AFM Applications In Fish Systems

Refer to the AFM Information for Use document (IFU) for more details and AFM performance data

- Freshwater Fish
- Marine Fish systems
- Coral Systems
- Jellyfish Systems
- Parasite control
- Phosphate removal applications

©Dryden Aqua Technology; Aquarium N° 1a

Table Of Contents

GENERAL - AFM® for use in Aquarium/Zoo Filtration Systems 3

Preamble 3

Applications & Benefits of AFM® use in Aquaria/Zoos. 4

AFM® application in LSS for Aquaria 6

AFM® for Salt Water Aquariums 7

Points to consider 7

Specialised systems 8

Coral and Jellyfish systems 8

AFM® for parasite reduction in displays and Quarantine systems 9

Introduction 9

Display/exhibit Systems 10

Examples of solutions for existing systems 10

Aquarium Quarantine / Aquaculture Hatchery Systems 12

Application specific benefits 12

Points to consider: 12

AFM® for phosphate removal from exhibit water 13

Points to consider: 13

GENERAL - AFM® for use in Aquarium/Zoo Filtration Systems

Preamble

In Dryden Aqua we believe in prevention rather than cure and our philosophy is to remove and eject as much organic contaminants as fast as possible, before it becomes a biological problem needing post treatments to prevent algae or pathogen problems.

Source Water

Water is never the same from any source. Different sources will contain different contaminants and, irrespective of contaminants, may have very different water chemistry. Filtration of incoming water is key to the biosecurity of any aquarium or aquaculture facility. The bio-resistance, mechanical filtration performance and long term stability of AFM® media offers a simple, one stop treatment solution for a large proportion of incoming water filtration challenges. AFM® is not however the answer to all problems and, a knowledge of the incoming water chemistry is necessary in order to specify any complementary treatment that might offer e.g. viral protection or, the ability to remove heavy metals.

Recirculation Systems

Many LSS schematics and filtration practices have evolved over decades to overcome inherent system's weaknesses. In different countries these have evolved in different directions and, in many cases have become part of a design culture. The fact that these have evolved in different ways in different continents demonstrates that there are a number of approaches to filtration of aquarium water that can work. The schematics that feature in this document should therefore be used for guidance only, in the knowledge that other approaches are possible.

AFM® can also offer significant advantages by reducing oxidation demand and noxious disinfection by-products in chlorinated systems.

AFM® is only one of a series of components that contribute towards the efficiency of any LSS. AFM® cannot substitute for biofiltration but, if correctly used, its efficiency in organics removal will substantially reduce the load on biofilters, allowing for smaller biofilters to be installed (i.e. land mammal systems that include fish and therefore need biological filtration as part of the overall system). It will also significantly reduce oxidation demand, with consequent reductions in ozone demand and reliance on protein skimmers. (See the YouTube video - AFM® Aquaria - E-learning video)

As a result of AFM®'s filtration finesse, it is also possible to substantially reduce the turnover rates that have traditionally been applied in LSS, in certain scenarios, and to benefit from substantial energy savings.

Backwash velocity is the key to performance of any media filter and AFM® will provide a significant performance advantage over sand or non-activated crushed glass media. Even in systems where backwash flows are compromised AFM will still perform substantially better than all other media, but it will not perform as to full potential.

N.B. Media layering can be tailored to your specific system. All recommendation in this document are generalised to the standard LSS systems we have encountered world wide. If you have a specific challenge, we are more than happy to help you determine the best layering for your systems requirements

DRYDEN AQUA

Applications & Benefits of AFM® use in Aquaria/Zoos.

Application	Water source	Advantages
All Systems		• AFM® offers increased media lifespan (10 - 20 years)
Raw Water intake	• Open seawater. • Borehole or sub surface beach	• Up to 1μ filtration of incoming water. • Helps to reduce heavy metal content in incoming water. • Stable filtration quality without clogging. • Dramatically improves biosecurity • Return on capital from savings is always under 2 years and often under 1 year.
Animal systems i.e. elephants etc	LSS Recirculation system	• AFM® offers stable filtration quality without clogging. • AFM® reduces turbidity, which improves water clarity. • AFM® reduces oxidation demand and ozone dosing requirement in ozonated systems. • AFM® helps stabilise pH and reduces requirement for chemical pH correction. • AFM® will not support bacterial growth/unwanted pathology, therefore improves biosecurity. • AFM® offers reduced energy and backwash water consumption.
Chlorinated Mammal Systems	LSS Recirculation system	• AFM® offers stable filtration quality without clogging. • AFM® will not support bacterial growth. No bacteria => no biofilm => **reduced oxidation demand** => reduced chemical consumption => reduced requirement for pH correction. • No biofilm = **reduction in trichloramine & Trihalomethane production (THM's)**. These are the major causes of eye and respiratory issues in mammal systems. • AFM® reduces turbidity, therefore improves water clarity. • AFM® offers reduced energy and backwash water consumption.

AFM® will not support bacterial growth thereby improving pH stability

Sand filters are enclosed vessels and the available oxygen in the circulating water is insufficient to satisfy the needs of the autotrophic bacterial nitrification process. Available oxygen is consumed and, a reduction in pH is therefore inevitable. This initial reduction in pH then triggers a cascade effect that results in anaerobia in the filter bed and colonisation by unhealthy heterotrophs that exert even further downward pressure on pH. This process may take 3 to 6 months (depending on temperature and load) before it starts to impact on system performance but, it is inevitable in any sand filter. Sea lion systems are particularly susceptible to this happening.

With AFM®, bacteria cannot settle and so there is no colonisation of the filter, no biofilm development, no increase in oxygen demand, and no pressure on pH.

Reduced water consumption during backwash

Due to sand's density and the biological fouling that takes place in a sand filter, backwash flows of 50 to 60m/h ($m^3/m^2/hr$) are required to effectively fluidise the bed to evacuate material trapped during the run phase. However, even at these flows, research has shown that a maximum of only 77% waste evacuation from the surface layers is achieved (Assessment methodology of backwash in pressurised sand filters, Fábio P. de Deus et.al.). To achieve a 15% bed expansion, as required to effectively remove the 77% debris levels, a flow of 70m/h is required (Study of the performance of Rapid sand filters after backwashing by Raw Water, Ahmed Fadel, et al.). Bacterial settlement is quickly followed by biofilm development which binds sand grains and prevents effective backwashing.

AFM® is less dense than sand and is bio-resistant. No bacteria => no biofilm => the media remains fluid => more efficient evacuation of >95% of particles during backwash. This is achieved with as little as 50% of the water required to backwash sand.

For many systems, especially in closed systems where salt is lost in backwash, Backwash water savings result in substantial water and salt cost savings.

Reduced energy consumption

As media bed filters start to capture particulates, the pressure differential between inlet and outlet increases, and this differential results in an increased energy consumption. AFM® captures particles not only by mechanical entrapment, but also by loose electrostatic and Hydrophobic adhesion of particles to the glass surface. As a result, filtered particles are retained throughout the bed and there is less pressure loss, while achieving more filtration of fines. The absence of biofilm and resultant clogging ensures that the pressure differential range remains consistent throughout AFM®'s 15 to 20 year lifespan.

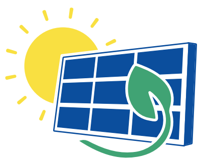
Typical sand filter pressure loss throughout the run phase will be 0.3 - 1 Bar. This compares with 0.2 - 0.5 Bar max for AFM®.This equates an extra 2 - 3m of head and a substantial annual running cost. Pressure loss will also increase dramatically once sand media starts to clog.

Doubling the pressure quadruples the energy consumption!

To show our dedication to sustainability and practice what we preach, AFM is wholly made by sustainability practices:

AFM® is manufactured from 100% recycled bottle glass from the region

Waste (metal, paper, plastic) and non-target product (flint glass, CSP, fines) are separated and recycled or used in other industries. Sludge is responsibly disposed of (incinerator)

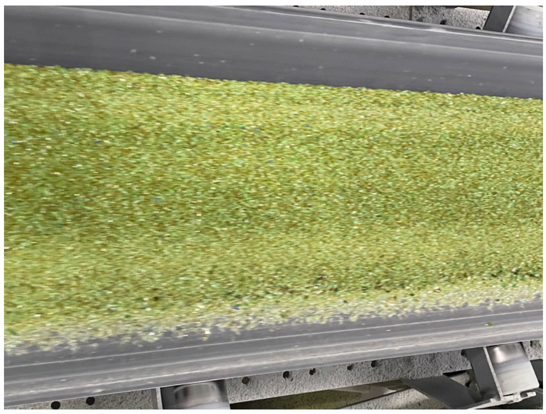


The production process is 100% energy and water self-sufficient, using rainwater in a closed-loop filtration system and up to 850,000 kWh self-generated solar power per year

Once AFM® has reached its end of life, it can be returned to the Dryden Aqua factory where it will undergo the same process of cleaning and decontamination and is re-manufactured into new AFM®

Raw material in

AFM out



AFM® application in LSS for Aquaria

Application Type	Associated Processes	AFM® Type and Grades	Typical velocity m/hr		% reduction
			min	max	
Intake Systems See: Application for use Intake systems	• Heavy algal loads • Drum filtration • Vortice separators • Coagulation & Settlement tank • Metals removal • Pre-aeration step - See IFU • Coagulation/Flocculation	• 200mm Anthracite • AFM®ng Grade 1 - 70% of remaining media depth • AFM®ng Grade 2 - 30% of remaining media depth • AFM®s Grade 3 to top of laterals		<15	95%
Freshwater Systems	• Good water circulation in exhibit to re-suspend particulates and to reduce dead-spots • Coagulation/Flocculation options • NoPhos dosing prior to filters for Phosphate removal • APF coagulation & Flocculation ensures removal down to 0.1µ • Alkalinity >150 & <300 • Separate biological filtration is required	• AFM®ng Grade 1 - 60% - 50% of remaining media depth • AFM®ng Grade 2 - 40% - 50% of remaining media depth • AFM®s Grade 3 to top of laterals	10	30	95%
Marine Systems	• Good water circulation in exhibit to re-suspend particulates and to reduce dead-spots • Coagulation/Flocculation options • NoPhos dosing prior to filters for Phosphate removal • APF coagulation & Flocculation ensures removal down to 0.1µ	• AFM®ng grade 1 - 60% - 50% of remaining media depth • AFM®ng grade 2 - 40% -50% of remaining media depth • AFM®s grade 3 to top of laterals	10	30	95%
Quarantine	• Optional • 0.5 micron cartridge filters after AFM filtration • UV sterilisation after AFM filtration	• AFM®ng grade 1 - 60% - 50% of remaining media depth • AFM®ng grade 2 - 40% - • 50% of remaining media depth • AFM®s grade 3 to top of laterals	10	15	95%

Note:

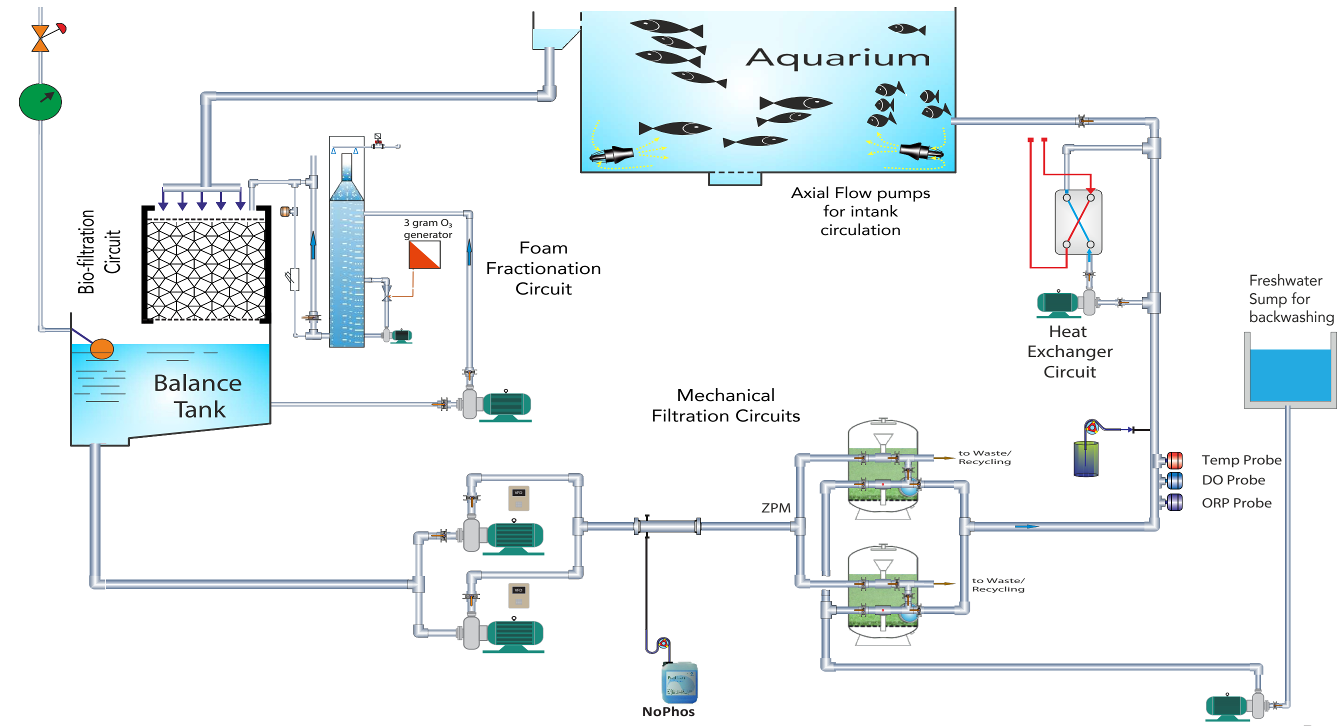
- For instruction on use of *ACO* see Dryden Aqua Downloads website - ACO for aquariums
- DA Gen - Advanced Oxidation. The most effective reduction of organics without the harmful by-products such as chloramine and THM's. Requires on 0.1mg/l of free chlorine for effective and safe water quality control. Free radicals do the work that is currently been done by high chlorine dosing.

AFM® for Salt Water Aquariums

Points to consider

- Media Filtration - See our YouTube video - [AFM® Aquaria - E-learning video]
- Biofiltration - AFM® will not support biological growth and provides no support for nitrifying bacteria. Most aquaria have some biological filtration capacity in de-gassing towers or gravel/rocks/decor. Alternatively, a good aerobic biological trickling or fluidised bed biofilter should be added, especially in a closed system aquarium or one with a low make-up/water change volume i.e. <20% per week. If several filters serve a single system, then media should be changed in a staged approach to allow time for biofiltration capacity to adjust.
- Ozone dosing - AFM®ng filtration removes organics more efficiently from the system, resulting in dramatic reductions in ozone demand and some systems only needing ozone after feeds. This reduction in ozone demand should be anticipated before media change to AFM®, by controlling the air/ozone flow rate and double checking controls/set points to ensure that a max ORP of 375mV cannot be exceeded.
- Backwash and backwash recovery systems - Filters should be backwashed at minimum 40m/h, preferably with clean filtered water. Filtered aquarium water can be used and common practice is to use filtered water drawn directly from adjacent filters. Best practice is, however, to use separate backwash pumps drawing clean freshwater from a dedicated backwash reservoir. Freshwater delivers an osmotic shock to any residual bacteria in the filter and is also recommended for salt loss reduction. Recovery of backwash water for re-use for further backwashes is also possible.
- N.B. Whereas water savings are a key and easily attainable objective we do not advise total recycling of all water. All LSS systems require at least a nominal percentage water exchange per week

Below are some common systems designs for Marine LSS.



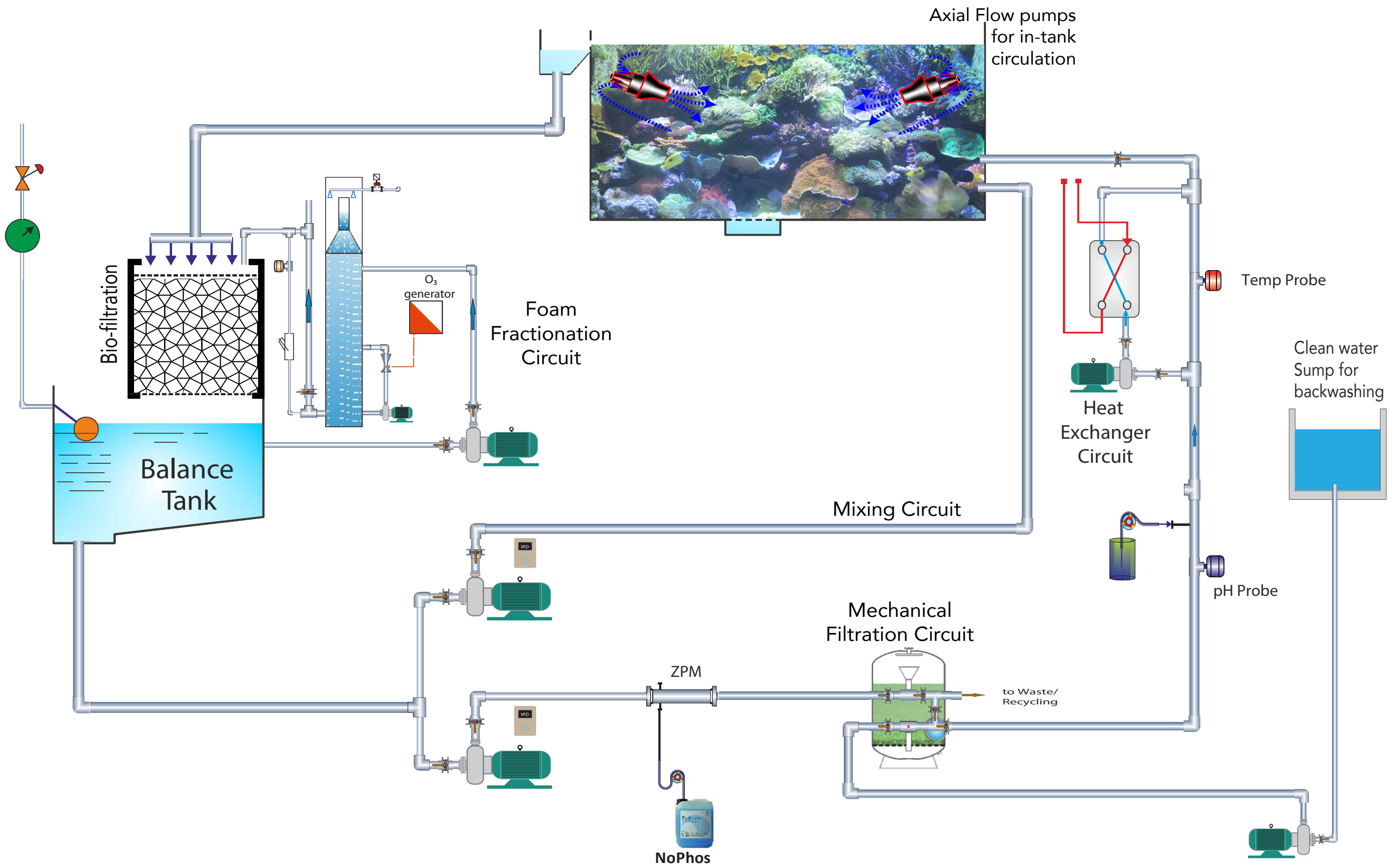
Specialised systems

Coral and Jellyfish systems

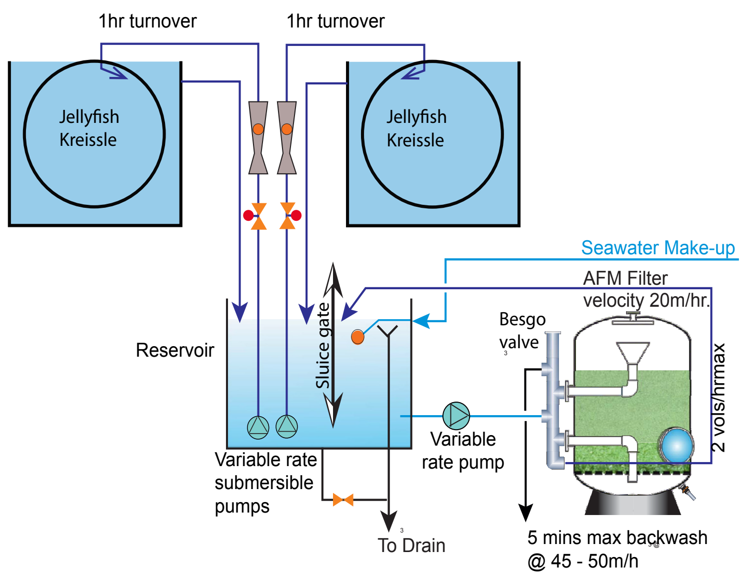
Corals and Jellyfish are filter feeders. If a sand-filtered system is changed to AFM®, filtration efficiency will always be much improved. We would therefore recommend that filtration turnover be reduced in any converted system, in order to leave enough nutrients/particulates in suspension for filter feeders.

Alternatively, new coral and jelly systems can use 2 parallel circuits driven from a common sump. The exhibit circulation loops have a controlled and constant flow, irrespective of load, and should be kept running 24/7. A separate filtration loop can either be isolated via sluice gate, valve or it can be slowed down during feeding periods to ensure that the AFM® nutrient removal rate is reduced to a minimum. The filtration loop can be re-initiated at full speed once feeding is complete, to rapidly improve water clarity without changing the flows in the exhibit.

Large coral system



Jellyfish system



AFM® for parasite reduction in displays and Quarantine systems

Introduction

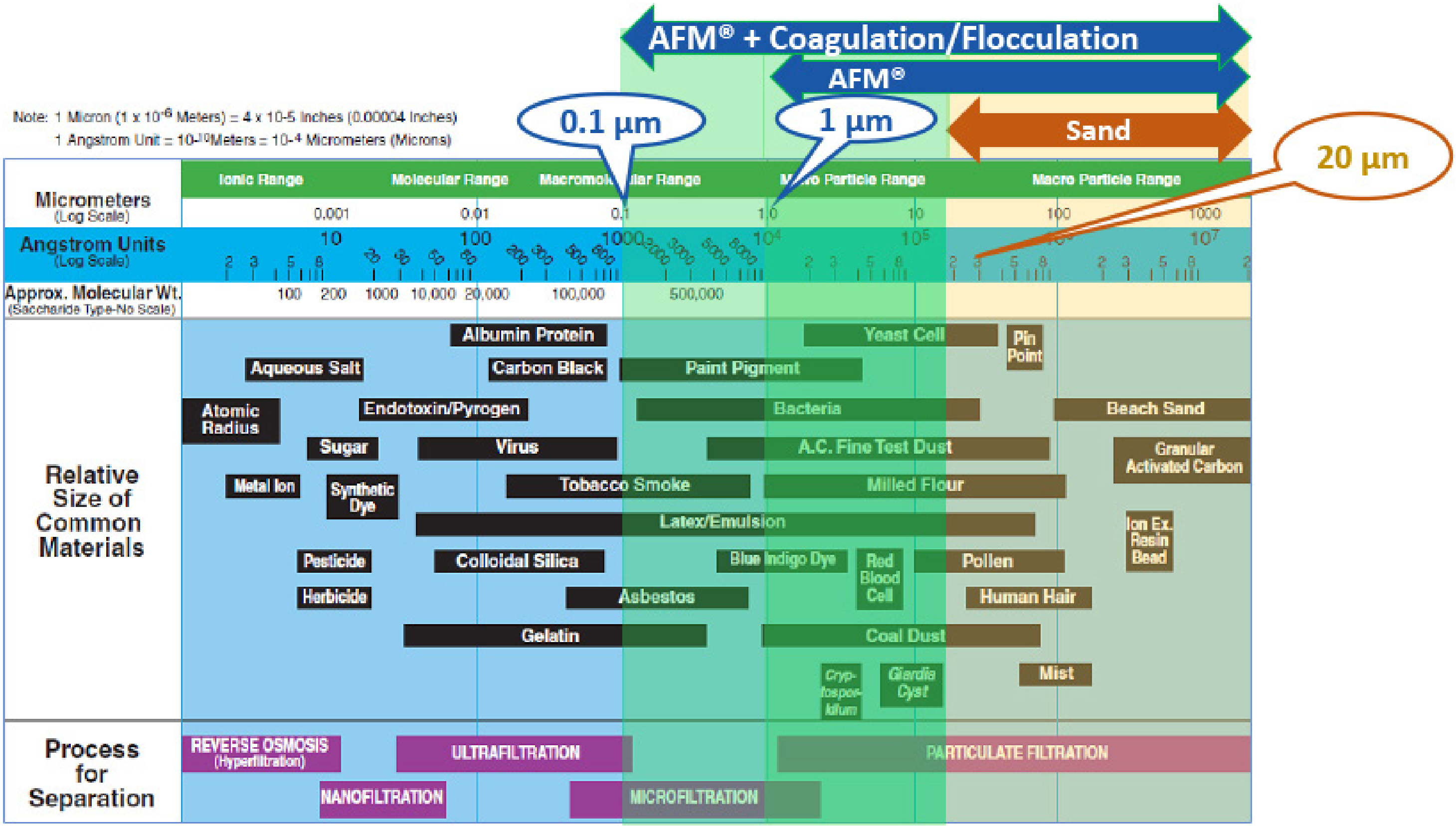
Aquariums around the world are often plagued by virus and parasite problems. Treatment can be difficult as neither biofilters, nor delicate species within the population, can tolerate the medication.

Disease or parasite outbreaks in exhibits often result from stress factors which can include transport, environmental, husbandry or water quality related stress. Good husbandry will prioritise identification and removal of stress factor/s to reduce or eradicate all root causes of trauma. Aquariums do however often simply learn to live with the problems rather than eradicating them.

Disease or parasite problems are often exacerbated by anaerobic zones in static biofilters, in the substrate or, particularly in sand filtration media where prevention of colonisation of the filter is simply impossible.

Dryden Aqua's philosophy is to treat the problem at source. AFM® is bio-resistant and will not support biological growth. As long as standard backwash protocols are respected, bacteria and pathogens cannot colonise the media and this source of perpetuation of infections is eliminated. The lack of bacteria and biofilm in the filter also ensures that primary protection is afforded, as filtration quality is both better (1 micron) and more stable.

If infected fish are introduced into a system or, if other factors are driving infection rates, then AFM®ng's 1 micron filtration will remove some of the parasite load by removing free swimming stages in parasite life cycles such as the Theront stage of the Cryptocaryon life cycle.

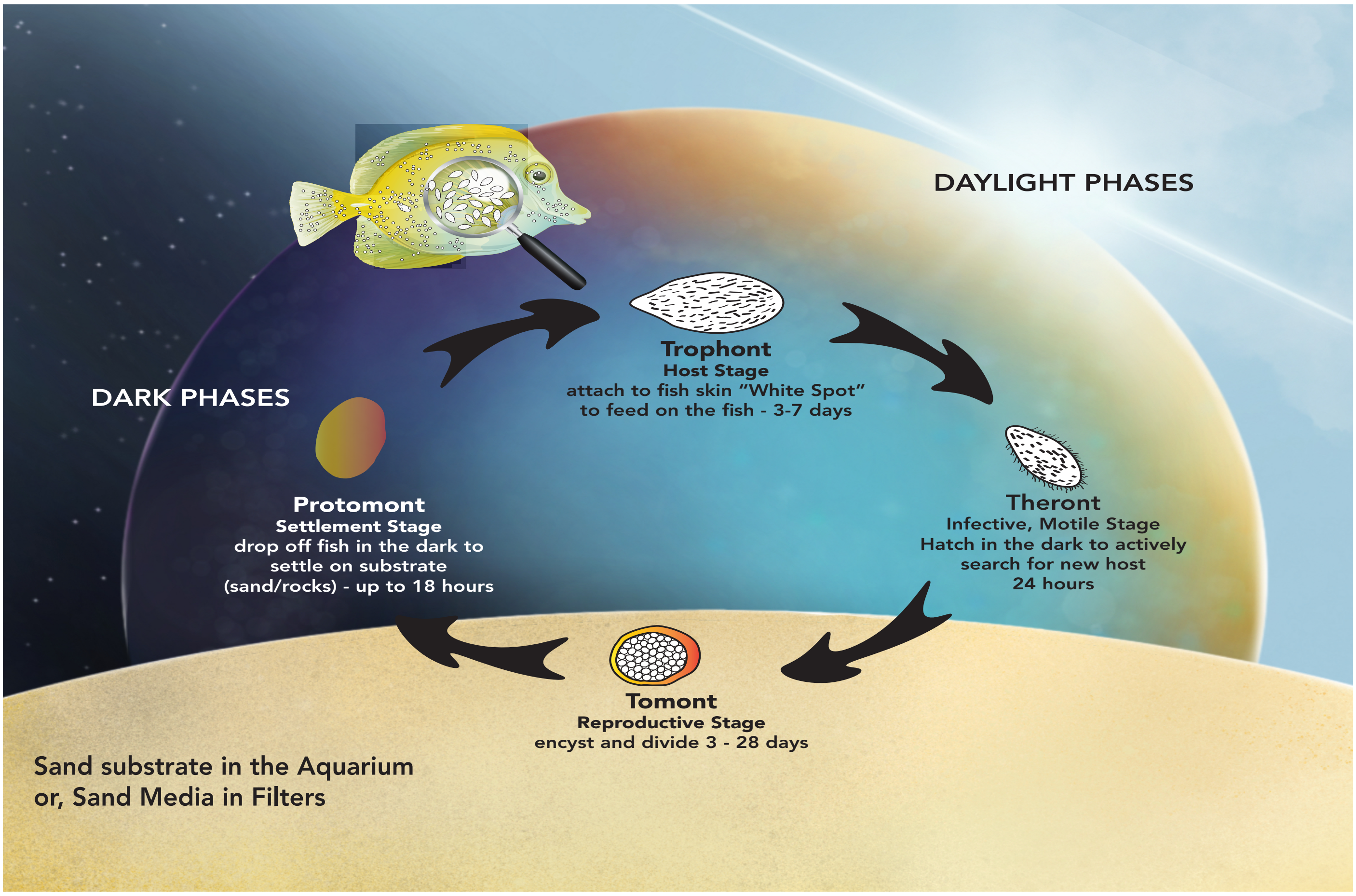


Display/exhibit Systems

New/refurbished or immature systems often battle with parasite problems, as ammonia and nitrite levels are still unstable (known as "new tank stress syndrome"). During this period, sand filters and the biofilms within them, provide the perfect environment for settlement of sedentary stages of parasitic life cycles, for their proliferation and for their subsequent release back into the aquarium water.

1 micron filtration with AFM® will easily and consistently remove the vast majority of motile or suspended bacteria and parasites in each filtration cycle. As AFM® is bio-resistant, the media will not support the subsequent growth and proliferation of sedentary or encysted forms, such as the Tomont stage of Cryptocaryon or Vibrio spp., that would otherwise colonise the filter. Proliferation of bacteria within an AFM® filter is limited by the bacteria's inability to attach to the AFM® grains and by their periodic evacuation in backwash water.

Cryptocaryon life cycle



- AFM®ng's 1µ filtration will filter out all motile stages in the Cryptocaryon life cycle
- AFM® will not support bacterial growth and will not become a source of pathology via the Tomont, reproductive stage

Examples of solutions for existing systems

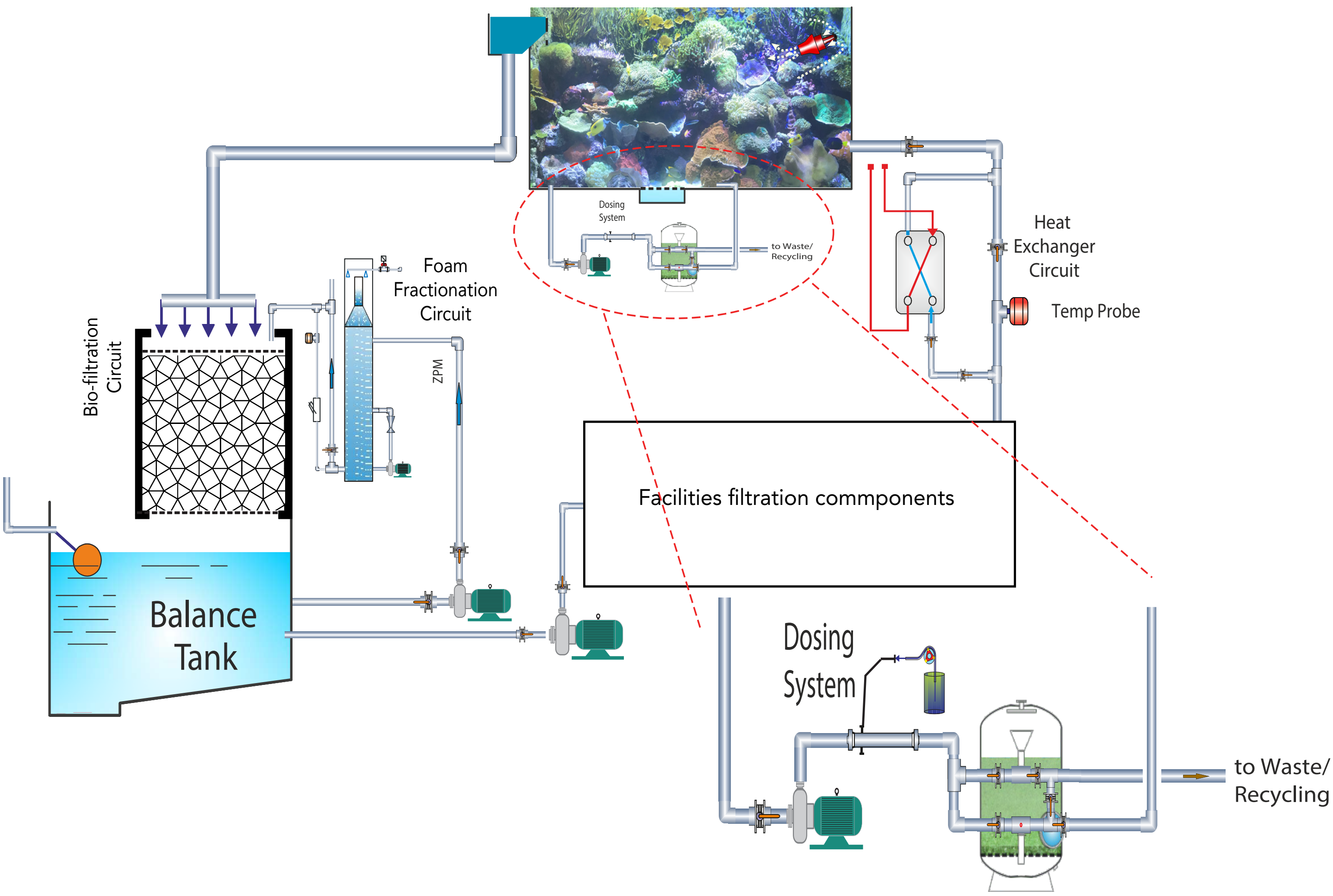
If it is not practical to immediately replace the sand in an exhibit filtration with AFM®, an AFM® filter can be installed on a by-pass loop to help reduce the system's parasite load in the short term, pending removal and replacement of all sand media and to crop/reduce parasite levels.

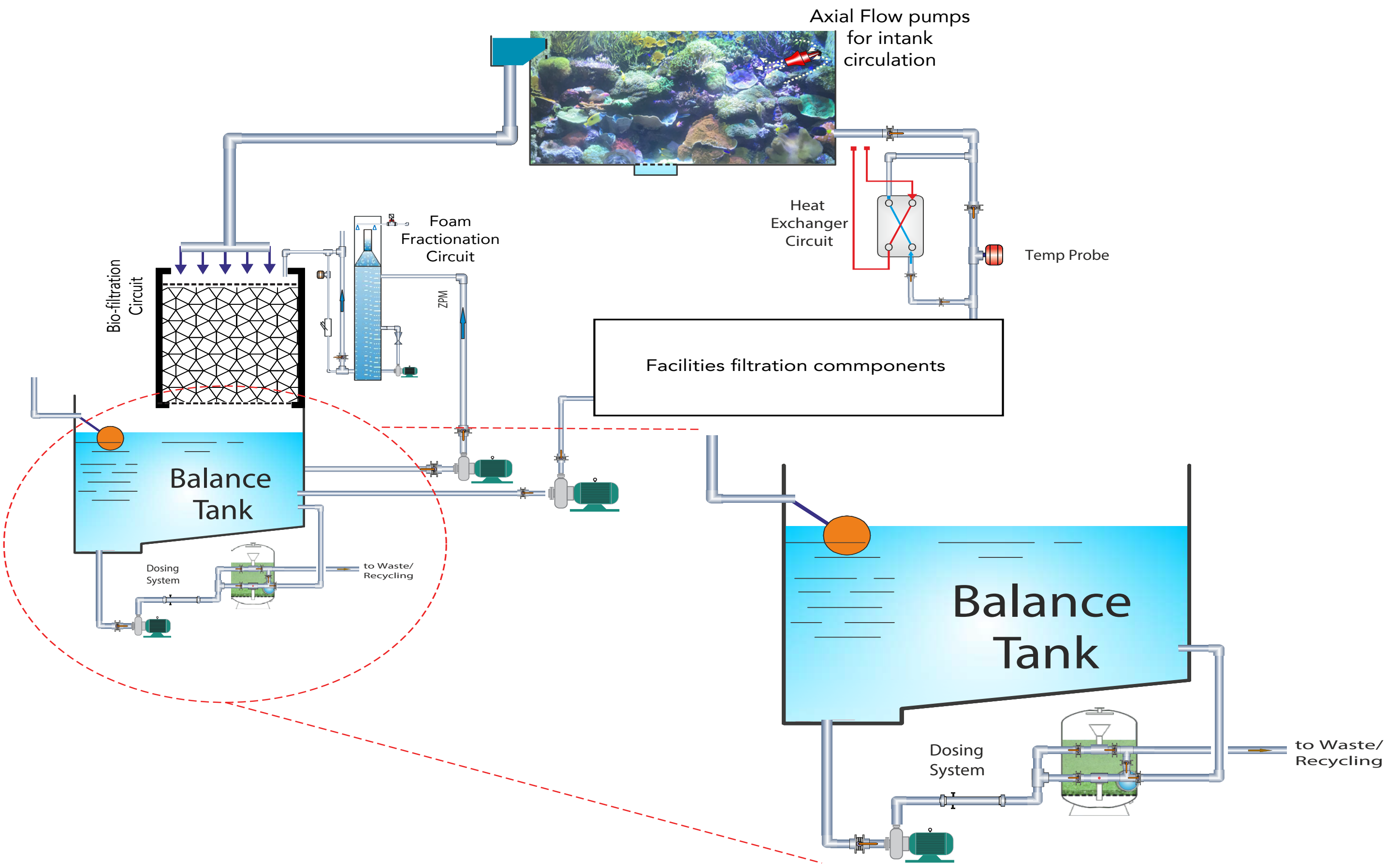
In the first drawing, a second filter has been installed on a by-pass loop on a large aquarium in a common system. This filter can contain either AFM® grade 0 or AFM®ng Grade 1 and will remove pathogens and parasites down to 1 microns. This loop can easily be added to any existing system.

In the second option the a similar bypass loop is installed around a balance tank of sump.

The AFM® filter will serve to continuously reduce the parasite load within the aquarium. AFM® grade 0 can be backwashed at a flow of 20 - 30m/h. AFM®ng would require 35 - 40m/h to properly expand the media and eject 98% of filtered particles, pathogens and parasites.

See the two filtration options below:





Aquarium Quarantine / Aquaculture Hatchery Systems

In principle, quarantine systems are designed for acclimatisation or treatment. The fact that the fish are in an unnatural environment will, however, impose additional stress that makes them more susceptible to disease. Some medications and/or prophylactic treatment may also add to stress levels.

The same applies in aquaculture hatchery systems, where sensitive juvenile stages of fish are carefully nurtured and fed.

In both quarantine and hatchery facilities, pre-treatment of incoming water is recommended in order to provide bio-security, to protect against pathogens, bacteria or viruses. Most systems rely on post-sand filtration UV sterilisation to ensure that both incoming water and wastewater is not contaminated. UV irradiation is however only as good as the clarity of the water flowing through it and, if sand filters are used to pre-filter the water, these are periodically ejecting floc containing parasites, viruses and bacteria into the 'filtered' water. This floc cannot be penetrated by UV light and periodic contamination of the quarantine/hatchery systems is inevitable. In aquaria, micro-fibre filtration or cartridge filters are often used in an effort to catch any stray floc released by the sand filters, but this presents a huge operational maintenance burden.

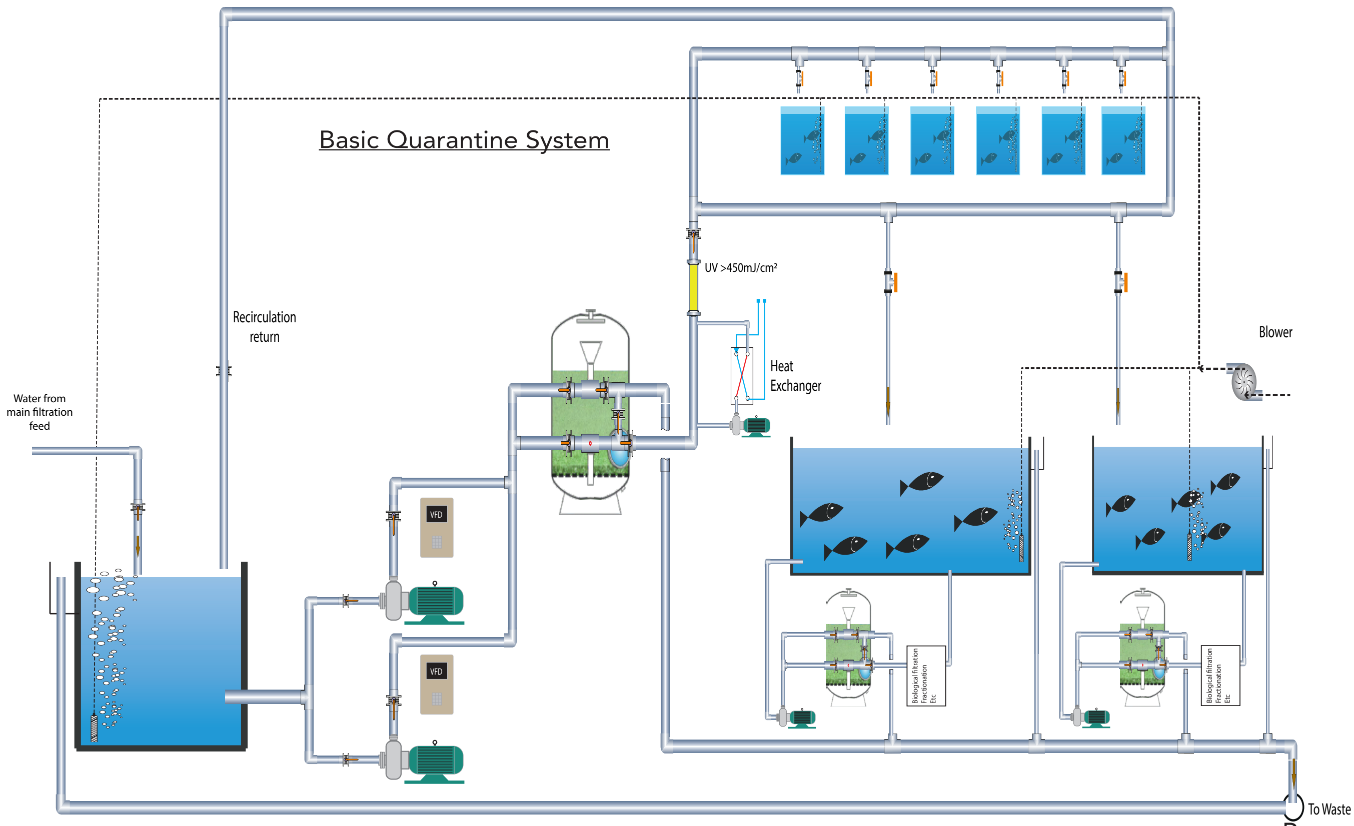
For all aquarium LSS and Aquaculture RAS we recommend AFM®ng Grade 1 (AFM IFU - See pg 19), which filters 95% of particles larger than 1 micron without flocculation or coagulation. AFM®ng's hydrophobic surface properties ensure better filtration of hydrophobic contaminants. In addition to particulate contamination, it is particularly effective in filtration of organics, pathogens and parasites and will ensure clean water for UV units. AFM®ng is particularly effective in removal of bacteria, but it will not remove viruses. The clean water from AFM® filtration nevertheless ensures optimal transmittance for virucidal treatment by UV irradiation.

Application specific benefits

- Fine, 1 micron filtration with greater biosecurity, especially for sensitive parasite prone systems.
- Clear water and stable filtration quality facilitates efficient UV irradiation.

Points to consider:

- If using AFM®ng grade 1 - Coagulation/Flocculation can be used to achieve 0.1micron filtration and even better pathogen removal performance.
- AFM® grade 0 is best suited at filtration velocities of <10m/h. AFM® grade 0 should only be used if backwash flow rates of 35 - 40m/h can't be achieved.
- AFM®ng Grade 1 will remove 95% of particles >1 micron, even at a flow rate of 20m/h.



AFM® for phosphate removal from exhibit water

Total phosphate analyses include phosphates in three forms;

1. Soluble reactive phosphate is referred to as free phosphates or orthophosphates.
2. Organic phosphates are found in plankton, algae and bacterial cell biomass.
3. Inorganic phosphates bound up in rocks and minerals or, compounds such as struvite.

Total phosphate can be analysed by wet chemistry in the lab but it is difficult to analyse in the field.

Orthophosphates are easily analysed in the field, but are literally only the tip of the iceberg. Organic phosphates are contained within the mitochondria of all cells and fuel the mechanism (ADP <=> ATP) for nutrient transport across cell membranes. All algae, bacteria and animal feed therefore contain phosphates. Oxidation or UV lysis of cell membranes will therefore simply release bound organic phosphates into the water as free orthophosphates.

In view of the above, any strategy for phosphates control must include both effective filtration and removal of organics, as well as control of free phosphates.

Points to consider:

- "Mature" sand filters will perpetuate rather than reduce phosphate levels, as biological activity in sand filters is uncontrolled.
- Aggressive use of ozone for sterilisation rather than flocculation will liberate organic phosphates into solution.
- UV irradiation will lyse algal and bacterial cells with the same effect.
- AFM®ng will provide stable filtration of 95% of particles >1µ and will remove a huge proportion of the organic phosphates that might otherwise be transformed into free phosphates.
- When coupled with pre-coagulation and flocculation, filtration efficiency can be further improved to 0.1µ.

In summary, prevention is better than cure and phosphates management starts by efficient cropping of organics by good AFM® filtration.

Water treatment to remove Orthophosphates

AFM® provides a sustainable and efficient primary means of removing phosphate from wastewater.

Animal systems can also have high phosphates input from the feed. AFM® filtration will efficiently remove bound phosphates from most sources but, will not, on its own, remove free phosphates from solution.

Chemical coagulation can, however, be used in conjunction with AFM® for removal of orthophosphates from the water. For animal systems, we recommend the use of our NOPhos product, which is lanthanum chloride based and can even be safely used with corals, so there is no safety concerns using it in mammals systems. The lanthanum chloride binds the phosphate into lanthanum phosphate extremely efficiently, making is removal by AFM a simple task, however if used in filters systems with sand media, the lanthanum phosphate will quickly bind up the sand into a concrete like block, making filtration impossible.

At Dryden Aqua we have been using Lanthanum salts (NoPhos) to remove phosphate in the aquarium and aquaculture industries for over 20 years. Lanthanum chloride is dosed into the water at a 1:1 stoichiometric ratio to bind free phosphates as lanthanum phosphate. 10ml of NoPhos will remove 1 g of phosphates. NoPhos should be dosed by dosing pump into the water prior to the AFM® filters using an aggressive cavitating static mixer such as a Dryden Aqua ZPM or dosing just before the pump, this ensures maximum efficiency in coagulation and the most economic use of NoPhos. The process is simple, reliable and sustainable when Lanthanum chloride (NoPhos) is used.

Ferric chloride is sometimes used, but is less efficient than lanthanum. The oxidation, by aeration, of ferric to ferrous will ensure coagulation of iron for more efficient removal by AFM® and will eliminate the risk of iron breakthrough.

Both Lanthanum and Ferric phosphates will rapidly clog any sand filter. As long as backwash protocols are respected with a slightly higher 45m/h backwash velocity for iron/phosphates removal, then AFM® will never clog.

Dryden Aqua fine bubble air diffusers

The new AFM® factory in Switzerland

Linked in

DrydenAqua.com