Wisconsin Department of Natural Resources
Wastewater Operator Certification

Recirculating Media Filters Study Guide

Subclass A3

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Preface

The Recirculating Media Filters Study Guide is an important resource for preparing for the certification exam and is arranged by chapters and sections. Each section consists of key knowledges with important informational concepts you need to know for the certification exam. This study guide also serves as a wastewater treatment plant operations primer that can be used as a reference on recirculating media filter systems.

In preparing for the exams:

1. Study the material! Read every key knowledge until the concept is fully understood and known to memory.

2. Learn with others! Take classes in this type of wastewater operation to improve your understanding and knowledge of the subject.

3. Learn even more! For an even greater understanding and knowledge of the subjects, read and review the references listed at the end of the study guide.

Knowledge of the study guide material will be tested using a multiple choice format. Every test question and answer comes directly from one of the key knowledges.

Choosing a test date:
Before choosing a test date, consider the time you have to thoroughly study the guides and the training opportunities available. A listing of wastewater training opportunities and exam dates is available at http://dnr.wi.gov by searching for the keywords “Operator Certification”.

Acknowledgements

The Recirculating Media Filters Study Guide was the result of a collaborative effort of yearlong monthly meetings of wastewater operators, trainers, consultants, the Wisconsin Wastewater Operator Association (WWOA) and the Wisconsin Department of Natural Resources. This study guide was developed as the result of the knowledge and collective work of the following workgroup members:

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Chapter 1 - Theory and Principles

Section 1.1 - Definitions

1.1.1 Define aerobic (oxic) [O2].

Aerobic is a condition in which free and dissolved oxygen (DO) is available in an aqueous environment.

1.1.2 Define anaerobic [Ø].

Anaerobic is a condition in which free, dissolved, and combined oxygen is unavailable in an aqueous environment.

1.1.3 Define anoxic [NO2, NO3, SO4].

Anoxic is a condition in which oxygen is only available in a combined form such as nitrate nitrite (NO2-), (NO3-), or sulfate (SO4) in an aqueous environment.

1.1.4 Define denitrification.

Denitrification is a biological process where bacteria convert nitrate (NO3-) and nitrite (NO2-) into nitrogen gas (N2) under anoxic conditions.

1.1.5 Define fouling.

Fouling is a condition in which solids accumulate on top of or between the media that results in a decrease in the flow through the media.

1.1.6 Define headers.

Headers are perforated piping used to convey and distribute wastewater to the filter media.

1.1.7 Define hydraulic retention time (HRT).

HRT is the period of time that wastewater remains in a tank. This term is also known as detention time.

1.1.8 Define nitrification.

Nitrification is a biological process where nitrifying bacteria convert nitrogen in the form of ammonia (NH3) into nitrate (NO3-) and nitrite (NO2-) under aerobic conditions.

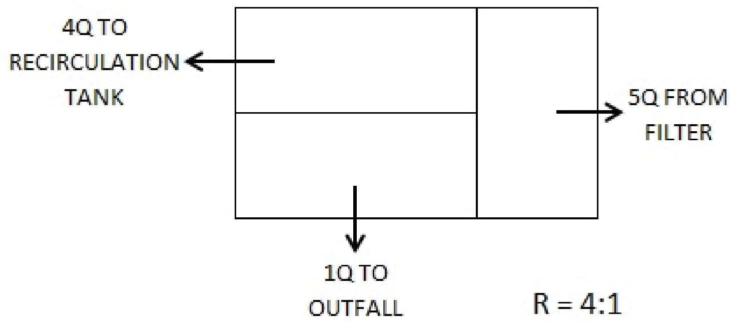
1.1.9 Define ponding.

Ponding is a condition in which wastewater accumulates on the surface of the filter media due to fouling.

1.1.10 Define recirculation ratio.

Recirculation ratio is a ratio of flow that is routed back to the recirculation tank relative to the flow that is routed to the outfall.

Figure 1.1.10.1



Source: Iowa Department of Natural Resources and MSA Professional Services

1.1.11 Define secondary treatment.

Secondary treatment is the biological treatment of wastewater. A recirculating media filter is a type of secondary treatment. Secondary treatment provides a high level of removal of biodegradable organic pollutants to protect receiving water quality that clarification alone cannot provide.

1.1.12 Define treatment facility overflow (TFO).

A TFO is a release of wastewater, other than through permitted outfalls, from a wastewater facility into a water of the state or the land surface. All TFOs must be reported to the Department of Natural Resources within 24 hours of the occurrence.

Section 1.2 - Principles of Recirculating Media Filters

1.2.1 Discuss the applicability of using recirculating media filters for wastewater treatment.

Recirculating media filters should be used only for residential strength waste and is most applicable to small rural communities. High-strength wastes from commercial or industrial users may cause organic overloading, in turn causing fouling of the filter media leading to ponding and clogging of the distribution piping. High-strength waste may also cause the loss of treatment within the system.

Recirculating media filters may be a good option for small communities that need to provide a higher degree of treatment than ponds or lagoons can provide but is simpler and less costly to operate than mechanical activated sludge treatment systems.

1.2.2 Discuss the treatment process.

Recirculating media filters are an aerobic, attached growth, secondary treatment unit following primary treatment. The treatment process utilizes aerobic microorganisms that grow on the filter media. The typical depth of the filter media is 24 to 36 inches, with most biological treatment occurring in the upper 12 inches of the filter media. Under the aerobic conditions of the recirculating media filter, the microorganisms oxidize organic matter present in the wastewater. The treatment process is a combination of biological decomposition, biochemical conversions, and filtration.

1.2.3 Explain the purpose of media and the material it is composed of in a recirculating media filter.

The filter media serves as a structure to support microbiological growth. Common types of media include rock, gravel, sand, or other granular material. Additional forms of media may include textiles, glass, chipped tires, or a variety of other materials. It is important that the media provides void spaces for air infiltration, in order to maintain an aerobic environment and prevent fouling.

Figure 1.2.3.1

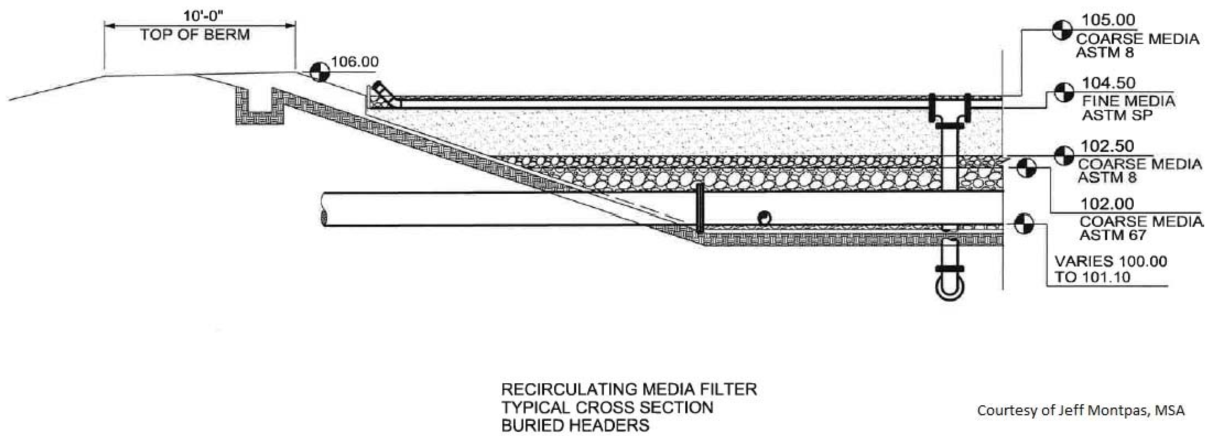
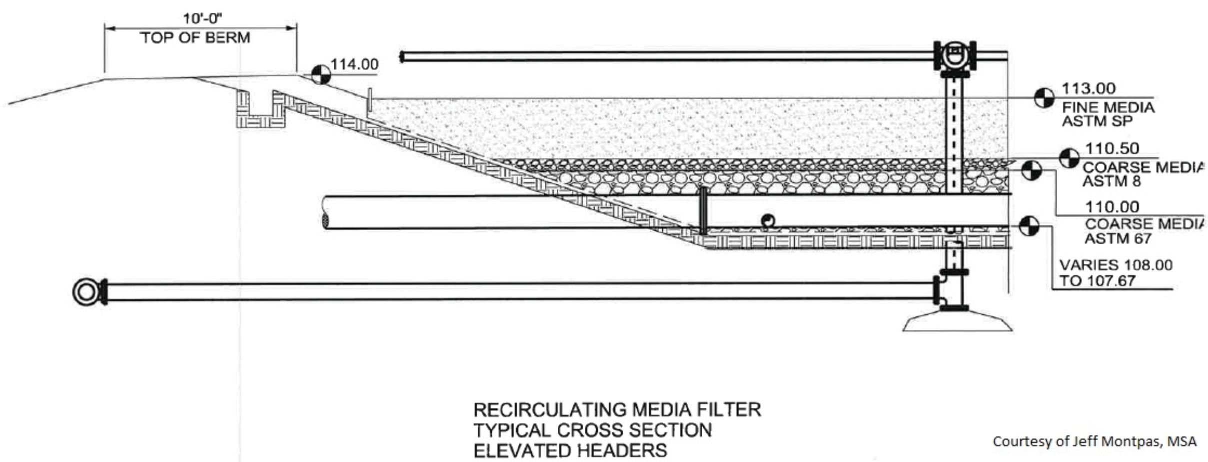


Figure 1.2.3.2



1.2.4 List the environmental conditions that support the growth of aerobic bacteria in a recirculating media filter.

Aerobic treatment processes must operate under the proper environmental conditions to support a healthy, growing population of microorganisms in the filter media for efficient wastewater treatment. The following factors will affect a healthy population of microorganisms:

A. Food

Incoming wastewater to a treatment plant provides the food that microorganisms need for their growth and reproduction. This food is mostly organic material. The more soluble the organic material is, the more easily microorganisms can use it. Since the amount and type of organic loading in the treatment plant affects the growth of the microorganisms, influent total biochemical oxygen demand 5-day test (BOD5) and soluble BOD5 are tests an operator can perform to determine the amount and type of incoming food for the microorganisms.

B. Flow

Incoming wastewater must flow through a treatment plant at a rate that allows microorganisms sufficient time to consume the incoming food (BOD). The recirculation ratio is thus very important for the proper level of treatment (see key knowledges 2.2.1 and 2.2.11).

C. Oxygen

Recirculating media filters are an aerobic process. Many bacteria in the filter need free oxygen (O2) to convert food into energy for their growth. Dosing cycles, proper organic loading, and pump rest periods help ensure adequate oxygen in the bed.

D. Temperature

All biological and chemical reactions are affected by temperature. Microorganisms’ growth and reaction rates are slow at cold temperatures and much faster at warmer temperatures. Most microorganisms do best under moderate temperatures, 10°C to 25°C (50°F to 77°F).

E. pH

Biological and chemical reactions are affected by pH. Most microorganisms do well in a pH environment of 6.0 to 9.0. Acidic (low pH) or alkaline (high pH) conditions can adversely affect microorganism growth and survival. Operators need to measure influent pH to ensure proper plant pH conditions.

F. Nutrients

Microorganisms need trace nutrients such as nitrogen, phosphorus, and some metals for their metabolism. Most incoming wastewater to a treatment plant, especially domestic, contains an abundance of these trace nutrients. The ratio of BOD to nitrogen to phosphorus should be at least 100:5:1. Influent wastewater can be tested to determine this nutrient ratio.

G. Toxicity

Incoming wastewater to a treatment plant may, at times, contain materials or compounds that are toxic to microorganisms. Depending on the concentration of toxic material, microorganisms could be destroyed or their metabolic rates affected, thus impairing the wastewater treatment plant efficiency.

1.2.5 Discuss nitrification in a recirculating media filter and the effect of temperature on ammonia removal.

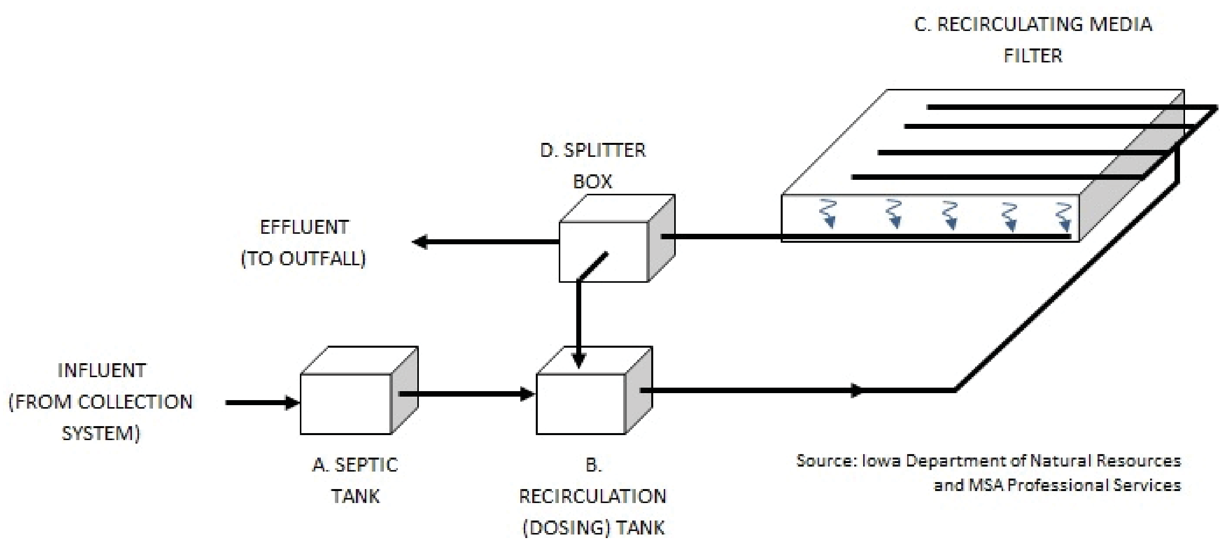
Recirculating media filters are able to remove ammonia through nitrification in the filter bed during warmer temperatures. Nitrification works best at temperatures between 10°C to 30°C (50°F to 85°F). At temperatures at and below 6°C (43°F), a loss in nitrification can occur. If nitrification is negatively affected by cold temperatures, effluent ammonia levels will rise and can result in permit limit violations.

Section 1.3 - Process Description

1.3.1 List and show the stages of a recirculating media filter system.

A. Primary treatment (commonly septic tanks)
B. Recirculation tank (also referred to as a dosing chamber or tank)
C. Media filter
D. Splitter basin

Figure 1.3.1.1



1.3.2 Describe the role of primary treatment preceding recirculating media filters.

Primary treatment is required and its main purpose is to remove settleable solids prior to secondary treatment. Without proper removal, excessive solids can accumulate and clog the media filter, causing organic overloading, anaerobic conditions, ponding, and fouling. Primary treatment also serves to reduce organic loading and remove grease, which can hinder biological growth on the filter media.

1.3.3 List and describe the ways in which primary treatment can be achieved.

A. Centralized septic tank
Septic tanks are the most common primary treatment unit for recirculating media filters. The influent flow to the treatment plant is divided into two parallel septic tank treatment trains that allow for continuous operation during maintenance, cleaning, or other emergencies. Each septic tank has multiple settling compartments. Submerged transfer pipes between compartments are used to prevent the forward flow of fat, oils, and grease (FOG) and passive filters are used to capture floatables. The septic tank's primary purpose is to settle out suspended solids, but it also provides contact with anaerobic bacteria that break down waste and lower biochemical oxygen demand (BOD).

B. STEP (septic tank effluent – pumped) or STEG (septic tank effluent – gravity) collection system

In a STEP or STEG collection system, individual homeowners and small businesses each have septic tanks where their wastewater is initially treated. Similar to a centralized septic tank, home septic tanks provide primary treatment to settle out suspended solids. Once the wastewater undergoes primary treatment, it is pumped or flows by gravity to the collection system and then to the recirculating media filter.

C. Pond or lagoon system
A recirculating media filter following a pond or lagoon system can act as a final polishing treatment. The pond or lagoon system provides the majority of BOD and total suspended solids (TSS) removal. Then the recirculating media filter provides final BOD polishing and nitrification for ammonia removal.

1.3.4 Describe the function of a recirculation (dosing) tank.

The purpose of a recirculation tank is to receive the primary treatment effluent and the recirculating media filter effluent that has been returned from the flow-splitter device. The recirculation tank is a wet well that consists of three or more submersible pumps. One to two of these pumps will be in operation each dosing cycle to pump wastewater from the recirculation tank to the media filter. Normally, the pumps are sized to handle the combined demand of peak hourly flow, recirculating media filter effluent return, and rainfall.

1.3.5 Describe the function of a flow-splitter device.

The purpose of a flow-splitter device is to divide the effluent from the recirculating media filter into two different directions. A portion of the flow is rerouted back to the recirculation tank and the remainder is routed to the outfall for discharge. The flow-splitter device consists of a variety of mechanisms which are used to split the flow such as weirs, piping, and valves (discussed in key knowledge 2.3.3). The operator controls the recirculation ratio and the number of passes with the filter through the division of this flow.

Chapter 2 - Operation and Maintenance

Section 2.1 - Definitions

2.1.1 Define dosing cycle.

The dosing cycle is the interval of time from when the pumps start running to dose the filter until the end of the rest period (when the pumps start to run again).

2.1.2 Define hydraulic loading rate (HLR).

HLR is the volume of wastewater applied per day to an area of the media filter. HLR is typically expressed in gallons per day per square foot (gpd/ft^2).

2.1.3 Define organic loading rate (OLR).

OLR is the pounds of biochemical oxygen demand (BOD) applied per day to an area of the media filter. OLR is typically expressed in pounds of BOD per day per square foot (lbs BOD/day/ft^2).

2.1.4 Define weir.

A weir is a level control structure used to provide uniform flow.

Section 2.2 - Methods

2.2.1 Describe the importance of the recirculation ratio for operating recirculating media filters.

An operator can control the level of treatment through the number of times wastewater passes through the filter. By increasing the recirculation ratio, a higher portion of water is recirculated back to the filter. Each additional pass through the recirculating media filter results in heightened treatment.

Recirculation ratios typically range between 1:1 and 5:1, and are higher in winter than summer. An operator must find a balance that is right for their system, by factoring in energy efficiency, treatment limits, the season, and other considerations.

2.2.2 Discuss the significance of dosing cycles and their frequency.

The microbial growth on the filter media is mainly made up of aerobic microorganisms. These microorganisms rely on the infiltration of air between the grains of media for their oxygen supply. Intermittent filter dosing provides time for air to re-enter these voids after wastewater is applied. Typically, dosing frequency is 48 times a day or more. This helps to ensure that the media stays wet. Hydraulic overloading or organic overloading can clog these pore spaces. Without oxygen, anaerobic microorganisms can take over. Anaerobic reactions are less efficient than aerobic reactions and can produce odors.

Monitoring the dissolved oxygen (DO) levels in the returning filtrate in the splitter box can be used as a way to monitor filter performance. Low DO levels in the filtrate (less than 4 mg/L) may indicate too high of a dosing volume, ponding, low percolation, high temperature, or too high of organic loadings. Normal oxygen levels above 4 mg/L indicate good system performance.

2.2.3 Discuss the benefits of using static screens or filters prior to the dosing tank.

The benefit of having a static screen prior to the dosing tank is to capture floatables (such as cigarette butts) that pass through the primary treatment (usually septic tanks) that can clog the distribution headers.

2.2.4 Discuss the advantages and disadvantages of elevated headers and buried headers.

A. Elevated headers

1. Advantages
   a. No prescreening required
   b. Lower electrical cost to operate
   c. Larger holes less prone to plugging
   d. Fewer and larger laterals

2. Disadvantages
   a. Larger water surface with more weed growth
   b. More filter maintenance for cleaning and weed control

c. Passes solids to filter media
d. Lower filter coverage

B. Buried headers

1. Advantages
   a. No surface water for weed growth
   b. Less filter maintenance
   c. Allows for better distribution because holes are spaced closer together
   d. More laterals for better filter coverage

2. Disadvantages
   a. Pre-screening required
   b. Higher electrical costs
   c. More prone to plugging due to solids
   d. More maintenance for cleaning

2.2.5 Discuss the purpose of multiple pumps and pump alternation.

Recirculation pumps should alternate each cycle to ensure equal wear of the pumps. Having multiple pumps also provide a back-up in the event of maintenance, pump failure, or high-flow conditions.

2.2.6 Describe the importance of filter bed rotation.

Filter bed rotations help to control ponding and weeds by allowing the beds to dry and re-aerate. Weeds can be removed and the media raked or tilled if needed. Maintenance and repairs can be made at this time, if needed, to exposed distribution piping and headers. A recommendation is to rotate beds every 3 to 6 months, especially in the spring and fall. An operator should determine the best bed rotation schedule for their particular system.

2.2.7 Discuss the importance of organic loading rate (OLR).

The OLR depends on the strength (concentration) of the wastewater and the flow to the filter. The OLR is expressed as the amount of wastewater applied to the filter media in pounds of biochemical oxygen demand (BOD) per day per square foot of media surface (lbs of BOD/day/ft^2). The recommended loading rate for a recirculating media filter is 0.003 to 0.005 lbs of BOD/day/ft^2. Strong wastewater containing high levels of organic material can reduce a filter's performance over time and result in a clogged filter or filter odors. Black deposits on the header around the orifices are an indication of anaerobic conditions created by organic overloading. Conversely, wastewater low in BOD will not support the microorganisms necessary for treatment.

2.2.8 List and discuss the different methods to control dosing.

Dosing wastewater to the filter media can be controlled by three different methods. These methods are as follows:

A. Automatically
By automatically controlling dosing, the operator uses water level-sensing equipment to

activate a pump(s). This method uses set points within the programming of the dosing pump(s) or the treatment facility to dose wastewater to the filter media. The dosing pump(s) run until the water level within the dosing chamber drops to a set level turning off the pump(s).

B. Manually
Manually turning on a pump(s) requires the operator to use the manual controls for the pump(s) at the dosing station. This typically consists of a three position selector switch for each pump located within the panel. The typical switch settings are hand, auto, and off. This indicates manual operation (hand), automatic operation (auto), or off. To manually dose wastewater to the media filter, the operator will turn the selector switch to hand on a pump(s) to activate the pump(s) until the water level in the dosing chamber is sufficiently lowered to provide storage for influent flow to the chamber.

C. Timer
Using a timer allows a pump to activate during low influent flow periods to the facility. The timer is typically a part of the programming for the operation of the dosing system and can be set at any interval the operator deems appropriate. A typical time is 30 minutes between pump activations during low flows. When a timer-activated pump turns on, it will typically pump wastewater to the filter media for 1 to 5 minutes to maintain a wetted condition throughout the media.

2.2.9 Explain the purpose of inspection ports.

Inspection ports are used to evaluate the media in the filter and are located in the upper and lower levels of the media filter. The upper level inspection port is used to determine whether the media filter is operating properly. If there is standing water in the upper portion of the media, then the media may need to be turned over or replaced to allow for the downward flow through the media. The lower port is used to evaluate the drainage from the filter bed. More than 4 to 8 inches of water in the bottom of the media filter may mean that the drain lines in the filter are plugged.

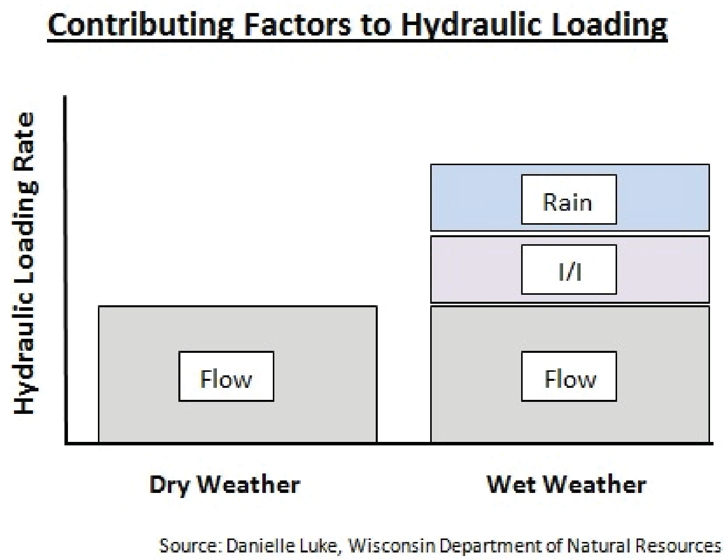
2.2.10 Discuss the significance of hydraulic loading rate (HLR).

The HLR is the volume of wastewater applied to a filter bed in a day. It is controlled by pump dosing cycles and recirculation rates. During wet weather, collection system infiltration and inflow (I/I) and the rain falling on the bed itself will increase the HLR. A typical HLR of pre-settled wastewater is 3 to 5 gallons per square foot of filter media per day (gpd/ft^2) for coarse sand and gravel media. The HLR will also affect the organic loading rate based on the BOD of the wastewater being applied. An operator can control the organic loading rate by regulating the HLR.

2.2.11 Discuss operating a recirculating media filter in wet weather conditions.

During wet weather, there will be an increased loading to the recirculating media filter beds due to higher flows from I/I and precipitation on the beds. In cases of extreme rain events, it may be necessary to decrease the flow to the bed to prevent hydraulic overloading. This may require that if only one bed is in use, additional filter beds be used. Decreasing the recirculation ratio can also be done.

Figure 2.2.11.1



Section 2.3 - Equipment

2.3.1 List the operational equipment used in a recirculating media filter system.

A. Influent flow-monitoring device
B. Influent fine screen (buried header system)
C. Influent sampler
D. Dosing pumps and controls
E. Effluent flow-monitoring device
F. Effluent sampler
G. Disinfection (if required by the permit)
H. Control panel

2.3.2 Describe submersible pumps and their use in dosing tanks.

Submersible pumps are placed in dosing tanks to pump wastewater to the filter beds for treatment. Raw wastewater entering the dosing tanks and recycle water from the filter bed entering the dosing tank is stored in the same fashion as a lift station wet well. Once the water level reaches a set point, a pump(s) is activated to dose a set amount of water to the filter. The set amount is determined by the float or transducer setting in the dosing tank. The volume of water stored in the dosing tank should be sufficient to run the pump(s) for a minimum of 10 minutes every 30 minutes during normal flow.

2.3.3 Describe how the different flow-splitting devices work (weirs, piping, and valves).

There are three different methods identified in this guide for splitting flow from a media filter. All three methods accomplish the same goal, which is to discharge a preselected ratio of treated wastewater for disposal or discharge and the remaining treated wastewater back to the dosing chamber. The three methods are V-notch weirs, flow-splitter manhole with pipes, and a recirculating splitter valve.

A. V-notch weirs

Weirs, typically V-notch weirs, are installed in a recirculation chamber where flow from the media filter enters the chamber and is then split between the discharge to the outlet or back to the dosing chamber. The weirs are cut into plates that are then inserted into channels in the wall within the chamber. The outfall weir is a single plate with a combination V-notch weir and rectangular weir. The weir plates to the dosing chamber can have a 30, 60, or 90 degree notch. The weir plates are provided in multiple configurations allowing the operator to select the recirculation ratio necessary to maintain proper treatment and meet permit standards.

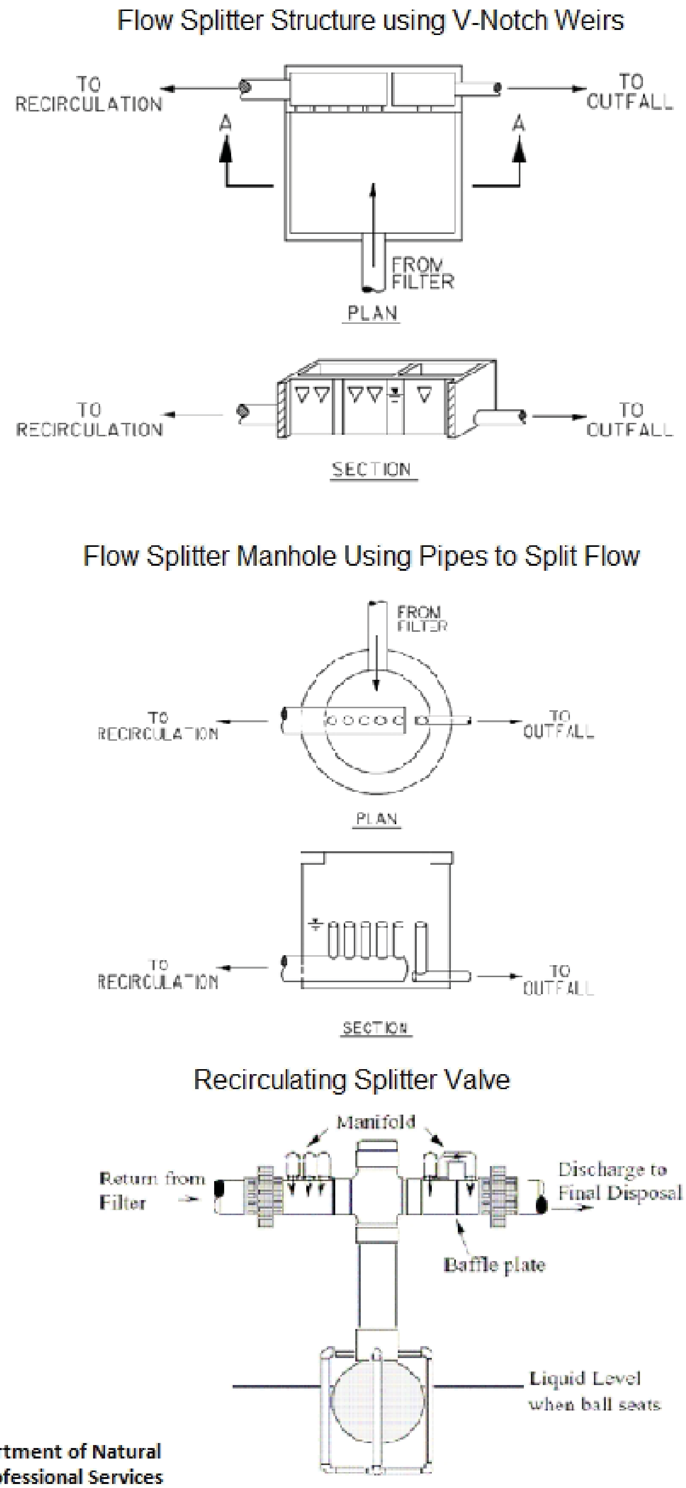
B. Flow-splitter manhole with pipes

A flow-splitter manhole using pipes accomplishes the same control as the weirs. Flow enters the splitter manhole from the media filter, where there will be a pipe that discharges to the outfall and a pipe that discharges back to the dosing chamber. Each pipe will be capped on the end. A single hole will be drilled in the top of the outfall pipe to control the discharge. The hole can be plugged by inserting a pipe the same diameter into the hole and capped on top. The pipe to the dosing chamber will have four holes drilled into it and a pipe that can be removed or inserted depending on the recycle ratio chosen by the operator.

C. Recirculating splitter valve

The recirculating splitter valve is located in the dosing chamber and operates by using the water level within the chamber to direct flow either to the discharge or back into the chamber. After the wastewater is pumped onto the filter media, the float ball in the splitter valve is lowered. As water flows through the return line from the media filter, treated wastewater is directed back into the chamber until the water level in the tank reaches the elevation where the float ball closes the discharge pipe. Once this occurs, treated wastewater is directed to the discharge until the pump is activated and the water level of the chamber is lowered.

Figure 2.3.3.1



Courtesy of Iowa Department of Natural Resources and MSA Professional Services

Section 2.4 - Preventative Maintenance

2.4.1 Discuss the method and frequency of solids removal from settling or septic tank(s). For proper system operation, the accumulated solids in the septic tank(s) should be removed regularly, consistent with the recommended removal rates in the O&M manual. A sludge depth finder can be used to determine the solids depth in the septic tanks. The contents of the septic system must be removed and disposed of by a licensed and certified septage hauler in accordance with chapter NR 113, Wisconsin Administrative Code. The permittee should obtain the following copies of records from the licensed septage hauler, be retained for at least five years, and make them available on request to the Department of Natural Resources. The records include: the licensed hauler used; the volume of waste pumped; dates when the waste was removed; the land application site DNR number; the method used to satisfy the pathogen and vector attraction control (injection, incorporation, or pH adjustment) requirements of chapter NR 113, Wisconsin Administrative Code; and/or the treatment plant where it was disposed. Winter application is not allowed.

2.4.2 Describe the following tasks and explain why each is important in recirculating media filter maintenance.

A. Filter bed tilling and vegetation control
Unless specifically designed to promote growth in the upper layer of media, all growth should be kept off the surface of the media. If done frequently, the operator will deal only with small weeds having little root depth. Removal can be accomplished by raking the surface stones to dislodge the developing roots. If weeds are allowed to get well started with significant roots in the stones, removal will require hand pulling, probably with follow-up work to prevent plants from becoming re-established from the roots that were not removed in the initial attempt.

B. Septic tank effluent screen cleaning
Effluent screens help reduce solids that enter the dosing chamber. Cleaning and maintenance of these screens is important to the operation of the treatment system. After the initial installation of the screen, the operator should inspect and clean the screens every two weeks. If clogging does not appear to be a problem, then the operator can extend the interval between cleanings. The operator should look for signs of surcharging such as high-water lines on the walls and debris on top of the screen. Should screens become plugged and the water surcharges over the top of the screens, larger solids may enter the dosing tank and be pumped to the filter beds. These larger solids may cause plugging of the lateral lines or the distribution holes to the media.

C. Lateral flushing
Lateral flushing is recommended each time a bed is taken out of service to rest. Lateral flushing is the process of cleaning the build-up out of the distribution laterals to maintain proper flow and disbursement to the media. Laterals can be cleaned by using the flow from the dosing tank to the specific bed. The operator can remove the end cap or open the flushing valve on a lateral to remove solids build-up in the lateral and disbursement holes. If flushing is not sufficient to dislodge the clogging, the operator can use a high-pressure jetting system to dislodge the solids. In this procedure, the laterals need to be off line. This process is completed by running a high-pressure nozzle up and down the inside of the lateral 2 or 3 times to clean the solids.

D. Pump control floats cleaning and maintenance

Pump floats control the operation of the dosing pumps to the filter media. On a weekly basis, the operator should check the condition of the floats making sure there is no debris in the tank that could cause a float to malfunction. At the same time the operator should check to make sure there is not a build-up of grease on the floats that could affect the operation of the float. If the operator notices debris in the tank, it should be removed. In the event of a grease build-up on the floats, the operator should spray the floats off with a hose.

E. Draining back the dosing pipes
Draining back dosing pipes is a maintenance item during the winter months. Draining the dosing piping will prevent pipes from freezing when the outside temperature drops below freezing. The operator should exercise any drain back valves on the force main to the filter bed monthly to maintain proper operation. Exercising of the valves should be done when dosing pumps are not running.

2.4.3 Describe how to prevent freezing in distribution headers.

Distribution headers can freeze up during winter's cold temperatures. In order to minimize the risk of freezing, the wastewater being pumped through the headers and laterals needs to be drained back to the dosing tank or into the filter bed. In order to drain the header back to the dosing tank, a drain back valve is required on the force main downstream of the pumps. Typically this valve is an automatic valve that operates once the pump(s) turn off after a dosing cycle. One drawback to this type of system is that it will drain the entire force main back to the dosing tank.

A second option is to drill a hole in the force main just above the bottom of the media filter and liner. This hole will allow any wastewater in the header or laterals to drain into the bottom of the media filter while allowing the force main to remain full up to the filter bed. This option should be done only if the force main is deep enough or insulated to prevent freezing.

Chapter 3 - Monitoring, Process Control, and Troubleshooting

Section 3.1 - Sampling and Testing

3.1.1 Discuss the monitoring and sampling requirements for a recirculating media filter system.

Recirculating media filter influent and effluent monitoring, sampling locations, and frequencies are found in the Wisconsin Pollutant Discharge Elimination System (WPDES) permit. Influent and effluent flows must be measured daily. Biochemical oxygen demand (BOD), total suspended solids (TSS), and other parameters are sampled and tested according to the WPDES permit and reported on monthly electronic Discharge Monitoring Reports (eDMR).

3.1.2 Identify sampling locations used to determine BOD and TSS removal from primary treatment and recirculating media filters.

Sampling and testing the influent and effluent of a treatment plant will provide the information needed to determine the percent removal of any pollutant through the entire treatment process. Sampling influent and effluent BOD and TSS is required as part of all WPDES permits.

Testing the same parameters between treatment units can also provide valuable process control information. For example, in recirculating media filters, in-plant sampling of the effluent from the primary treatment (commonly septic tanks) will provide the BOD and TSS removal from the primary treatment. This can help an operator determine when to pump solids out of the septic tank. Samples collected from the recirculation (dosing) tank will give the most accurate information on the BOD and TSS loading to the filter media and the possible need for changing the recirculation ratio.

Section 3.2 - Data Understanding and Interpretation

3.2.1 Explain why a filter bed should never completely pond over.

Wastewater that ponds on the media surface and does not properly percolate through will not receive adequate treatment. The ponded wastewater and upper part of the media filter can become anaerobic creating odors. Undesirable slime, algae, and vegetation may also grow.

3.2.2 Discuss why a filter bed should not become overgrown with vegetation.

Media filters should be kept weed-free. While vegetation and weeds growing in filter media will uptake water and nutrients, once they die and decay, the growing and accumulating vegetation can lead to matting on the media surface and plugging within the media. This can then result in ponding. Rototilling heavy weed growth into the media can result in ponding as well. Manually removing weeds and vegetation, roots and all, is the best preventative maintenance practice for keeping beds free of decaying vegetative matter on and in the media.

Section 3.3 - Corrective Actions

3.3.1 Discuss problems and corrective actions associated with a recirculating media filter.

Figure 3.3.1.1

Problem	Cause	Corrective Action
Ponding	Organic overloading plugging the filter media	Reduce organic overloading by placing another media filter in service; put ponding filter offline and allow to dry out then till up the media
Weeds	Lack of maintenance	Pull weeds and roots and develop a maintenance plan for vegetation control
Plugged headers	Excess solids	Jet headers
		Check amount of solids in settling tank and remove if necessary
Freezing	Excessively cold weather	Shorten pump cycle times
		Try back flushing with warmer water
		Check the slope of the headers and adjust to allow draining during non-dosing
Uneven distribution of flow across media	Plugged headers and/or orifices	Unplug headers and orifices
Odors	Detention time too long in septic tank	Take a septic tank out of service to reduce hydraulic detention time

3.3.2 Discuss the need of replacing filter media.

If ponding is a constant issue in the filter media due to fouling, replacement of the media may be considered. The reason for the fouling must be determined so the problem does not reoccur. Reasons may include:

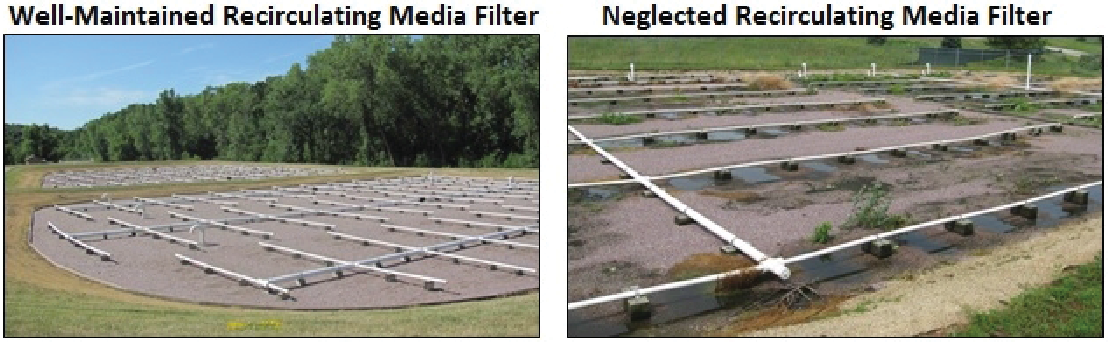
A. Excessive solids (see key knowledge 1.3.2)
B. Improper rotation of beds (see key knowledge 2.2.6)
C. Organic over loading (see key knowledge 2.2.7)
D. Lack of vegetative control (see key knowledge 3.2.2)

An engineering consultant should be contacted for media evaluation and for replacement.

3.3.3 Show the difference between a well-maintained and neglected recirculating media filter.

Figure 3.3.3.1

Well-Maintained Recirculating Media Filter **Neglected Recirculating Media Filter**



Chapter 4 - Safety and Regulations

Section 4.1 - Personal Safety

4.1.1 Discuss operator safety concerns and considerations for recirculating media filters.

A. Confined spaces
Many workplaces contain spaces that are considered to be confined because their configuration hinders the activities of personnel who must enter into, work in, or exit from. Operators and maintenance personnel should be familiar with spaces at their facility that may be classified as confined or permit-required confined. Each facility should have a manual in place for proper entrance into any of these spaces. Proper entrance and safety procedures should be followed at all times when entering.

B. Lock-out/tag-out
Lock-out/tag-out is a safety guideline that should be followed by all operators and maintenance personnel. Lock-out/tag-out is the process off turning of the electrical supply to the equipment that is in need of maintenance and/or repair, releasing stored energy, and placing locks with tags used by those performing the maintenance on the piece of equipment. The same person placing the tag should be the only person to remove the tag. This process is done to reduce the potential for accidents or electrocutions.

C. Splash
Splash protection is necessary to keep operators and maintenance personnel safe while at the treatment facility. Splash protection should be worn anytime when handling wastewater or any chemical type. Splash protection most commonly consists of rubber gloves, rubber apron, and eye protection with safety goggles, spectacles, or face shield.

D. Slips, trips, and falls
An operator needs to be careful while walking around the treatment plant. Open hatches, above ground piping, and slippery surfaces can lead to a falling injury. Not rushing and being aware of the surroundings will prevent these types of accidents.

E. Personal protection equipment (PPE)
An operator should always wear all required PPE to prevent personal injury. Areas where specific PPE is required should be clearly posted. PPE includes:

1. Steal-toe boots with a height of 6 inches from the ground to the top of the boot (for supporting the ankle) and an oil-resistant sole

2. Hearing protection (ear plugs or ear muffs) for use in areas with a decibel level above 85

3. Safety glasses or a face shield to protect the eyes and face

4. Pre-tested gas detector when in a confined space and/or a self-contained breathing apparatus (S.C.B.A.)

5. Protective gloves suitable for the type of work being performed

Chapter 5 - Calculations

Section 5.1 - Recirculation Ratio

5.1.1 Given data, calculate the recirculation ratio for a recirculating media filter bed.

GIVEN:

Flow to media = 100,000 gallons per day (gpd)
Effluent flow to outfall = 20,000 gpd

FORMULA AND SOLUTION:
[MGD = million gallons per day]

Recirculation ratio = recirculated flow (MGD) ÷ effluent flow (MGD)
= 0.080 MGD ÷ 0.020 MGD
= 4; recirculation ratio is 4:1

5.1.2 Given data, calculate the flow rate (MGD) to the media.

GIVEN:

Recirculation rate desired = 3:1
Effluent flow = 25,000 gpd

FORMULA AND SOLUTION:

Recirculation flow (MGD) = effluent flow (MGD) × recirculation rate
= 0.025 MGD × 3
= 0.075 MGD

Section 5.2 - Organic Loading Rate

5.2.1 Given data, calculate the organic loading (biochemical oxygen demand (BOD) lbs/day/ft^2) to a recirculating media filter bed.

GIVEN:
[gpd = gallons per day]

Influent flow = 30,000 gpd
Influent BOD = 220 mg/L
Media bed surface area = 12,000 ft^2

FORMULAS AND SOLUTION:

BOD loading (lbs/day) = flow (MGD) × BOD (mg/L) × 8.34
= 0.030 MGD × 220 mg/L × 8.34
= 55 BOD lbs/day

Organic loading rate (lbs/day/ft^2) = incoming BOD (lbs/day) ÷ media bed surface area (ft^2)
= 55 BOD lbs/day ÷ 12,000 ft^2

= 0.0046 BOD lbs/day/ ft^2

Section 5.3 - Hydraulic Loading Rate

5.3.1 Given data, calculate the hydraulic loading rates (HLR) (gallons per day (gpd) per square foot) during dry and wet weather.

GIVEN:

Filter media surface area = 10,000 ft^2
Dry weather flow = 38,000 gpd
Wet weather flow = 50,000 gpd
Rain fall = 3.6 ins

FORMULAS AND SOLUTION:

Dry weather HLR (gpd) = influent flow (gpd) ÷ media area (ft^2)
= 38,000 gpd ÷ 10,000 ft^2
= 3.8 gpd

Wet weather HLR (gpd/ft^2) = influent flow (gpd) ÷ media area (ft^2)
= 50,000 gpd ÷ 10,000 ft^2
= 5.0 gpd/ft^2

Rain fall (gpd) = media area (ft^2) × rainfall (ft/day) × 7.48 (gals/ft^3)
= 10,000 ft^2 × (3.6 ins/day ÷ 12 ins/ft) × 7.48 gals/ft^3
= 10,000 ft^2 × 0.30 ft/day × 7.48 gals/ft^3
= 22,440 gpd fell onto and was treated by the recirculating media filter

Rain fall HLR (gpd/ft^2) = rain fall HLR (gpd) ÷ media area (ft^2)
= 22,440 gpd ÷ 10,000 ft^2
= 2.24 gpd/ft^2

An additional 2.24 gpd/ft^2 of water was treated by the filter from the rain fall for a total of 7.24 gpd/ft^2 treated during the wet weather occurrence.

Section 5.4 - Dosing Cycle Volume

5.4.1 Given data, calculate the volume of water pumped (gals) and pump run time (mins).

GIVEN:
[gpm = gallons per minute]

Tank length = 30 ft
Tank width = 12 ft
Lead pump off setting = 95.0 ft
Lead pump on setting = 96.5 ft
Pump capacity = 400 gpm

FORMULAS AND SOLUTION:

Area pumped (ft^3) = length × width × [pump on setting (ft) - pump off setting (ft)]
= 30 ft × 12 ft × (96.5 ft - 95.0 ft)
= 30 ft × 12 ft × 1.5 ft
= 540 ft^3

Volume pumped (gals) = volume (ft^3) × 7.48 gals/ft^3
= 540 ft^3 × 7.48 gals/ft^3
= 4,039 gals

Pump run time (mins) = water volume (gals) ÷ pump capacity (gpm)
= 4,039 gals ÷ 400 gpm
= 10 mins

5.4.2 Given data, determine the dosing cycle to a recirculating media filter.

GIVEN:

Forward flow = 30 gpm
Recycle flow = 150 gpm
Dosing tank volume between pump off and on = 4,000 gals
Pump capacity = 300 gpm
Number of pumps operating during dosing cycle = 1 pump

FORMULAS AND SOLUTION:

[NOTE: Dosing cycle is the time for the pump(s) to run plus the time to fill the tank to initiate another pump run.]

Pump run time (mins) = tank volume (gals) ÷ pump capacity (gpm)
= 4,000 gals ÷ 300 gpm
= 13.3 minutes

Tank fill time (mins) = tank volume (gals) ÷ [forward flow (gpm) + recycle flow (gpm)]
= 4,000 gals ÷ (30 gpm + 150 gpm)
= 4,000 gals ÷ 180 gpm
= 22.2 mins

Dosing cycle = pump run time (mins) + tank fill time (mins)
= 13.3 mins + 22.2 mins
= 35.5 minutes or 35 minutes 30 seconds

References and Resources

1. **UW WATER LIBRARY**

   Most of the resources listed on this page can be borrowed through the UW Water Library as part of a partnership between the UW Water Library, the Wisconsin Wastewater Operator Association (WWOA), Central States Water Environmental Association (CSWEA), and the Wisconsin Department of Natural Resources. Instructions for borrowing materials from the UW Water Library can be found by visiting the website provided below, clicking on 'WISCONSIN RESIDENTS', and then clicking on 'HOW TO BORROW MATERIALS'.

   www.aqua.wisc.edu/waterlibrary

2. **RECIRCULATING MEDIA FILTER TECHNOLOGY ASSESSMENT AND DESIGN GUIDANCE (2007)**

   MSA Professionals and Iowa Department of Natural Resources

   www.iowadnr.gov

3. **RECIRCULATING MEDIA FILTER DESIGN GUIDANCE (AUGUST 2008)**

   MSA Professional Services, Inc and Minnesota Pollution Control Agency

   www.pca.state.mn.us/index.php/view-document.html?gid=10148