ENVIRONMENTAL / HEALTH PRODUCTS & SERVICE

PO BOX 21
Richfield, WI 53076
Phone: (262) 628-1300

PO BOX 101
Phillips, WI 54555
Phone: 715-339-3497

E-Mail: ken-ehs@juno.com

Small Wastewater Flow Moving Bed Biofilm Reactor (MBBR)
The EHS SMART-Treat™ Onsite Moving Media Treatment System

Owner/Operator Start-Up, Operation and Maintenance Manual

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General Introductory Statements --- EHS Equipment Supplied & Workmanship

System components are assembled with quality workmanship and in accordance with general engineering guidelines so that the combined functioning of these components should produce designed effluent quality.

- The majority of components are manufactured by various companies. Most of the unit process components have their own equipment coverage regarding warrantee. EHS does not supply or supplement any of the assembled equipment components warrantee or equipment coverage.
- It is up to the system owner to read the I-O-M manuals, determine operations and maintenance for each component and carry through with O&M in the proper manner, and follow suppliers/ manufacturers recommendations regarding unit process equipment warrantee issues and coverage.

EHS "makes" the biofilm carrier element retention screens and the air distribution piping.

Biofilm Element Retention Screens & Air Distribution Piping:
General cut sheets identify these products. Products are manufactured with attention to detail and good workmanship regarding assembly practices & industry standard PVC weldment procedure.

Flow: A flow meter in good working order is usually specified & essential to determine loading.

Tankage: On a case-by-case basis, sufficient aeration tank volume is usually provided, should additional biological surface area be needed to accommodate current or future increases and flow and organic load.

Surface Area:
Biofilm Carrier Elements (media surface area) material is high density polyethylene (HDPE) and is manufactured according to Biowater Technologies specifications. The biofilm carrier elements are produced from a material & with procedures that ensure proper operation for its service life.

Aeration:
Aeration is provided for microbial aerobic activity and growth according to standard design practices of the industry for the anticipated present and future flows and loads defined by the industry (or whoever supplied the inlet criteria)

EHS-supplied equipment Installation, Start-Up, Operation & Maintenance

<u>Supplied Equipment Installation Supervision:</u>
EHS will provide supervisory guidance, under contract, regarding general installation of supplied equipment at a predetermined hourly or daily rate. When installation site is more than 50 miles from EHS offices, travel and living costs will be charged.

<u>Process Startup Services:</u>
EHS will provide brief operation training to the lead maintenance person within the specified (paid) installation window. Included with the hourly or daily rate, EHS will provide initial start-up

guidance (and observation of start-up if wastewater water flow has occurred through aeration tankage within the time EHS is on-site for installation guidance; however, there is usually a time difference between installation and equipment start-up that does not accommodate EHS to be on site at start up)

In the event EHS is not on site at the day of supplied equipment start up, EHS may provide for startup procedures suggestions and possible adjustments to equipment to accommodate start-up via phone or video conferencing.

With a maintenance agreement in place, or with a pre-paid, pre-planned schedule, EHS will provide some allotted time at the site for a site evaluation and short follow-up training session for main maintenance personnel within one year of startup.

<u>Operation, Maintenance and Sampling:</u>
It is up to the system owner or their representative to read the I-O-M manuals, determine operations and maintenance for each component and carry through with O&M in the proper manner, and follow suppliers/ manufacturers recommendations regarding unit process equipment warrantee issues and coverage.

EHS will not take troubleshooting or routine samples but will review and approve of sample locations, methods and sampling protocol and laboratory results; and may take samples, and may provide opinions or suggestions, if appropriate. If there is a disagreement regarding sampling protocol or method, or location, EHS will voice an opinion on the matter. EHS will not pay for lab testing, but will review process performance data supplied, suggest possible operation and sampling adjustments (infl. effluent) if data indicates adjustments be made to improve process performance. If there is a process issue, then influent parameters need to be clearly defined and compared to design values. If actual values are higher than design values, it is solely up to the system owner to address these higher influent values, or provide for purchase of additional equipment to accommodate higher than design flows or loads.

If process performance is in question, then toxicity tests may need to be conducted, at equipment purchaser's expense. A list of cleaning agents and other chemicals used in the building where the wastewater is sourced may need to be generated. If it is found that there is toxicity in the wastewater which may hinder biological performance, the chemical identified would need to be changed to a biodegradable product.

Other Equipment Available through EHS

Dependent on the scope of supply of an application, EHS typically offers additional equipment.

--Standard offering, with or without tanks: Grease trap, septic, flow equalization, anaerobic, anoxic, aerobic, chemical mixing, clarification, pump

--SMART-Treat pkg. (items selected as needed for the job): Biofilm carrier elements, aeration distribution headers, inlet/outlet carrier element retention screens, airlift or electro-mechanical pumps, intermittent big bubble mixers, blower bases, housings, blowers and associated equipment, elec. controls

--Other equipment available: Dissolved oxygen sensors, flow meters, valves and air measurement equipment, UV disinfection equipment, chemical metering pumps

DESCRIPTION AND PRINCIPLE OF OPERATION; O & M GUIDELINES

The Private Onsite Wastewater Treatment System (POWTS) known as the Moving Bed Biofilm Reactor (MBBR) system consists of typical septic tank (and grease interceptor when needed) for primary solids separation, aerobic reactor tankage, secondary (biological) solids separation, and effluent discharge to subsurface destinations for final disposal.

The MBBR process uses aeration and mixing in wastewater tankage with small biofilm carrier elements to grow bacteria and treat wastewater flows. Air is mechanically compressed and distributed to the aerobic reactor tank. Oxygen in the air diffuses into the thin biofilm that naturally grows on the biofilm carrier elements. The biofilm carrier elements move at random throughout the aerobic reactor tank. As air passes through the water and past the media, the wastes in the water act as food for the microbes growing on the moving media. Cleaned water is discharged while settled biological solids are occasionally returned back to the primary solids separation zone (septic tank) for normal routine disposal along with primary settled solids.

The system reduces BOD_5, TSS, and Nitrogen as Ammonia Nitrogen or Total N. Supplying oxygen to the wastewater stream reduces BOD5. TSS is reduced through settling and filtration. Nitrogen as Ammonia Nitrogen is reduced by converting ammonia to nitrate. Up to 70 %- 85% denitrification (nitrogen removal) is achieved with recirculation and blower sequencing. Total Nitrogen below 10 mg/l is achieved with specific engineering techniques for nitrogen removal. Fecal coliform and Total Phosphorus reduction is possible with additional passive (non-mechanical) or active (mechanical) system components.

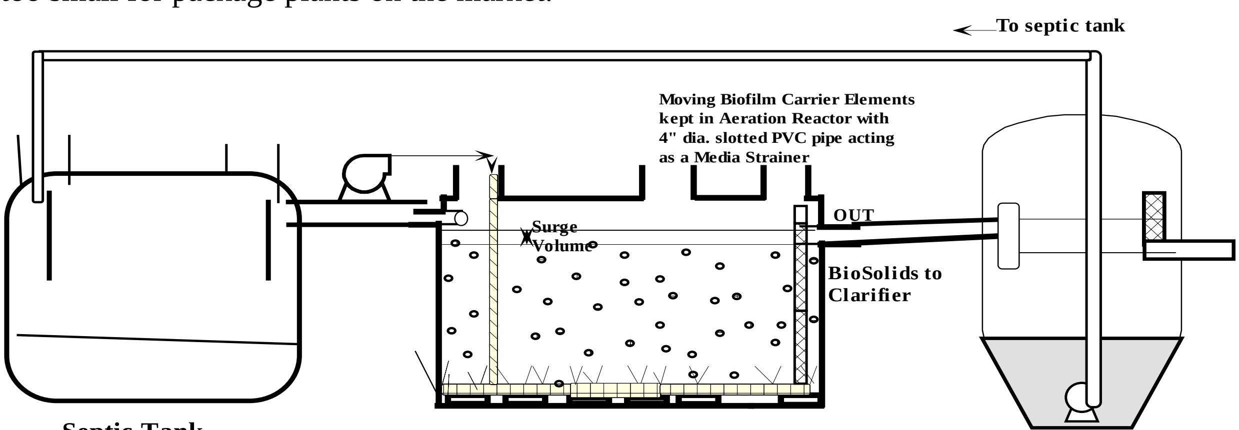
The basic idea was to have continuously operating, non-cloggable biofilm reactors with no need for backwashing or return sludge flows, low head-loss and high specific biofilm surface area. This was achieved by having the biomass grow on small carrier elements that move along with the water in the reactor. Coarse-bubble aeration in the aeration zone and interruption of aeration (or mechanical mixing in an anoxic/anaerobic zone) in the wastewater treatment tankage provide a highly treated effluent, with easy, low-cost operation. The biofilm carrier elements are made of 0.96 specific gravity polyethylene and shaped like small cylinders, with a cross in the inside of the cylinder and longitudinal fins on the outside. There are two basic sizes, (with diameters of 12 and 18 mm, and 8mm and 15 mm height. To keep the biofilm elements in the reactor, a screen or perforated plate or pipe is placed at the outlet of the reactor. Agitation moves the carrier elements over the surface of the screen; the scrubbing action prevents clogging.

This relatively new fixed film wastewater treatment is economical, reliable, and easy to install and operate, compact, and is highly flexible with regard to influent hydraulic and organic loads. This process can be easily integrated into a variety of different stages of infrastructure development to treat domestic, industrial or combined flows. This process is used for a various flow ranges in both domestic & industrial treatment. A brief description of this process for small commercial and domestic wastewater treatment applications makes it easier for regulators to understand the benefits of this technology and allow greater use of this technology in small flow applications.

A small flow newsletter by International Association on Water Quality (1997) indicated that as small flows become more prominent and treatment requirements become more stringent, cost-effective, and efficient treatment systems need to be developed for on-site treatment and existing plant upgrades. Neu and Rusten (1997) indicated that a relatively new system that could be downsized from current municipal and industrial applications is the Moving Bed Biofilm Reactor (MBBR) process. This patented process has been developed over ten years ago. There are more than 200 operating or planned installations worldwide since 1990, from small community or multi-home units to large municipal plants such as Wellington, New Zealand (population equivalent = 200,000).

Almost any size or shape tank can be built or retrofitted with the MBBR process. The filling of carrier elements in the reactor may be decided for each case, based on degree of treatment desired, organic and hydraulic loading, and temperature and oxygen transfer capability. A maximum filling of about 70% (volumetric filling of carrier media in the empty reactor) of the smallest carriers corresponds to a specific biofilm growth area of about $350 m^2/ m^3$ (over 2,900 ft^2/yd^3 or over 107 ft^2 / ft^3). The biofilm carriers at this specific fill level displace a water volume of about 12%. The reactor volume is totally mixed; there is no dead space or unused space in the reactor.

This system is ideal for small installations such as single family or multi-home clusters, mobile home parks, and small unsewered communities. It can also serve to upgrade overloaded activated sludge, trickling filter, or RBC package-type or full-scale plants, or for converting unused volumes into biofilm reactors for increased capacity or nutrient removal. This process also fills an important flow niche; that size from too large for available modular (home) systems to the flows that are just too small for package plants on the market.



EHS Small Wastewater Flow MOVING BED BIOFILM REACTOR (MBBR)

The following table shows a sample of the design sizing variation when using the MBBR system with the approved component manual. Flow rates or pollution loads are converted to population equivalents. An appropriate treatment system is designed using the MBBR component manual.

***BOD REDUCTION ONLY*· MBBR MIN tank volume, depth, media, air.**

Population Equivalents	Tank Vol, min gallons	Water Depth, min, FT	% Tank Media Fill	Media Vol, FT^3	Max Air @ Peak Q, CFM
6	200	3.3	16.1	4.3	5
12	200	3.3	32	8.6	10
30	250	3.3	64	21.3	21
100	840	4.5	64	71	38
500	4175	6	64	354	139
1000	8250	10	64	707	153

Start-up Procedures

Preparations

- Check that the outlet sieve is secure and unable to move or tip in place. A vertical section of pipe should come up from the Sieve Tee. On the top end of the pipe (6-8” from cover), a strainer device should be placed inside of the pipe. A rope section attached to the strainer will allow the strainer to be removed to be able to clean the inside of the strainer—if needed. The Strainer atop the sieve extension is to prevent carrier elements that might be lifted by foam—from entering the clarifier section. There should be NO openings in the wall between the aerobic reactor stages or between the reactor and the clarifier that are larger than 1/6 inch. All gaps <u>must be less</u> than 5 mm.

- Check that the aeration system is level and secured to the reactor bottom. All concrete weight blocks should be in their proper locations straddling the air distribution header. In order to obtain an even distribution of air, the aeration grids and laterals should be level to within a maximum of ¼ inch (6 mm) tolerance.

Aeration Grid Test

- Fill the reactor with water to a depth of 2-3 feet for initial testing of the blowers and aeration system. The aeration grid test will also show where any air leaks are within the system which might require fixing.

- Start one blower and aerate the reactor at full capacity with all valves in the open position, if there are valves. Observe the aeration pattern of the tank. The entire tank floor should have good distribution of air from the grid system across the entire tank floor. Due to spacing between the aeration grids, you should easily see these areas of minimal air flow during the aeration grid test, but will be difficult to see when operating at the normal water level in the reactor. See the picture below showing the air distribution in the tank.

- After testing the first blower it is recommended to test the other blower(s)—if others are supplied for the treatment system. The valves located in the process air lines can also be checked—if valves were installed. Also notice the pressure relief valve on the blower. With the full depth of water in the tank, set the pressure relief valve to just above the point where air escapes from the valve. Do this at least 15-20 minutes after blower has been in operation. Allowance of this time will most likely assure that all water is purged from the aeration grid header. Additional adjustment (closure) of the pressure relief valve may be needed after several weeks of run time.

FIGURE 1 - TYPICAL AERATION GRID PATTERN

- Once the tanks are completely filled with water (**after start-up and media placed in the reactor**) you will want to test the blowers at design air flow rates and observe the aeration pattern at this air flow. There will be lots of turbulence within the water at this time due to the reactor and the amount of air being added to the system.

Due to the degradability of constituents in the wastewater, monitoring of the system should begin within a week of startup. Typical analyses that may be conducted early in the startup period include COD (total & soluble), ammonia, total nitrogen, phosphorus and TSS/VSS. This will allow evaluation of BOD & total nitrogen removal and of biomass growth and to increase the flow rate and load to the reactor based on the results.

It is estimated that the system should be treating the raw wastewater at the design flow rate within 2-3 weeks of starting the system. Along with analytical testing, the basin should be monitored for temperature, dissolved oxygen concentration, pH and flow rate.

Shut Down Procedures

If it becomes necessary to stop the supply of raw feed to the bioreactor for a short period of time, less than four (4) weeks, the reactors should be moderately aerated to keep aerobic conditions.

If it becomes necessary to stop the supply of raw feed to the bioreactor for a longer period of time, one month or longer, it is recommended to aerate the reactors for two weeks after the stop of raw feed and drain the reactor. Prior to re-introducing wastewater to the biofilm reactor should be aerated 5 days prior to re-loading the reactor with raw wastewater. When re-starting the raw feed to the bioreactor, start at 50% design flow and work up to 100% within 3-4 days—if possible.

Biofilm Carrier Transfer

If for any reason the biofilm carriers have to be transferred from one basin to another, the biofilm carriers can be pumped using a vacuum truck or a recessed impeller/sludge style pump. The pump should have a minimum of 2.5 inches of clearance for pumping and the biofilm carriers should have aeration to provide for a constant mix of the reactor contents such that one is not pumping 100% biofilm carriers but a combination of biofilm carriers plus wastewater.

Operation & Maintenance of the Treatment System

This general Start-Up, Operation & Maintenance manual will be submitted to the customer (system owner and/or maintainer) upon installation of the SMART-Treat™ system. The maintenance of the system is like typical wastewater treatment systems. The aeration system, sieve assemblies and biofilm carriers require very little operator attention. The SMART-Treat™ O&M manual provides general and specific guidelines for system care, operation and maintenance.

General MBBR System Operation & Maintenance Considerations

Level of Maintenance

There are general O&M guidelines that can be used in any small flow wastewater treatment system that has a fixed film moving bed process. This is a general guideline for all small flow medium or high-strength plants.

A large part of operation of this system deals with adherence to the maintenance schedules provided by the manufacturers of components of the system. Also, maintenance table included in this section.

Inspection

Critical inspection checklist

- Proper blower operation
- Proper air distribution to diffuser grid
- Check for proper operation of media movement
- Clean Media Sieves periodically, if needed
- After biological treatment and biological solids settling, take effluent sample from clear water zone if chemical analysis is to be performed to determine effluent quality
- Clean final filter periodically (if applicable)

Level of Maintenance Table

High Maintenance	Medium Maintenance	Low Maintenance
If a Restaurant, adhere to In-Restaurant Grease Removal Procedures (Daily)	In biological solids separation compartment, check for proper pump operation & solids removal@ 3-month intervals	Check sludge depth in Septic Tank and remove solids as needed if solids level rises to 1/3 of liquid depth or above (potentially 3-4X/year intervals if restaurant or other high-strength ww, yearly, or less often if domestic flows)
If Grease Trap (owner to check monthly- remove grease as necessary to keep grease from entering Septic Tank)	See blower manufacturer recommendations for maintenance schedule	Check blower output & Clean or Change blower air filter-Annual **Note: It has been the experience of EHS that 2-3x/yr filter maintenance extends blower life.** EHS offers maintenance agreements for this work.
Blower- If blower stops or alarm alerts- address blower issue.\	Check aerobic reactors monthly for uneven air distribution, foaming	Clean effluent filters as needed, if used. Annual cleaning or less intervals, clean more often if needed

General Operation & Maintenance – Unit Process Considerations

A Fat, Oil & Grease Removal

A SMART-Treat™ MBBR on a restaurant wastewater system requires grease removal prior to biological treatment. A tank fitted with grease removal baffles should be installed. *Remove accumulated fat, oil, and grease at regularly scheduled intervals with minimum removal at six-month intervals. Frequent grease removal is especially important during the 1st year from start date of the system, to provide aerobic microbes time to acclimate to the food supply.*

For the biological treatment to function properly, the grease trap must be properly maintained at all times, with a record of maintenance sent to the contracted system maintainer annually. The main idea is to prevent as much fat, oil, and grease from entering the wastewater treatment system as possible. This will help to avoid line plugging, system failure, and future repairs or maintenance. An upper limit of 100 mg. /l for septic tank effluent prior to biological treatment is suggested. Proper treatment may not be attained if this limit is exceeded.

A surface clean-out access to the 4-inch line just upstream from where the flow enters the grease trap is recommended. If the flow backs up into the building or it is difficult to remove water from any sink or drain, check and clean the main line to the grease trap, or call a qualified professional to do so.

B. Septic Tank

Initially after start-up, check solids depth at six-month intervals. Pump septic tank as needed to maintain solids accumulations to less than 1/3 depth of the liquid level. If it is determined that a less frequent schedule can be maintained, adjust monitoring and pumping schedules accordingly. Have a septic pumper check for proper baffle and inlet/ outlet function.

C. Aerobic Treatment

Introduction

The aerated biological reactor tank is a fixed film biological treatment system that uses plastic biofilm carrier elements (media) that microbes attach to and grow on. (Other examples of fixed film treatment are trickling filters and rotating biological contactors). The biofilm carrier elements with attached biomass moves around the reactor tank that is filled about 30 -70 % with these plastic elements. The wastewater and media in the reactor tank is aerated by course bubble aeration, which serves as the force of motion for the plastic elements. To prevent carrier elements from moving out of the reactor compartments, sieves or screens made of 4-inch PVC are attached to the outlets of the aerobic reactors.

Air is diffused into the liquid by a weighted PVC pipe grid aeration system. Hole configuration is standard of the industry for this type of course bubble reactor system, Each aerobic reactor will have an air distribution system. Within each reactor there will be air headers. The air distribution pipes will be secured in place with plastic hold-downs and stainless steel cement screws to cement pads. (Alternatively, the header pipes could be weighted down with steel pipe sections, or sandwiched between two (2) sections of concrete block. Typically, total airflow from a centrifugal rotary or regenerative blower will be adequate for BOD removal with unequalized flow. Airflow can be sized for nitrification, denitrification or for equalized flow conditions. The aeration zone may contain two separate biological treatment stages, if desired.

SMART-Treat™ Process Startup

The microbes inherent in the wastewater should be plentiful enough to initiate biomass growth on the carrier elements. It may take several days to witness visible biofilm on the carrier elements. For quicker startup, a small quantity of good quality aerobic settled biomass from a municipal plant secondary clarifier may be introduced into the biological reactors.

Wastewater is cleaned by the biomass attached to the carrier elements. The plastic material that these elements are made from does need an initial period (24-48 hours) for the surface film to be reacted with biofilm before the elements will start to move within the reactor. There may also be some foaming initially, until biofilm accumulates on the carriers and treats the waste. A small quantity of anti-foaming agent as manufactured by Nalco Chemical Company (or equal) could be used in the reactor tanks if foaming occurs. The anti-foaming agent should always be kept on hand in the even of a spill that accidentally enters the treatment system.

As a standard practice, low-foam detergents and cleaners should replace any foaming cleaners BEFORE new wastewater system startup. Also, common sense should dictate the purchase and use of cleaners that enter the wastewater treatment system... Toxic agents such as chlorine or any halogenated compounds should be avoided. See your county extension agents or conservation and zoning officials for a list of acceptable and non-acceptable cleaners. There should be an equal volume of air from the air distribution headers, spread across the tank bottom. If extraordinarily uneven air seems to be bubbling up in one area of the tank compared to other areas, it is possible that the air distribution system is cracked or broken. Call a service technician for inspection and/or repair.

Normal Operation

The biofilm carrier elements are kept in the reactor with filter/sieve equipment specifically designed to allow liquid to flow from compartment to compartment without resistance. The movement of the carrier elements automatically cleans the outer surface of the screens. If inner surfaces of the screens need to be cleaned, there are inspection ports or manhole access ports that will allow a brush to be inserted into the inner portion of the 4-inch diameter screen for a quick and easy brush stroke or two.

The aeration tank effluent screens have nominal openings no larger than 0.20 inches. This dimension would positively hold all biofilm carrier elements in the aeration reactors while allowing sloughed biological floc to pass through the screens from aerobic reactor to aerobic reactor, or to the clarification zone.

The procedure for normal operation is that there should be adequate aeration to maintain a positive dissolved oxygen concentration in the liquid being treated. That dissolved oxygen will be in the 1-3 mg/l range. Biomass grows on the biofilm carrier elements. Normal color is medium to light brown. The movement and aeration automatically sloughs biofilm, which then is in suspension in the tank, up to a concentration of 100-300 mg/l or more. As nutrient-filled wastewater enters from the septic tank more microbes grow and slough. The microbes pass to the solids settling zone and normally settle to the bottom of this tank. Rectangular tanks can be used without modification if the suction draw around the airlift or electromechanical pump is within a 7' radius of the pump (in other words—if the distance between pump & vertical wall is =/< 3.5') In rectangular tanks where there is >3.5' from pump to vertical wall, an insert or fillet may be shaped with stainless steel thin plate (or plastic) to create the necessary slope for solids to settle well. In those situations, it may be best to use a settling tank with sloped sidewalls-see below. In other biosolids clarifier designs, the settling tank is typically spherical or conical in shape, so the tank wall slope is at least 60 degrees from horizontal. Good quality microbes should settle readily in the volume provided. Effluent quality is expected to be 30 mg/l or less TSS.

Common-Sense Maintenance of Biological Treatment Systems:

Biological treatment will dramatically reduce the pollution load entering the soil in the drainfield and the groundwater. However, biological upsets that could reduce treatment efficiency could occur. All residents, owners and users of the treatment system should follow common-sense protocol that will promote a healthy biota in the aerobic treatment system. This includes water conservation measures, and common-sense use of cleaning materials, which, in too large a quantity, could negatively affect the biological treatment system. Most County Environmental Health Departments and County Conservation Departments should have and ample supply of written materials that describe the practical DO'S AND Don'ts of septic system and biological treatment system operation. This note is to encourage owners to actively discuss points that will make the POWTS system operate optimally, and to take steps to insure a healthy biota in the aerobic treatment system.

Toxic substances or abuse of the system will cause failure and may be expensive to repair. Some things that could cause the biological system to loose efficiency and/or fail:

- Total Fat, Oil & Grease content in the septic tank effluent (influent to aerobic treatment) of more than 100 milligrams per liter
- pH of the aerobic treatment influent out of the range of 6.0 to 9.0 standard units.
- Excessive water use—an accurate and calibrated water meter, read and recorded on a periodic basis of not less than monthly, to monitor water use. In cases where water use in excess of daily design flow, design target effluent may not be met and shall void any design guidelines for effluent or process performance.

  Likewise, if organic constituents are above design inlet conditions, design target effluent may not be met and shall void any design guidelines for effluent or process performance.

  - Chemicals, detergents, or cleaners not compatible with biological wastewater treatment or aerobic microbes.

- Non-biodegradable chemicals or detergents that may cause damage to microbes' ability to function properly or to cause damage to drainfield area.
- Grease and sludge removal MUST be performed at not less than 6-month interval, and preferably quarterly

All of the above bulleted items are the responsibility of the owners/users of the treatment system. Any deviation will void all guarantees and relive the installer, contractor, designer, inspector and maintainer of all claims during the guarantee period, and beyond, should the above items occur after the guarantee period**.**

Biological Upset Conditions

If poor quality microbes are produced in the aerobic zone, with consequent poorer settling than expected, elevated solids concentrations may escape to the clear water zone. The first place to look to determine what caused the condition is to carefully examine the procedures used in food preparation and cleaning. Whether if a bar, restaurant, or other commercial facility generating high-strength waste, or a typical domestic waste generator, check the cleaning/maintenance procedure. Most likely something was introduced to the system that caused a toxic or overload condition for the microbes. Changes in these areas will most likely cure the problem.

When the septic pumper is on site to conduct routine maintenance of the grease trap and septic tank, it is recommended that the solids level in the clarification zone be checked, and if over 18 inches solids depth is found, that this tank compartment be at least partially emptied as part of the system solids removal routine.

Preventive action: Adjustment of aeration to try to improve microbe quality, or other measures.

It has been shown that microbes using the nutrients in the wastewater have benefited from periods of high and low dissolved oxygen cycling. The advantage usually is prevention of aerobic filaments, which means that long, hair-like strands of microbial growth have a harder time surviving if there are low DO and high DO cycles. If aerobic filament growth predominates, the best remedy is to try to change the microbiology to select for more efficient microbes. The technique to selection of better biological floc-formers, which improve settling characteristics and improve effluent quality, is to reduce oxygen input. For small plants, the best way to do that is to cycle the air delivery blower on and off.

A dissolved oxygen measurement [using a field test kit, or a DO probe on a portable DO meter (preferred method)] in the aerobic reactor would determine the dissolved oxygen level. If the DO level is above the 1-3 mg/l range, the control panel timer could be set to allow blower on-time cycling. It may take several adjustments to select the optimum on/off cycling. Start with a 4-hour ON time and 2-hour OFF time. Adjust up or down dependent on dissolved oxygen levels at the beginning and end of each blower ON cycle. Check nitrate-nitrogen concentrations in the MBBR reactor at the beginning and end of the OFF time cycle. Also observe for settling characteristics (improvement or deterioration in settling).

A more drastic measure is to cleanse the biological system of much of the biota and start afresh.

Chlorine or caustic application will usually kill much of the microbe mass in the aerobic reactor. Many times this step is not necessary, but in some extreme cases it might be. Extreme caution should be used when handling chemicals. To do either of these procedures, it is recommended that a trained professional (POWTS system inspector/maintainer) be involved.

D. Solids Settling Zone (clarification) & Final Filtration

Following the aerobic reactor tank there will be a solids settling tank. It will function to separate biological solids that flow through from the aeration tank... Gravity-settled solids will accumulate at the bottom of clarifier and be pumped on a timed basis once per day for about 2 minute's duration to the septic tank for disposal on a routine schedule.

[At a future time if determined to be necessary, this same pump system could be set for a recirculation mode of up to 200 % of average forward flow. This would aid in denitrification in the septic tank, if nitrogen removal ever became necessary. Provision of ammonia conversion to nitrate (nitrification) would need to be addressed with equipment additions in the aerobic zone]. Maintenance items would include checking to verify that the pump(s) are operating properly, with no clogging. In continuous operation situations, these pumps have an expected life greater than 2 years. They have internal sealed bearings, and so bearing or seal failure may be the first area of total pump failure. At that point, simply replace the pump with a new one.

E. Clear Water Infiltration

System drainfield or final effluent disposal components should be serviced by a qualified service provider according to the operating permit.

Troubleshooting Considerations

The only moving mechanical components of the SMART-Treat™ MBBR component system are the aeration blower and the solids removal/recirculation pump. (In the event an airlift pump is used to transfer settled biological solids, a portion of the aeration blower air supply could be used for clarifier solids removal, thereby eliminating the submerged mechanical pump). These components have extended but limited life expectancies, and as with all mechanical components require maintenance.

Should the blower or pump fail, standard visual and audio warning would be provided from the blower control center. It is recommended that any blower or pump failure should be repaired as soon as practical. Prolonged blower failure could result in improper treatment and potential flow restrictions with time. A standby blower is recommended, but optional. A trained, state-certified inspector/maintainer will be available on 24-hour call. The owner will retain a current service contract at all times.

If the blower would fail, the biofilm carrier elements would stop movement. However, flow could continue by gravity through the treatment system as normal. The treatment system would begin to act as a normal septic system. No flow restrictions would be evident. Treatment would be reduced, compared with aerobic system effluent, but would be of a higher quality than septic effluent alone.

The solids removal/recirculation pump could fail independently from the blower. If the solids removal pump failed, water would continue to flow through all tankage by gravity similar to the way a standard septic system would function. However, water quality to the ground infiltrative surface would continue to be higher in quality than septic tank effluent due to the added treatment and filtration which would continue to occur (anaerobically). However, as with most aerobic treatment systems, it is important to service the failure as soon as possible. The system may function for 2-3 weeks or longer without an operational blower or pump.

NOTE: **Any biomass buildup on the media or in the tank solids separation zone would be immediately reduced upon restart of operating components.**

Troubleshooting Guide

Action	Potential Cause(s)	Potential Remedy(ies)
Water Backup	Grease accumulation in wastewater pipe or tankage. Final Filter blockage. Distribution box malfunction. Flooded drain field.	Determine where blockage has occurred and clear blockage. For example, open pip clean-outs between building and grease trap and rod pipe.
Blower Failure	Dirty air filter Tripped breaker Motor or blower malfunction High water level	Change air filter Reset breaker Replace motor or blower Determine cause of high water, lower water level by cleaning filter or sieve strainers
Excessive foaming in aeration reactor (Normal during startup, but not normal under standard treatment conditions)	Spill or excess use of foaming cleaners Toxic condition preventing microbes from normal function	Some foaming at initial startup is typical. If persists Reduce or stop use of foaming cleaners Change situation that causes toxic condition to microbes
Biofilm Carrier Elements do not move with normal aeration flow	Could be startup related (normal) condition Biomass may have sloughed unevenly due to toxic condition Uneven wetting of carrier elements	Provide ample time for biofilm conditioning of carrier elements. Adjust aeration pattern Gently immerse elements with instrument. *Adequate treatment exists w/ stationary biofilm carrier elements, as long as aeration persists.*
Grossly uneven air pattern in aeration reactor.	Broken or shifted air distribution headers Plugged air distribution headers	Adjust valve to close off broken header, or to unplug any plugged headers. Report to system maintainer for inspection or repair

Action	**Potential Cause(s)**	**Potential Remedy(ies)**
Carrier elements accumulate in one of the aeration compartments or in clarifier	Broken Sieve strainer or treatment stage divider Note: Carrier elements will never flow out of tank to drain field due to multiple fail-safe features: (submerged collection weir in clarifier, and final filter)	Report to system maintainer for inspection or repair
Solids removal pump failure	Burned out motor or clogged pump	Determine why pump failed and unclog or replace
Biological solids do not settle well	Toxic or overload condition of incoming wastewater Too low or too high air delivery	See Aerobic Treatment section in O&M guidelines, above, for recommended remedies
Standing water in drainfield or mound. (Highly pretreated water should have no problem penetrating most suitable soils at loading rates of 1-2 gpd/ft2)	Uneven flow distribution Soil clogging: due to: Poor treatment. Improper installation procedures in drain field	Check distribution box for proper function Examine soil clogging layer, test water quality for proper treatment

Case Study: Small Flow, High Strength Moving Bed Biological Reactor (MBBR)

Northern Wisconsin Golf & Supper Club

A golf & supper club in Northern Wisconsin had a failing drainfield. The restaurant owner was notified under WI Dept of Commerce Statute 83, effective July 1, 2000 that restaurant wastewater is a high strength wastewater. Therefore, aerobic treatment was required. Site plans and a MBBR component manual were prepared and approved, and the system was installed & started 10/28/01. After a successful startup and acclimation period, the MBBR POWTS system has performed very well within one month of start-up; with treated water quality reported better that designed for. Sampling period was 5 months. Advantages include: economical, a very high biological surface area in a small footprint, therefore takes up less space than other systems, ease of installation and startup, and the ability to increase treatment capacity without the addition of more tankage.

Design Wastewater Flow (DWF): 4500 g.p.d, Restaurant and two 2-bedroom cabins
<u>Design Parameters (Septic Tank Eff) Sample Collected 10/27/00. Certified Lab Results</u>

All results: mg/l	BOD	COD	TSS	pH (su)	FOG	TKN/TN	TP
GT Eff-Anticipated	600-1200	>1500	300-500	6-9	<150	40-60/<100	8-15
GT Eff- Sampled	577	1023	242		60	104.4	16.5
Anticipated Final Eff	<25		<30			<2 / <15	

BOD Full Design Flow: anticipate 706 mg/l or 26.5 pounds/day TBOD removal122.5 %)
Total Nitrogen: If needed, ammonia reduction and total nitrogen removal to can be accomplished to <15 mg/l with additional media, increased recirculation, and/or blower on/off sequencing.

Results: Up to 30 samples were taken during the first 5 months, field & lab tests were conducted (state-certified labs: City of Phillips WWT Plant & Environ. Task Force Lab, Stevens Point, WI)

	BOD5, mg/l	**TSS, mg/l**	**TKN, mg/l**	**NH3-N, mg/l**	**NO3-N, mg/l**	**Temp-C**	**pH**	**DO,mg/l**
GT Eff	**1619**	**540**	**78**	**46.7**	**--**	**14.6**	**5.3**	**0.5**
ST Eff	**164**	**125**	**--**	**--**	**--**	**9.8**	**6.9**	**0.4**
Final	**16.2**	**14.5**	**2.5**	**0.5**	**8.3-10.5**	**7.0**	**7.1**	**5.4**
% Rem	**99.0**	**97.3**	**96.8**	**93.4**	**--**	**--**	**--**	**--**

Low STE values from solids removal / recirculation from clarifier, resulting in 85 % Total Nitrogen Removal, with 5 minute pumping of clarifier solids to Septic Tank each 6 hours.

ENVIRONMENTAL / HEALTH PRODUCTS & SERVICE

PO BOX 21
Richfield, WI 53076
Phone: (262) 628-1300

PO BOX 101
Phillips, WI 54555
Phone: 715-339-3497

E-Mail: ken-ehs@juno.com

Field Inspection & Service Report

EHS SMART-Treat™ Small Wastewater Flow Moving Bed Biofilm Reactor

INSTALLATION		AUTHORIZED SERVICE PROVIDER	
Owner Name		Name	
Installation Address		Street/Mailing Address	
City	ST Zip	City	ST Zip
Tel Fax	Email	Tel Fax	Email

Installation Information		
Model / Serial Number	Date of Installation	Date of Last Pump out

INSPECTION	YES	NO	MAINTENANCE PERFORMED & COMMENTS
Electrical Panel(s)			
Visual Alarm Operating			
Audio Alarm Operating			
Blower(s)			
Air Inlet Filter Clean			
Blower Venting Adequate			
Excessive Noise			
Excessive Vibration			
SMART-Treat™ Unit(s)			
Unusual Color or Odor			
Media Movement OK (Adequate, even turbulence)			
Biosolids Settling (clarifier)			
Solids Removal pump OK			
Effluent			
Clear Color			
Septic Odor			
Pump out Required			
Primary Settling (septic tank)			
Biosolids Settling (clarifier)			
Effluent (field data, Optional)	**Limit**	**Result**	
Estimated Daily Flow			
pH (std units)	6-9 S.U		
Temperature			

OWNER SIGNATURE	TECHNICIAN SIGNATURE	SERVICE DATE

EHS Preventative Maintenance Inspection Summary
For the SMART-Treat™ Moving Media Small Flow MBBR System

- Use the SMART-Treat™ MBBR Troubleshooting Guide in the O & M Manual to diagnose situations that arise upon inspection. Send copy of the inspection and maintenance report to EHS or call EHS (262-628-1300) if you have any questions.

- **ELECTRICAL PANEL**
  - Check for proper visual and audible alarm function. This can be done by tripping breaker for blower or mechanical solids removal pump.

- **BLOWER**
  - Remove Blower Access Housing. Inspect, clean or replace filter. Assure adequate air circulation into blower cover—clean vents, openings, or louvers, if needed.
  - Check for proper hose or piping connection tightness. Assure no air leakage.
  - Check for excess heat on blower, listen for unusual noises.

- **SMART-Treat™ MBBR REACTOR**
  - From observation manhole, check for even air bubbling and media movement within aerated reactor
  - Check for and note unusual odor from manhole. A musty odor is OK; a septic odor may indicate a potential problem.

- **BIOSOLIDS SETTLING ZONE (clarifier)**
  - Check for proper solids removal pump operation

- **EFFLUENT**
  - Check for water clarity and odor. Protective gloves are suggested when sampling untreated or treated water. Disinfection of tools, etc that come in contact with water is suggested. To collect a sample for inspection, use a small bottle on the end of a stick, or a sludge judge placed into the water where the sample is to be taken and moved vigorously up and down to create a pumping action. A relatively clear water sample without a septic odor is the goal. Anything less could be cause for concern. Report sample observations in the report.

- **SLUDGE DEPTH**
  - At least annually (more often with high-strength wastewaters) check sludge depth in the primary solids settler (septic tank), and also in the Biosolids Settler (clarifier). Record sludge judge readings on the inspection and maintenance report. Advise customer when pump out is required. Again, disinfect anything that comes in contact with sludge or water from this system.

EHS Small Flow SMART-Treat™ MBBR: Small Footprint with BIG Treatment Capacity

- Serving domestic and commercial / light industrial applications up to 100,000 gal / day. **The logical system for our customers, our economy, and our environment.**

EHS PO Box 21, Richfield, WI 53076 Ph: 262-628-1300, Email: ken-ehs@juno.com