LOW PROFILE POLYGEYSER FILTER

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Introduction to the AST LPPG Filter

The AST LPPG is a new addition to Aquaculture Systems Technologies' line of products. Utilizing advanced Polygeyser® technology, this filter designed to cope with high loading with ease. The auto-pneumatic backwash paired with auto-pneumatic sludge removal enables this filter to operate for extended periods of time without intervention.

LPPGs can be circulated via gravity with an airlifted return or simply with a water pump. The gravity fed, airlift configuration requires no water pump and is energy efficient.

Patented: US Patent 9,227,863 & Patent Pending, Canadian Patent CA 2287191 European Patent EPO 977713

The system's filtration is a "bioclarifier" capable of performing both biological and mechanical filtration in a single profile. AST Polygeyser® filtration is capable of handling biological loads 50% to 100% higher than our Bubble Bead® or Propeller Bead® Filters equipped with standard bead media. Additionally, the AST LLPG offers a very high degree of reliability and are virtually immune to clogging and caking, since they backwash automatically without moving parts or electronics.

The elimination of water loss associated with backwashing is a key element in this new technology. In most applications, dozens of backwash sequences can be automatically executed before sludge removal is required. There is no water loss associated with the backwash process and the water loss associated with sludge drainage is negligible. This strategy is particularly advantageous for marine systems, where the loss of saltwater and need for large backwash water treatment units are minimized.

The pneumatic strategy breaks the linkage between backwash frequency and water loss and allows the nitrification capacity of the unit to be fully utilized. Frequent backwash sequences have proven advantageous for optimizing nitrification. Numerous gentle scrubbing cycles promote high rates of nitrification by maintaining a healthy thin biofilm on the bead surfaces. Typical backwash cycles occur once every three to six hours. In recirculating bioclarifier applications, the AST LPPG filter operates concurrently as a clarifier and biofilter, total ammonia nitrogen (TAN) levels below 0.3, 0.5 and 1.0 mg-N/l can be expected at feed loading rates of 0.5, 1.0 and 1.5 pounds feed per cubic foot of EN bead media (8, 16 and 24 kg-feed m^{-3} day^{-1}), respectively.

Specifications

Model	Media Volume (cubic ft)	Surface Area (square ft)	Flow Rates (gpm)	Growout Feed Rate** (lbs/day)	Lbs of fish supported*	Recirculating Tank Volume (gallons)	Internal Sludge Storage (cubic ft)
LPPG 10	10	3500	75-150	7.5-15	750-1500	1500-6000	4
LPPG 17	17	6000	130-255	11-25	1300-2500	2500-10000	7

* Larger units are custom designed

**Warmwater fingerling to growout includes safety factor

Airlift Specifications

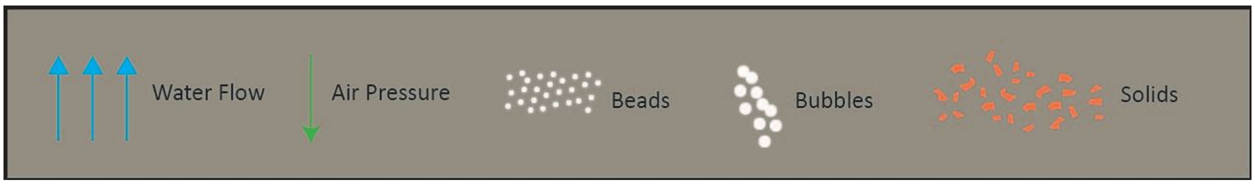
Model	Filter water elevation (inches)	Estimated airlift submergence (inches)	Minimum fish tank water elevation* (inches)	Design airlift flow (gpm)	Transfer pipe diameter (inches)	Airlift pipe diameter (inches)	Airlift air** required (cfm)
LPPG 10	38	35	44	100	4	6	25
LPPG 17	38	35	44	170	6	8	43

* assumes energy efficient submergence to lift ratio of four and a conservative headloss of across filter of nine inches

**airlift operation only; 3-4 cfm per pound feed required for overall RAS operation

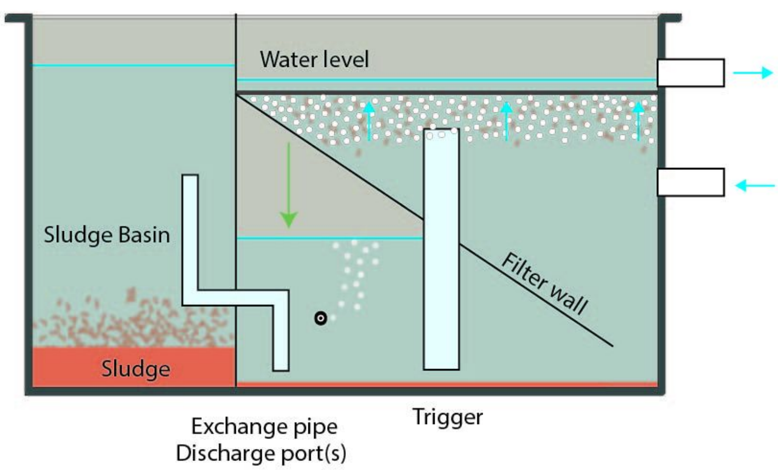
Backwash Operation

These exceptional filters backwash automatically, several times a day. The user does not need to open or close any valves during the backwash sequence. The filter does not require an electric timer. The backwash cycle is regulated by the air that is injected into the charge chamber. The filters clean and recycle the dirty water produced in backwashing every two to three hours. Sludge is only removed once or twice a week.



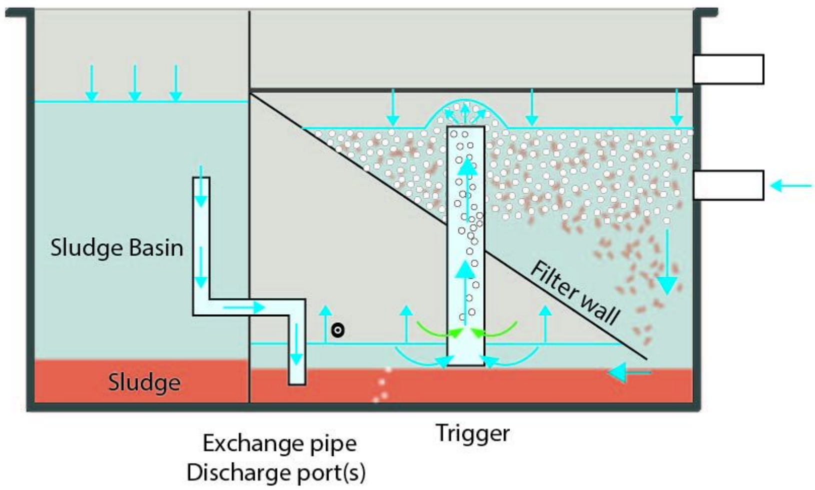
Before Backwash

The water moves from the inlet up through the bead bed. The bead bed provides surface area for the water purifying bacteria and captures solids within the aquatic system. Solids are collected within the bead bed. Air is slowly injected into the charge chamber, gathering in the top of the charge chamber. As more air enters, this displaces the water in the charge chamber, replacing it with air. The rate of air injection controls the length of time between backwashing events. Sludge settles in the sludge basin from the last backwash cycle.



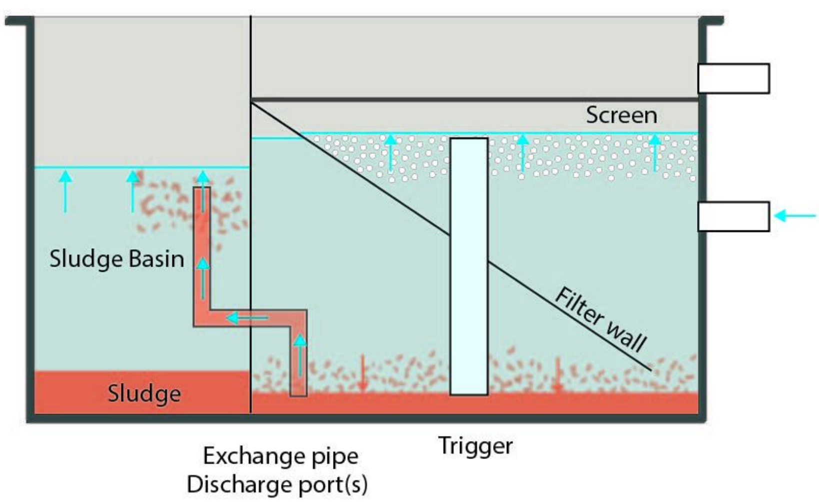
Backwash

Air has made its way through the trigger into the bead bed. The bubbles agitate the beads; knocking solids and excess biofilm off the beads. The beads in the drop zone are scrubbed by the escaping bubbles. Solids are released from the bead bed and settle towards the bottom of the filter. Clarified water is drawn from the top of the sludge basin, due to the refilling of the charge chamber. No water flows out of the filter during the short 3-5 second backwash event; instead, the dirty backwash water is pushed toward the charge chamber.



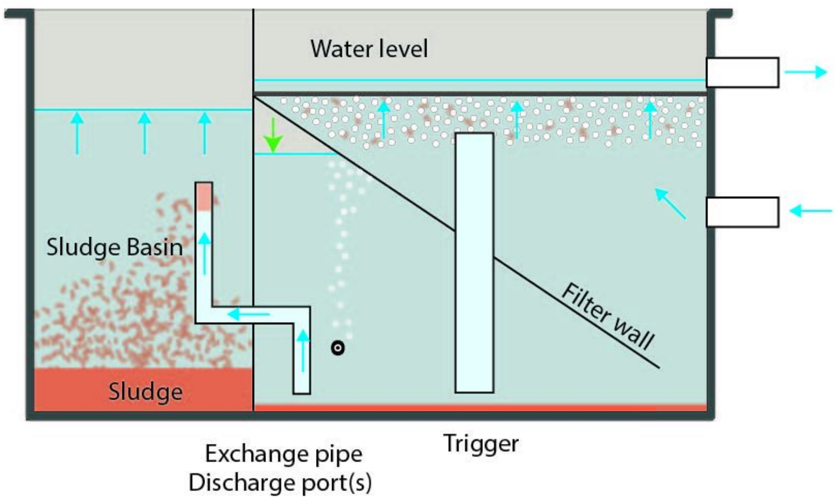
Late Backwash

Water continually fills the filtration chamber. At the same time, the air pump is continuing to push air into the charge chamber. As the filter refills with water, the sludge is discharged into the sludge basin, refilling it to the active water level. Solids that have collected under the bead bed are swept up and out of the discharge ports and are deposited in the isolated sludge basin. The filtration chamber is refilled with the water from the inlet. The beads float back in place to reform the bead bed. As soon as the water rises to the outlet, normal filtration resumes.



Normal Filtration

The water moves from the inlet up through the bead bed. The bead bed provides surface area for the water purifying bacteria and captures solids within the aquatic system. Air is slowly injected into the charge chamber.. As more air enters, this displaces the water. The water level drops trapping water in the settling zone, and solids from the last backwash settle into the sludge basin. The rate of air injection controls the length of time between backwashing events.



Periodically Drain Sludge

The filter will continue to filter and backwash itself several times a day. After the sludge has built up, the user can open the sludge valve to drain the concentrated sludge from the filter. The filter backwashing frequency is usually set for a few hours, resulting in the filter backwashing several times a day. Sludge accumulates in the sludge basin. Every few days, perhaps once a week, the sludge drain must be opened to let the sludge out. A natural fertilizer, the sludge can be mineralized and utilized in hydroponic grow beds or land applied where it will naturally degrade. This sludge will have a "rotten egg" smell that will dissipate with exposure to air.

Installation

1. Prepare your LPPG system's location. The tank must be installed on a level surface. The filter backwash and airlift performance is contingent on the filter being level.

2. The beads will be shipped in boxes alongside the filter. Beads can escape through the inlet piping to the filter chamber. To prevent this, close any open ended pipes leading to or from the filter chamber. Beads should then be added to the filter chamber and the screen mounted and bolted down.

3. Choose a configuration from *Plumbing configurations*; either water pumped or gravity fed airlift (see plumbing configurations for details) Attach air supply line to the barb connector. Install the air pump above the water level to prevent backflow flooding in case of power shortage. Air check valves should be used to protect the air pump from backflow. Install them between your air pump and the unit to avoid damage to your air pump. Valves on airlines to allow for airflow adjustment.

4. Fill with water to the midline of the outlet return pipe within the tank. See setup diagram for your configuration for further details.

5. Set the backwash air feed rate at the maximum to achieve the highest backwash rate attainable with your setup (possibly as much as once every 15 minutes). Let the unit operate in this manner for 12-24 hours, more if necessary. This allows the beads that have moved into the charge chamber to go back to form the filtration bed.

   Under normal operation the bead bed is formed by simple buoyancy. There is one screen in the head designed to constrain the beads. The unit’s pneumatic and hydraulic behavior is designed to substantially confine the beads to filtration bed. During shipping, a substantial proportion of the beads fall into the charge chamber where they are trapped (by buoyancy) in the charge chamber. So when the tank is first filled, perhaps fifty percent of the filtration bed is in the charge chamber. The unit’s trigger is designed to pass beads from the lower chamber, but only at a handful per cycle. The system must be operated at a high backwash frequency for a time to readjust the unit’s internal balance and move the beads back to the filtration chamber.

6. Adjust the backwash pump’s air flow down after the first day, so that the filter backwashes two to four times daily. Your application may benefit from adjusting the

backwash frequency up or down depending on loading (mass of fish and feeding amounts).

Remember to add water conditioner prior to adding fish. Fish can be added at reduced loading, or the system seeded with bacteria or chemicals (ammonia, nitrite) to encourage the development of biofilm for biological filtration. See *Acclimating your filter* for more details.

7. Sludge is generated and stored within an isolated sludge chamber. This sludge can be used as fertilizer for plants. In aquaculture applications, sludge production is estimated at 3-6 gallons per cubic foot of beads per day at design capacity (1.5 lbs feed/ft3-day). Sludge handling should be sized for a generation rate of about 10 gallons per cubic foot of beads per day. See *About sludge removal* for information about sludge discharge.

Plumbing Configurations

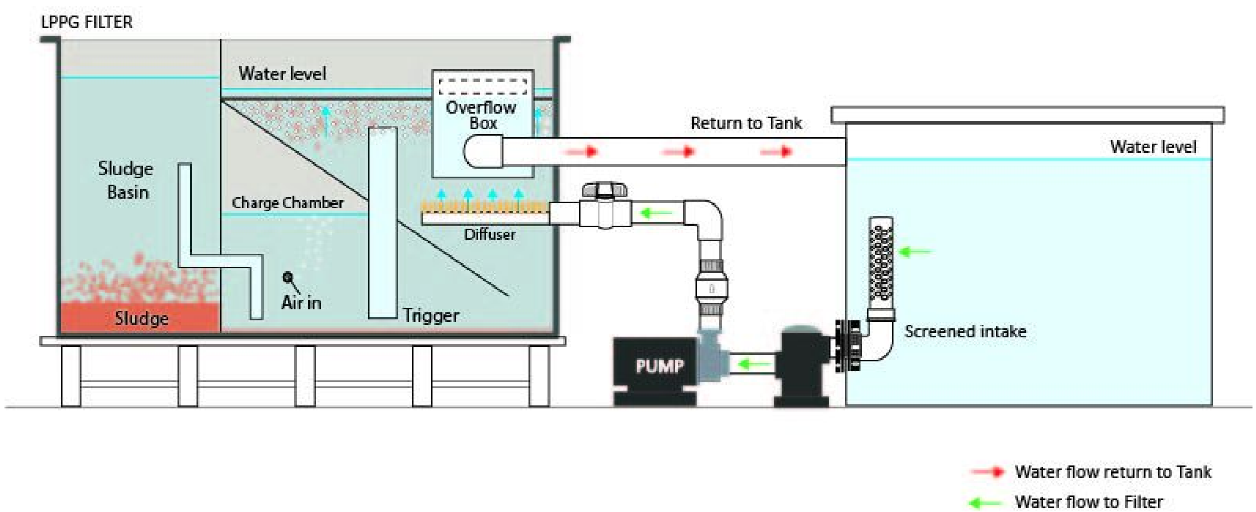
LPPG Pumped Configuration

LPPG CONFIGURATION:
WATER PUMPED

The filter should be raised so that the water from the overflow box can gravity feed back into the tank. The water pump provides flow to the LPPG Filter.

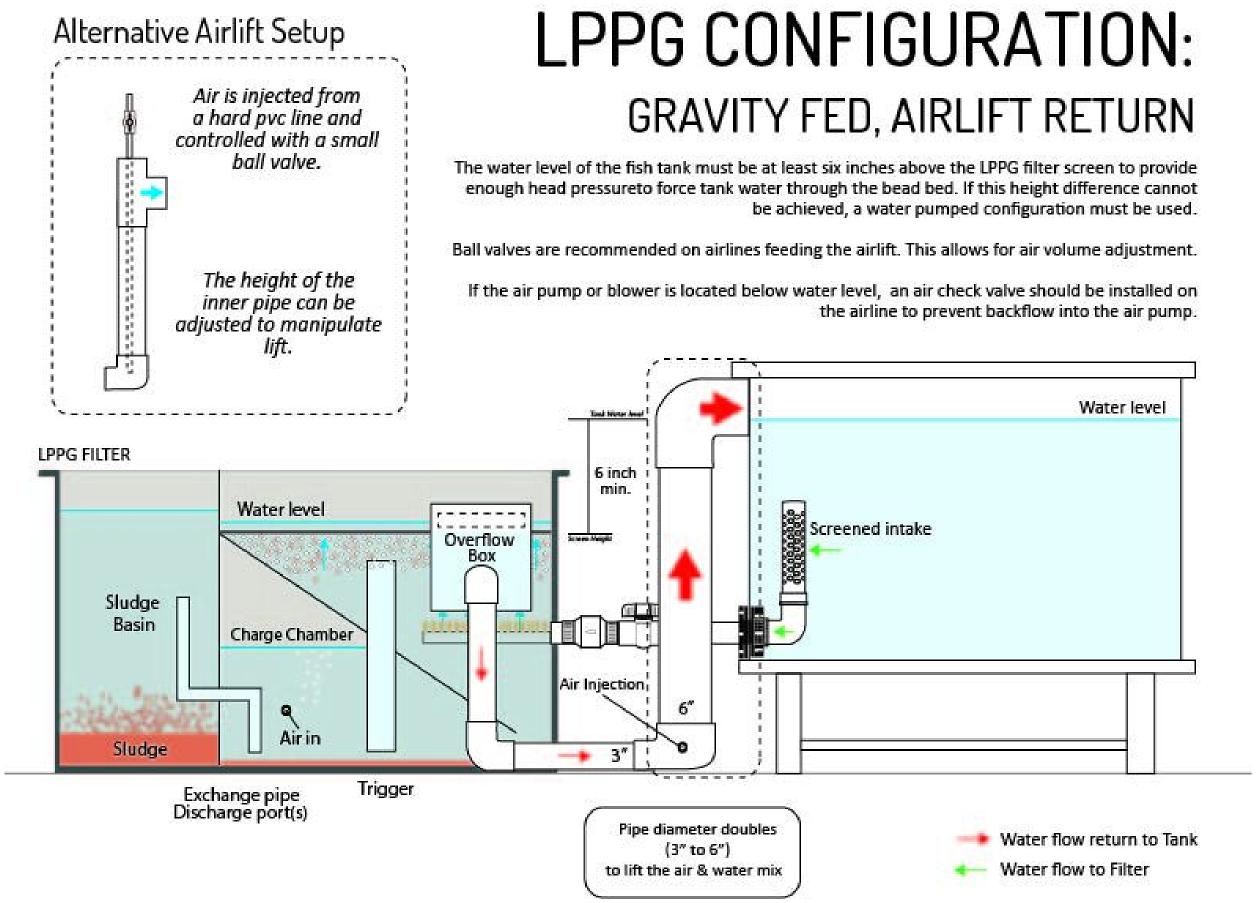
Ball valves are recommended on airlines. This allows for air volume adjustment.

If the air pump or blower is located below water level, an air check valve should be installed on the airline to prevent backflow into the air pump.



LPPG Gravity fed, Airlifted Return.

These airlift pipes circulate the water from the filter back to the tank. They are excellent for holding or culture tanks and are efficient with their energy usage, saving you money. A minimum of ⅜" airline tubing is needed for the airlift plumbing.



Adding a UV sterilizer

AST LLPG filters can be ordered with a preinstalled UV sterilizer as part of the plumbing. Where possible, the UV will be attached to the side of the filter. Large systems may use large UV's that cannot be safely mounted onto the units themselves. UV systems are recommended in applications where water clarity is a concern. UV sterilizers can be used to manage algae.

Additional filtration products, such as foam fractionation or chillers for saltwater applications can be provided by AST. Due to the large profile of these products, they will have to be installed alongside your AST LPPG Filter.

Adjusting your Backwash Frequency

Your integrated PolyGeyser® filter employs a static bed of beads to capture suspended solids and/or provide substrate for development of a biofilm to remove targeted dissolved pollutants (organics, ammonia). After time, the accumulation of solids in the bed begins to reduce the hydraulic conductivity of the bed and the flow passed through the unit declines. Each application has its own optimum interval for backwashing. In some cases, an extended backwash interval produces optimum performance and in others, and extremely short backwash interval is best. In broad terms, short backwash intervals (<6 hours) are associated with heavy loads. Best performance for lightly loaded applications is usually associated with extended backwash intervals (>12 hours).

In recirculating aquaculture where the filter is used solely as solids capture device reducing suspended solids, a high backwash frequency generally produces the greatest mass removal rate. In these applications, the targeted particle size range is usually of the order of >50 microns. Organics in the water will create a sticky surface that tends to stick particles together on the bead surface. Internal settling after a backwash is rapid, and backwash frequencies can be short (<hour) without adversely affecting filter performance. A good starting point for the backwash interval in a recirculating clarifier application is three hours. If the bed becomes too loaded with solids, the backwash may not be strong enough to dislodge the material. This can be easily remedied by increasing your backwash frequency. If a decline in flow through the filter is noticeable, increase the backwash pump airflow for more frequent backwashes.

If the application is focused on water clarity for display aquaria (lightly loaded), then the filter should be used as a clarifier focusing on small suspended particles. A clean bed of standard sized beads has relatively poor single pass removal efficiency (20%) for particles below 20 microns. Single pass capture of these particles is dramatically improved (>40%) once the bed begins to fill with biological or mineral solids. Excessive backwashing should be avoided in clarifier applications. Lightly loaded applications with a focus on water clarity (reduced turbidity) are generally associated with extended backwash intervals as few as twice a week. In lightly loaded applications seeking high water clarity, start with a backwash interval of once a day. Increase the backwash frequency (turn up the air) if the flow through the filter declines significantly as this is a sign solids are not being backwashed enough for your application.

Clarifier applications are relatively insensitive to backwash interval, the LPPG filter's biological function can be dramatically influenced by the backwash frequency. Here, backwashing influences several factors. Optimization of backwash frequency is application specific and may take experimenting to find the perfect settings.

Backwashing interval impacts biofiltration through several factors.

Factor	Importance	Comment
Biofilm thickness	Controls the mass of bacteria working Controls the rate limiting nutrient transport into the biofilm	
Water flow	Controls the targeted substrate concentration adjacent to the bead Controls oxygen transport to the biofilm Controls turbulence at the biofilm water interface	Best biological treatment is associated with the highest achievable flows
Mean cell residence time MCRT)	Determines the type of bacteria and protozoa that will be found in the filter.	

In recirculating aquaculture applications, PolyGeyser® filters are widely used as bioclarifiers simultaneously removing suspended solids, dissolved organics, total ammonia nitrogen (TAN) and nitrite nitrogen. Here the limiting process step is usually TAN conversion since the TAN must diffuse into the biofilm prior to conversion. Carbon to nitrogen ratios are relatively stable being fixed by the protein content range of the feed. Backwash frequencies must be increased with organic loading (pounds feed/cubic foot beads per day) to offset the smothering effect of heterotrophic bacteria on the slower growing nitrification bacteria. The general guideline for backflush frequencies is illustrated below:

Filter Model	Filter Volume (ft^3)	Air Flow Rate (SCFH)	Backwash Frequency (Times per Day)*	Feed Rate (lb/day)
LPPG -10	10	0.5	1	<2.5
		1	2	2.5-5
		2	5	5-7.5
		3	7	7.5-10

*Backwash frequency is dependent upon the air flow rates controlled by the rotometer supplied with the filter.

Filter Model	Filter Volume (ft^3)	Air Flow Rate (SCFH)	Backwash Frequency Times per Day)**	Feed Rate (lb/day)
LPPG filter 17	(2) 8.5*	0.5	2	<4
		1	3	4-9
		2	6	9-13

*The LPPG 17 filter contains two identical filters each controlled by its own airflow meter.
**Backwash frequency is dependent upon the air flow rates controlled by the meter supplied with the filter.

In recirculating applications, the backwash tuning success is reflected in the TAN and Nitrite concentration. It is not uncommon to see the TAN concentration reduced by 50% with a small change in backwash frequency. The limits of backwash frequency are defined by the nitrite oxidizing bacteria (NOB). Backwash too often and the NOB are "washed out" as the biofilms mean cell residence time (MCRT) drop; Wash too slowly and oxygen transport into the biofilm will drop, triggering or reversing the NOB oxidation process. Watch for the rise in nitrite as you optimize backwash frequencies. If nitrites increase during the optimization process, reduce the backwash frequency.

Failure to backwash frequently enough given your loading, leads to clogging of the bead bed as heterotrophic bacteria attack readily biodegradable organics. If your bead bed clogs, temporarily adjust for very frequent backwashes to dislodge clumped beads. After a few rapid repeated backwashes, the stubborn deposits should be knocked off. Then, reset your previous backwash air interval and add additional airflow for more frequent backwashing to prevent the buildup of excess solids in the bead bed.

AST LPPG filter: Airlift Air Pumps

Your AST LPPG filter requires powerful air pumps or blowers for operation. If you have not purchased a backwash pump with your system, you require a low volume continuous duty pumps that is sized to sustain the appropriate backwash frequency for your filter model.
A medium sized linear air pump is a good choice for airlift applications where backpressure is minimal. These units operate by oscillating a rubber diaphragm that moves air through a series of valves. These pumps are readily available in weather resistant configurations used for pond and home packed wastewater treatment units. The flow rates delivered by these blowers are generally in excess of the backwashing needs, so the unit should be selected based upon its maximum operational pressure. The larger linear pumps have shutoff pressures in the range of 10 psi which is suitable for most applications where the unit is not back pressured by downstream devices. Linear air pumps contain a replaceable rubber diaphragm that will ultimately fail (every 2-3 years depending on the model and pressure).

A small oil free continuous duty piston pump with an operational pressure rating of about 20 psi is suited for delivering air for a wide variety of applications. These units have small pistons that are driven directly by a small electric motor. Producing only moderate amounts of air, these units are recognized for sustained operation at moderate pressures.

Rotary vane compressors operate in a pressure range (0-15 PSI) well above the more widely recognized rotary vane blower (0-3 psi). A rotary vane compressor consists of a motor that spins a set of inclined high speeds blades that compress and accelerate air into the distribution system. They are capable of producing large volumes of air in the 10 psi range. These units are typically the air supply of choice for facilities containing multiple LPPG filters.

The common oil-less shop compressors can be used to backwash a LPPG filter unit. Commonly capable of producing pressures in excess of 100 psi, these units are capable of overcoming any pressure produced by a water pump. These units are powerful piston units that produce a relatively small volume of air at extremely high pressures. Normally installed with the delivery pressure regulated down to 20 psi, these compressors can be set to match virtually any water pump. Inexpensive shop compressors are not designed for continuous duty. A compressor tank is usually associated with the compressor unit and the motor operates intermittently to maintain the tank pressure. These units should be sized with a delivery capacity 5-10 times higher than the backwashing air capacity to assure the compressor operates only periodically. (Note: These compressors are typically rated in terms of cubic feet per minute at 100+ psi whereas backwash demands are rated in cubic foot per hour). Shop compressors are generally noisy and are poorly designed for a wet environment. Air input into the unit merely displaces water; there is no potential for internally damaging the unit by over pressuring the charge chamber.

Pump	Typical Pressure Range	Comments
Linear Air	0-10 psi	Excellent for backwashing of filters that are not back pressured by downstream constrictions, can be overpowered by shutoff head of water pump so should be protected by check valve when used with water pumps. Energy efficient.
Piston	0-30 psi	Generally suitable for all pressurized filter applications. Capable of generating pressures in excess of hull pressures thus cannot be overcome by properly sized water pump.
Rotary vane compressor	0-15 psi	Suitable for low pressure airlift applications and simplified pumped configurations.
Shop	0-150 psi	Oil free shop(piston)compressors with tank work well as a backwash air supply provided they are sized large enough to provide for extended cycle time. Tend to be noisy and over pressurized, but inexpensive.

About Sludge Removal

Internal Sludge Basin

Your LPPG has a built in sludge basin. Sludge is automatically discharged from filter into the isolated internal sludge basin during the backwash cycle. The sludge is an excellent fertilizer and can be mineralized for usage aquaponically or applied to terrestrial vegetation. The sludge should be purged frequently for best water quality for aquaculture applications. Heavily loaded systems should be drained every other day. Lightly loaded systems can be drained every three to four days. It is easily determined how much and how often sludge should be removed based on visual inspection of the sludge chamber. In heavily loaded systems, the settled sludge will fill the basin within a few days and require emptying. If floating debris persists, sludge should be discharged more often.

Manual Sludge Discharge: Raised Bucket Drain

To drain sludge unto a standard five gallon bucket, a few lengths of pipe and three 90° degree elbows can be used to increase the drain height so that the sludge can easily be drained into a bucket placed on the ground. You can now transport the sludge to plants requiring fertilization, or use it to make 'compost tea' to water your plants.

Parts:
QTY. 3 - 90 degree ball valves. Slip by slip
Length of PVC tubing
Ball valve included with filter

Recommended Air Pumps for Backwash

The Polygeyser® units have a charge chamber that must fill completely with air to trigger the backwash event. An underpowered air pump will not backwash the unit frequently enough to sustain ideal water quality.

We recommend using an air pump capable of producing the most frequent backwash intervals that may be required. The flow rate can then be regulated by installing an air flow meter, with a built-in regulating valve . AST offers an airflow meter kit which includes an acrylic flow meter, aluminum mounting bracket and two barb fittings.

Airlifted systems operate at a very low head. Several commercially available air pumps are capable of delivering the required volume and meeting the pressure demands for a single unit. Some recommended air pumps for backwash include:

- LPPG 10   AL-60   2.4 cfm@2.18psi
- LPPG 17   AL-80   3.0 cfm@2.18psi

Another option is to use small oil-less air compressor with a storage tank and built in pressure regulator. The storage tank will provide improved overall stability and means the air compressor does not run continuously. Additionally, the pressure regulator allows you to set the air output pressure so that it will be greater than the pump output pressure at all times. We also recommend this setup for operating multiple units. These types of portable air compressors are sold at common home improvement or hardware stores for easy availability. A possible disadvantage of using an air compressor is the sound produced when the compressor turns on to re-fill the storage tank.

The size of the compressor depends on the number of units you wish to backwash. A portable air compressor, which stores air in a tank at 90-100 psi, holds approximately 1.1 ft^3 (8.2 gal or 31 L) of air per gallon (3.8 L) of tank storage space. We recommend you choose a compressor with a tank volume of at least 8 gallons (30 L) per filter. The estimated time between successive compressor operations using a 8 gallon storage tank is approximately 30 minutes and the relationship seems to be linear so that an 16 gallon tanks runs only once per hour. Note the time between compressor operations is approximate and may vary depending on a number of conditions including compressor manufacturer, temperature, and elevation above sea level. Note: a larger tank storage volume is always better and simply means your air compressor will run less often to keep the tank full.

For Recommended Water and Air Pumps (for Airlift)

Please contact our dedicated and experienced sales staff at 504-837-5575.

Backwash Frequency Tables

The optimum frequency of backwash intervals varies with feed loading. The table below presents recommended backwash regimes and associated air flow rates.

Filter Model	**Filter Volume (ft^3)**	**Air Flow Rate (SCFH)**	**Backwash Frequency (Times per Day)***	**Feed Rate (lb/day)**
LPPG 10	10	0.5	1	<2.5
		1	2	2.5-5
		2	5	5-7.5
		3	7	7.5-10

*Backwash frequency is dependent upon the air flow rates controlled by the rotometer supplied with the filter.

Filter Model	Filter Volume (ft^3)	Air Flow Rate (SCFH)	Backwash Frequency Times per Day)**	Feed Rate (lb/day)
LPPG 17	(2) 8.5*	0.5	2	<4
		1	3	4-9
		2	6	9-13

*The LPPG filter contains two identical filters each controlled by its own air flow rotometer.

**Backwash frequency is dependent upon the air flow rates controlled by the rotometer supplied with the filter.

Troubleshooting

Elevated Nitrite (NO_2) Levels

- Elevated levels of Nitrite may occur if the dissolved oxygen concentration in the effluent leaving the filter drops below 2 mg/l. Low DO concentrations leaving the filter can often be solved by increasing the dissolved oxygen levels in the tank or pond through increased aeration or by increasing the flow rate through the filter.
- Elevated Nitrite levels may also occur if your total alkalinity (as $CaCO_3$) drops below 80mg/l. We recommended you maintain your alkalinity at 100-200 mg/l as $CaCO_3$ at all times. If you experience low alkalinity simply add baking soda to the system periodically to maintain proper levels.
- Elevated Nitrite levels can also occur from over washing the bead bed. If the flow rate, effluent oxygen and alkalinity are satisfactory, the backwash frequency can simply be reduced. This situation typically occurs when you go from periods of high loading and frequent backwashing to periods of reduced loading but still maintain frequent backwashing.

Low Effluent Dissolved Oxygen

- Low Effluent Dissolved Oxygen concentrations are usually the result of too low a flow rate. Effluent D.O. concentrations should be maintained above 2 mg/l at all times. If you are not flowing water through the filter at the filters maximum flow rate (90 gpm) simply increase the flow through the filter.
- Or you can increase the amount of aeration in the tank or pond to increase influent D.O. concentrations, which will usually result in increased effluent D.O. concentrations.
- Low DO concentrations may also occur if the backwash frequency is set too low. If the bead bed is allowed to clog, reduced flow and effluent oxygen concentrations will occur, which will affect the nitrification performance. Please refer to "Adjusting Your Backwash Frequency" section for recommended backwash frequencies at various feeding rates.
- Low D.O. concentrations can also result if you do not remove sludge and waste from the filter often enough. The sludge should be drained every 2-3 days to prevent excessive oxygen consumption by the activity of heterotrophic bacteria.

Pressure Loss/Reduced Flowrate

- Pressure loss and subsequently reduced flowrates may occur if the backwash frequency is set too low. The filter is designed to backwash frequently with minimal energy input, so if you do not backwash frequently enough the bed may clog. To overcome this problem, simply increase the air flow to effect a more frequent backwash.

- If this does not solve the problem, check the outlet screen for clogging and clean if necessary.

Sulfide Production

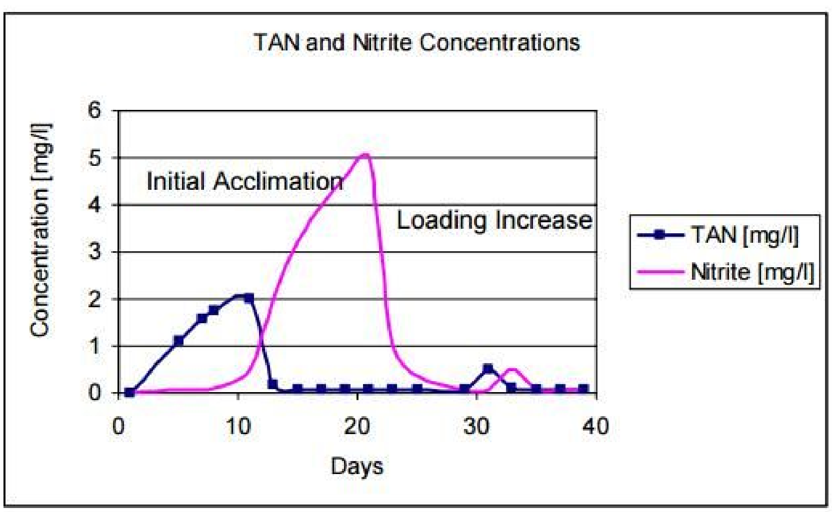
- Sulfide production in the *PolyGeyser* filter can occur in the offline sludge storage basin. These sulfides are isolated within the sludge. Water slowly returned to the pond from this basin **may** contain a low level of sulfides, however, it is first diluted by the recirculating flow (at a ratio of over 100 to 1) and then must pass through a two foot aerobic bead bed. **The aerobic bed assures any sulfide residuals are converted to the safe sulfur form of sulfate**. The processes that produce the sulfides are identical to the natural processes that occur in the bottom of virtually every mud pond and are instrumental in the recycling of trace elements essential for plant and fish nutrition. Sludge storage in the off line basin is a matter of convenience, the filter's operation does not require it, but, given the fact that there has been no observation of sulfide accumulation in any tank or recirculating pond waters, there seems to be no reason not to take advantage of this time saving feature.

Acclimating your Filter

Development of a biofilm layer on the media is required for biofiltration. This process takes 4-6 weeks. The bacterial culture, which grows attached to the beads, performs the biochemical transformations that are so critical in the purification of recycled waters. Initially the biofilter has no bacteria and the culture must be started. The process of growing the initial bacterial culture in the biofilter or adjusting an established culture to a change in loading is called acclimation. Fortunately, the process of biofilter acclimation is easy. It just takes a little time and food for the bacteria.

One way to acclimate a recirculating system with a biofilter is to add a few hardy fish, turtles, or mollusks to the system and start to feed them. The total suspended solids in the system will pose no problem because bead filters capture solids primarily by physical processes that are not dependent on the development of a biofilm. The heterotrophic bacteria will grow rapidly and quickly attach themselves to the beads, so BOD (biological oxygen demand) accumulation should pose no problem. The nitrifying bacteria, however, are very slow reproducers and may require almost thirty days under warm water conditions to establish themselves. Alternatively, pure ammonia can be dosed in the system up between 1 mg/l - 4 mg/l, redosing before the ammonia level reaches zero, until nitrate numbers begin to climb. Ideally, a concentration of 1 mg/l of ammonia should read zero within 24 hours. Then do a large water change and condition your new water for the fish. Keep in mind that if the bacteria go without organic waste or ammonia, they will die and the cycling process will have to begin anew.

During acclimation, the backwash frequency of your *PolyGeyser* filter should be 1-2 backwashes per day. This will keep the bead mixed and promote homogenous growth of nitrifying bacteria throughout the bead bed.



The graph illustrates the classical pattern of TAN (total ammonia nitrogen) and nitrite concentrations observed during filter acclimation with animals. The process starts with an increase in TAN concentrations. This indicate that the first group of nitrifiers responsible for ammonia conversion to nitrite are present in large numbers when the ammonia excreted by the fish stops accumulating and suddenly (within 36 hours) drops to near zero levels. At the same time there will be a sudden rise in nitrite levels, followed by a gradual increase which will continue until suddenly the second group of bacteria, Nitrobacter, catch up with their new food supply and the nitrite concentrations plummet. The filter is now considered acclimated to a light loading. This initial stage of acclimation is critical because during this period, populations of bacteria which breakdown organic waste become established and these bacterial populations adjust to operate under the water quality conditions and temperature regime found in your system. This unique culture of bacteria will remain in the biofilter for years if it is maintained properly.

Table 3 summarizes things you can do to accelerate the initial acclimation of the bead filter. These procedures can reduce acclimation time to as little as two weeks in a warm freshwater system. One of the principal limitations of acclimating a filter with animals is that little or no nitrite is available for the growth of Nitrobacter until the Nitrosomonas population has become established. This means that the very slow growing Nitrobacter cannot even get started for over a week. Therefore, you can simply reduce the acclimation time by adding nitrite at the start. The acclimation process becomes moot if you have an acclimated bead filter on your premises. Just exchange a few cubic feet of acclimated beads from the old filter with new beads and both filters will adjust rapidly. Lacking the beads, have a friend provide you with backwash water from an established filter. Just dump the sludge into the system. The bead filter will pick it up and leave the solids in intimate contact with the beads where the transfer of desirable bacteria will rapidly take place.

Table 3. Things You can do to Accelerate the Initial Acclimation of a Bead Filter

	Procedure	**How does it help?**
1	Add ammonia and sodium nitrite at a concentration of 1 mg-N/l on the first day.	Allows growth of Nitrobacter to start immediately.
2	Add backwash waters or beads from an established biofilter. *	Introduces species/strains of bacteria that are well suited for the bead filter's ecosystem.
3	Reduce Filter Backwash Frequency	Minimizes the loss of biofloc.

4	Raise the temperature of the system to 30° C.	Accelerates bacterial growth rates by increasing metabolic rates.
5	Adjust the pH to 8.0	Accelerates bacterial growth rates by increasing ammonia (NH_3) concentrations.
6	Add sodium bicarbonate to raise the alkalinity to 150 mg-$CaCO_3$/l	Accelerates bacterial growth rates by increasing bicarbonate availability.
*** Disease may be spread with the biofilm, so make sure the source is healthy.**		

You should be careful not to kill the animals used to acclimate the filter if you are not chemically seeding the system for cycling. Inexpensive domestic koi or goldfish are good choices if fish are used. However, it is important that the fish or animals used during acclimation are disease free so as not to infect your high quality fish later. These animals can tolerate **short-term** exposure to TAN and nitrite levels of about 5 mg-N/l without harm if you keep the pH between 7.5 and 8.0 and add some sodium chloride (rock salt) or calcium chloride. Chlorides help prevent nitrite toxicity by blocking nitrite transfer in the gills. The pH range keeps the TAN in the less toxic NH_4^+ form. It is usually the nitrite peak, which is twice to three times as high as the TAN peak, which damages the fish. If the fish show signs of stress (inactivity, lack of hunger, or gaping near the surface), remove them; you will have plenty of food for the bacteria in the water column already. The fish should be reintroduced into the system once both the TAN and nitrite levels fall below 1 mg-N/l.

The initial acclimation assures that the biofilter contains the right type of bacteria. However, you then must adjust the amount of bacteria to assure there are enough of them to process the ammonia produced by the animals in the system. Therefore, the next step in the acclimation process is to increase the density of animals in moderate steps allowing some time for the bacterial population to grow to meet the increased demand. This process of acclimation to increased loading is normally undertaken with the animals of choice, since the TAN and nitrite peaks are small and quickly disappear. As a general statement, an acclimated filter will completely adjust to a sudden increase in fish density (or feed level) within 72 hours. If the step increase is moderate (< 33 percent of current load), the acclimation will probably occur without noticeable peaks. The heights of the acclimation peaks are actually controlled by the density of fish in the system, not by the size of the biofilter. That is, the nitrite peak in a system with a fish density of 0.25 pounds/gallon will display a peak concentration one-half as high as a system with a density of 0.5 pounds/gallon. Table 4 summarizes additional methods that can be used to decrease transitional peaks. The process of acclimation to increased loading occurs naturally if the bacteria and animals are allowed to grow together. The bacteria always grow faster, maintaining the proper balance between the biofilm and the animal density. For example within a Koi pond, once the filter is acclimated to the fingerling density, the biofilter's ecosystem will take over and maintain the proper balance. Your management responsibility occurs when the natural growth processes are disrupted by sudden (unnatural) changes in the system.

Table 4. Things that Can be Done to Decrease Transitional Peaks of TAN and Nitrite When the Animal Density or Feed Rates are Increased

	Procedure	**How does it help?**
1	Increase your water loss from the system until the biofilters adjusts.	TAN and nitrite will be flushed with the water.
2	Discontinue or reduce feed rate during the transition.	TAN excretion rates from most animals increases with feeding.
3	Make loading increases in small increments (< 33 percent of current load) and separate steps by about 3 days.	Existing bacteria will absorb most of the increased load and reproduce rapidly.
4	Extend backwashing interval.	Decreases biofloc loss during the critical transition.
5	Adjust pH and alkalinity to optimum range.	Accelerates reproduction of nitrifying bacteria.
6	Artificially increase the TAN loading prior to the increase by dosing of ammonia chloride NH_4Cl) and sodium nitrite ($NaNO_2$) to a level of 1 mg-N/l.	Promotes growth of the critical nitrifying bacteria, enriching their density in the biofilm.

Appendix A: The Science behind Bioclarification

The term "Bioclarification" was coined some years ago by Dr. Ronald F. Malone, the inventor and patent holder of several bead filter technologies, to describe the ability of bead filters to perform both mechanical and biological filtration in the same unit. The ability of bead filters to perform these tasks is described in detail below.

Bioclarifier = Solids Capture + Biofiltration

Clarification

Bead filters perform well in the control of suspended solids across a broad spectrum of conditions. Bead filters capture solids through four identifiable mechanisms (Table 1). With the exception of adsorption, the solids capture mechanisms are physical in nature and are common to all types of granular media filters. As a general observation, the filters seem to control fine colloidal particles best with some biofilm development. This suggests that the biofilm absorption process is an important mechanism in the control of fine suspended solids and thus water clarity. Studies have shown that bead filters capture 100% of particles > 50 microns and 48% or particles in the 5-10 micron range per pass.

Table 1. Mechanisms Contributing to the Capture of Solids in a Bead Filter

Mechanisms	Comment
Straining	Direct capture of larger particles as they pass into small openings between the beads.
Settling	Sinking of suspended solids onto the surface of the beads.
Interception	mpact of particles directly onto the surface of a bed.
Adsorption	Small particles are captured and absorbed into the sticky biofilm.

The flow rate delivered to a bead filter is the principle management factor influencing suspended solids removal. The efficiency (single pass percent reduction in TSS) of a bead filter generally increases as the flowrate to the filter decreases; however, the capture rate (mass of TSS captured) tends to increase with flow rate. This apparent contradiction occurs because per pass efficiency is relatively insensitive to changes in flow rate, and so, minor drops in efficiency that occur with flow increases are more than compensated for by enhanced solids transport to the filter. Generally, recirculation rates used with closed or partially recycled systems should be maximized to obtain the lowest possible TSS level in the holding tanks.

Separation of captured solids from the bead bed is accomplished by sedimentation of released sludge after the bed is backwashed. Materials such as fats or wood chips merely float upward with the beads and are not removed. In sufficient quantity, these materials will eventually foul the bed requiring media replacement. Bead filters are also not well suited for the clarification of waters suffering from mineral turbidity problems caused by fine clays or other colloidal particles. Lacking good biofilm development, the mechanisms for the capture efficiencies are unacceptably low. Finally, the bead filters will impact but cannot control planktonic algal blooms. Although some capture occurs as a general rule, the algae can grow faster than they can be caught and thus little progress towards clarification is made. Application of the bead filter technology to the problem of colloidal mineral turbidity or algal blooms requires the use of supplemental treatments (chemical flocculation or U.V. disinfection, respectively) or the filter will be ineffective.

Biofiltration

In the biofiltration mode, bead filters are classified as fixed film reactors. Each bead (Figure 2) becomes coated with a thin film of bacteria that extracts nourishment from the wastewater as it passes through the bed. There are two general classifications of bacteria: heterotrophic and nitrifying, that are of particular interest (Table 2). The two bacteria co-exist in the filter, and understanding their impact on each other as well as on the filter is critical.

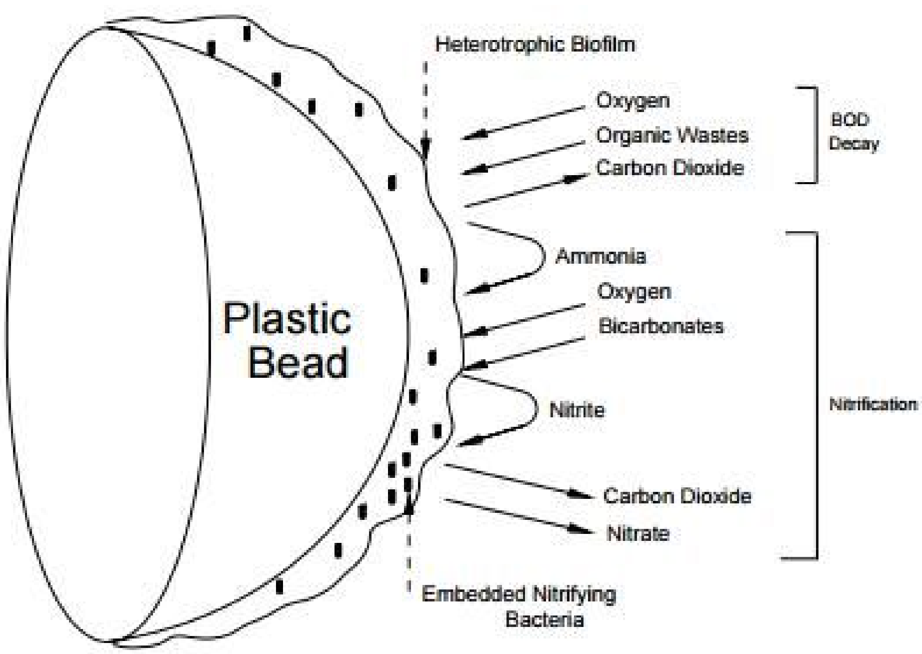


Table 2. In the Biofiltration Mode, Bead Filters Cultivate Two Types of Bacteria which Perform the Critical Biofiltration Function.

	Heterotrophic Bacteria	Nitrifying
Function	Remove dissolved organics (BOD) from the water column; breakdown and decay organic sludges.	Convert toxic ammonia and nitrite to nitrate(less toxic).
Reproduction Rate	Very fast (10 – 15 minutes)	Slow (12 – 36 hours)
Yield (mg bacteria/mg waste consumed)	0.6 – 0.8	0.05 – 0.10
Bead adhesion	Poor	Good

The classification of heterotrophic bacteria encompasses a great number of genera/species that share the common characteristics of extracting their nourishment from the breakdown (decay) of organic matter. Biochemical oxygen demand (BOD) is largely an indirect measure of the biodegradable organic material in water. Heterotrophic bacteria reduce BOD levels, consuming oxygen in the process. About 60 percent of the organic matter consumed is converted to bacterial biomass; whereas, the balance (40 percent) is converted to carbon dioxide, water, or ammonia. Heterotrophic bacteria grow very fast, capable of doubling their population every ten to fifteen minutes. If the BOD in the water being treated is very high (> 20 mg -O_2/l), the heterotrophs will quickly dominate the bead bed, overgrowing the slower growing nitrifying bacteria and consuming tremendous amounts of oxygen.

The second, yet more important, classification of bacteria is the nitrifying bacteria. These bacteria are specialists, extracting energy for growth from the chemical conversion of ammonia to nitrite and from nitrite to nitrate (Figure 3). Nitrate is a stable end product which, although a valuable nutrient for plants, displays little of the toxic impacts of ammonia and nitrite. Composed principally of Nitrosomonas and Nitrobacter, nitrifying bacteria are very slow growing and sensitive to a wide variety of water quality factors. It is not surprising that most bead filters used for biofiltration are managed to optimize conditions for nitrification.

LIMITED WARRANTY

Aquaculture Systems Technologies, LLC (AST) warrants the material and workmanship to be free of defects under designated use and normal service on its **AST LPPG Filters** for a period of one (1) year from the date of shipment. All warranty claims must be presented in writing to AST. Normal use and service requires the following:

1. The filter must be installed and operated according to the installation and operational instruction supplied by the manufacturer.
2. Excessive weight due to heavy pipes, valves, etc. must not be carried by the inlets or outlets.
3. The filter hull pressure must never exceed the maximum pressure rating as specified by the manufacturer.

This warranty applies only to the original purchase price, and is good only when the total payment for the equipment has been received. The limited warranty (expressed or implied) during the warranty period shall consist of the repair or replacement of the items of manufacture, at the discretion of **AST**, and said warranty applies only to the original purchaser.

This warranty is void if the items are damaged by negligence or accident after purchase; used for other than the intended purpose; or used with other items that affect the integrity, performance, or safety of these items. Liability does not cover indirect or consequential cost, including materials lost, labor or installation/reinstallation cost, injury, property damage, or damages caused by mishandling.

Returns for repairs must be pre-approved and the return authorization number prominently displayed on the outside of the shipping container. Returns will not be accepted without a "return authorization number". Returns for repair should be sent to the following address

"FREIGHT PREPAID":
Aquaculture Systems Technologies, LLC
108 Industrial Ave.
New Orleans, LA 70121

Manufacturer's liability for incidental or consequential damages is specifically excluded to the full extent permitted by the applicable law. This warranty gives you specific legal rights, and you may also have other rights, which may vary from state to state.

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