 – 5
Pea gravel hardness specification	> value of 3 on Moh's Scale of Hardness
Installation inspection	In accordance with ch. Comm 83 Wis. Adm. Code
Management	In accordance with ch. Comm 83 Wis. Adm. Code

II. DEFINITIONS

Definitions unique to this manual are included in this section. Other definitions that may apply to this manual are located in ch. Comm 81 of the Wis. Adm. Code or the terms use the standard dictionary definition.

A. "Dispersal cell" means a layer of gravel that receives effluent from a distribution network and distributes that effluent onto the sand.

B. "Single Pass Sand Filter" means an onsite wastewater treatment component that contains an underdrain, sand, a distribution network, a container and a cap. The cap offers protection for the distribution cell of the sand filter.

C. "Surge capacity" means a volume in a tank above the normal working level, which stores above average discharge of wastewater from the facility.

III. DESCRIPTION AND PRINCIPLE OF OPERATION

POWTS single pass sand filter component operation consists of a fixed film aeration unit process in which wastewater passes through a porous media. The bacteria attach themselves to the media and extract food and nutrients as the wastewater flows through the porous media. Oxygen diffuses into the thin film of water as air passes through the media by convection due to temperature differences. Air is also drawn in as the wastewater moves through the media. The component is designed to encourage passive air movement through the unit.

As the effluent passes through the filter, various physical, chemical and biological reactions take place. Suspended solids are filtered out. Bacteria convert organic matter to carbon dioxide and water.

Physical entrapment, increased retention time, and conversion of pollutants in the wastewater are important treatment objectives accomplished under unsaturated conditions. Pathogens contained in the wastewater are eventually deactivated through filtering, retention, and adsorption by the sand.

Below are two cross section views of single pass sand filters. Figure 1 is a single pass sand filter that discharges effluent from the filter by gravity. Figure 2 is a single pass sand filter that discharges effluent from the filter by the use of a pump.