

Dryden Aqua Integrated System for crystal clear and healthy swimming pool water.

A close-up photograph of a person's hand holding a large, conical mound of bright green, granular material. The granules appear to be small, spherical particles, possibly a type of algae or a bio-fertilizer. The hand is positioned over a body of water, and a stream of the green granules is falling from the fingers, creating a small cascade. The background is a blurred view of the water's surface under bright, natural light.



The diagram illustrates a swimming pool water treatment system. The pool is divided into three sections labeled 1, 2, and 3. Section 1 contains the main filtration tank (AFM Besgo) and a ZPM (Zero Pressure Manifold). Section 2 contains an APF (Automatic Pressure Filter) and a ZPM. Section 3 contains an ACO (Automatic Chlorine Dispenser) and a ZPM. A variable speed pump is connected to the system. Arrows indicate the flow of water from the pool, through the filtration and treatment components, and back into the pool.

- 1 Filtration with **AFM**®
- 2 Coagulation and flocculation with **APF** and **ZPM**
- 3 Catalytic oxidation with **ACO** and **ZPM**



About Dryden Aqua

Who is Dryden Aqua?

We are marine biologists specialising in swimming pool water treatment. Our mission is to eliminate toxic chlorine by-products and provide the best air and water quality on the market. For over 30 years we have been working with chlorinated systems for dolphins and other aquatic mammals before successfully introducing our technology to the pool industry. There are over 100'000 swimming pools worldwide using our products today.

Dr Dryden is a marine biologist with a unique knowledge combination of biology, chemistry and technology.

He is the developer of the activated, bio-resistant filter media AFM®.



What does Dryden Aqua stand for?

We stand for the best water purification with crystal clear water, minimal consumption of chlorine and no chlorine smell or other harmful disinfection by-products (DBPs). With Dryden Aqua integrated water treatment system, we reduce the cost of water treatment and combine a healthy swimming experience with environmental sustainability and economic benefit.

Pool 3 m deep, zero turbidity, 25 m visibility range



Our approach:

Prevent bacteria growth instead of killing bacteria

Swimming pool water treatment should prevent the transmission of pathogens between bathers and minimise harmful disinfection by-products (DBP). Traditional water treatment methods attempt to fight the transmission of pathogens by using more and more powerful disinfectant chemicals, UVc irradiation and ozone. But the transmission of pathogens is a biological problem; it therefore needs a biological solution.

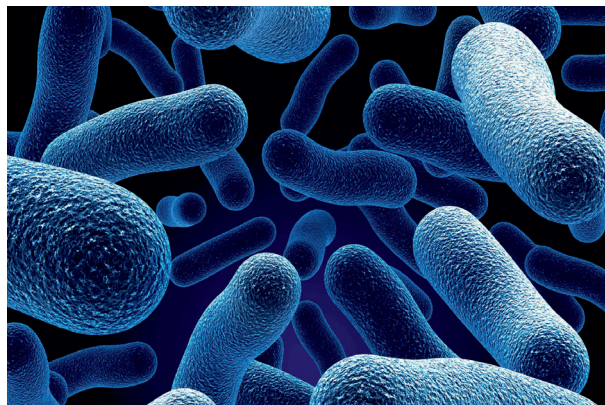
The approach of the Dryden Aqua integrated water treatment system does exactly that:

instead of using more and more powerful disinfectants and expensive equipment, we design a pool water treatment process that changes the water to make it difficult for bacteria and parasites to live and reproduce. We can achieve this task because we are biologists. We know what bacteria need to grow and we can remove it, this is a much better approach than trying to kill them with chemicals once the bacteria have become established in a pool circuit. That is why we achieve swimming pool water quality that is almost free of bacteria and parasites.

Our approach is based on three critical elements:

1. As a consequence of our bio-resistance of AFM® bacteria have no substrate on which they can grow and multiply.
2. We remove food for bacteria by advanced coagulation, flocculation and filtration.
3. DAISY: our **Dryden Aqua Integrated System** filters almost everything out of the water and reduces the chlorine demand to the lowest level possible. The lower the chlorine oxidation demand the lower the concentration of chlorine disinfection by-products in the water and in the air just above the surface of the water.

Our DAISY system provides crystal clear and healthy water without toxic disinfection by-products (DBP's), lowest chlorine consumption and low maintenance costs.



Dryden Aqua: we want to make the world a little better

The mission of Dryden Aqua is to make the world a little better and we start by making swimming pools safer and environmentally sustainable.

We are committed to fighting against pollution and to protect our environment from climate change. We are convinced to have found the main mechanism of global warming. In brief, our hypothesis is as following:

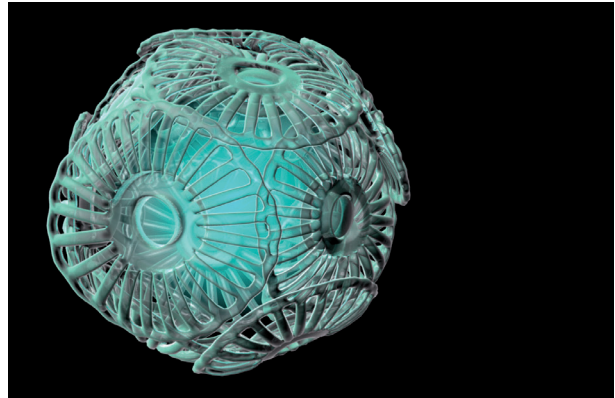
The increase in the CO₂ content in the atmosphere is *not* directly related to the increased CO₂ from anthropogenic emissions.

Scientific studies quantify that the burning of fossil fuels only accounts for between 1 % and a maximum of 5 % of all the CO₂ emissions into the atmosphere. This is a much lower amount than most appreciate. The UK Royal Society acknowledges that aquatic algae growth should have increased to compensate for the increased emissions of CO₂. Instead, quite the reverse has happened; marine phytoplankton productivity in the oceans has actually declined.

The increase of CO₂ in the atmosphere and acidification of the oceans is not caused by man-made CO₂ emissions but rather a decline in the ability of the ecosystem to metabolise the CO₂ in the atmosphere.

Marine phytoplankton converts carbon dioxide into oxygen through photosynthesis. They are responsible for 90 % of the planets CO₂ fixation and oxygen production. However since the beginning of the chemical revolution around 1950, fixation of carbon dioxide and marine productivity has dropped by 40 % which is the primary reason for the increase in atmospheric carbon dioxide.

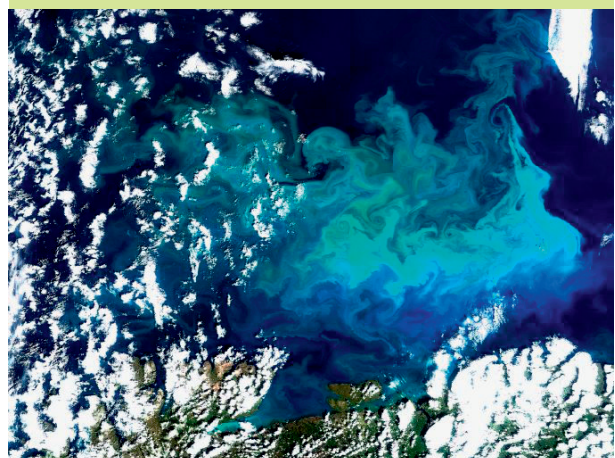
Bioactive toxins such as PCB's and PDBE fire retardants from municipal and industrial wastewater are increasing in all of the world's oceans and are at concentrations that can suppress photosynthetic activity, even in the southern oceans. The decline in productivity reduces CO₂ fixation, resulting in higher concentrations of carbonic acid causing ocean acidification and an increase in atmospheric CO₂. The impact of aquatic pollution and ocean acidification is much more dramatic than appreciated. We know from experience as Marine Biologists that at a pH of 7.9 the marine ecosystem will experience a cascade failure.



We are already beginning to witness huge shifts in the marine environment with much greater numbers of jellyfish and squid and declining fish populations. At a pH of 7.9, carbonate eggs cannot form. Given that most marine animals and many plants have carbonate shells, we are looking at a complete collapse of the marine ecosystem and the possibility that the terrestrial ecosystem system will follow. Basically we have a situation that could be much worse than climate change and it's happening now. Oceanic pH has already dropped from 8.3 to 8.09.

If we act now to prevent bioactive discharges of aquatic pollutants from municipal wastewater and industrial effluent, we have a chance to reverse the trend. We need the industry to stop using such toxic chemicals and we need to treat all of our wastewater. Not just in our own country but in every country; because we are all connected to the same ocean, atmosphere and planet.

We only have 25 years left to reverse the trend.



Plankton in the North of Europe, taken by Envisat satellite. In the past century the phytoplankton content of the oceans has decreased in almost all regions of the world. (Foto: picture alliance/dpa)

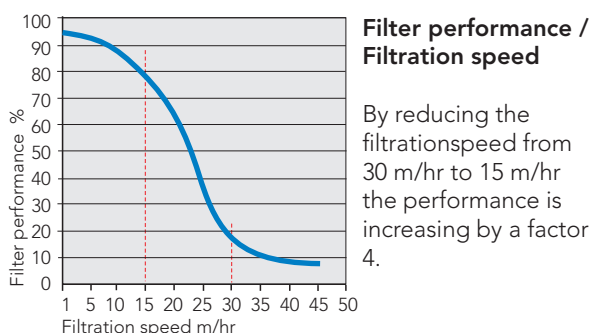
Pool Water Treatment: physical, chemical and biological facts

Physical: filtration speed – the lower the better

Sand is a good filtration media and sand filters can give a very good performance when operated properly in a good quality filter, such as a filter designed in accordance with the German DIN standard.

The performance of a sand filter with sand or AFM® is a function of the filtration velocity. The slower the water passes through the filter, the better the performance. However the relationship is not linear: i.e. if the filtration speed is reduced from 30 m/hr to 15 m/hr the filtration performance improves by a factor of 4. For this reason we recommend a filtration velocity of 15 - 22 m/hr.

According to German DIN standard the maximum filtration speed is 30 m/h. We recommend lower filtration speeds particularly for new installations. If it is not possible to re-design the system, a frequency inverter should be used to slow down the pumps at night by 50 % from 30 m/hr to 15 m/hr. This will improve the system performance and save money; indeed the capital pay-back is less than 12 months.



Biological: biology of sand filters

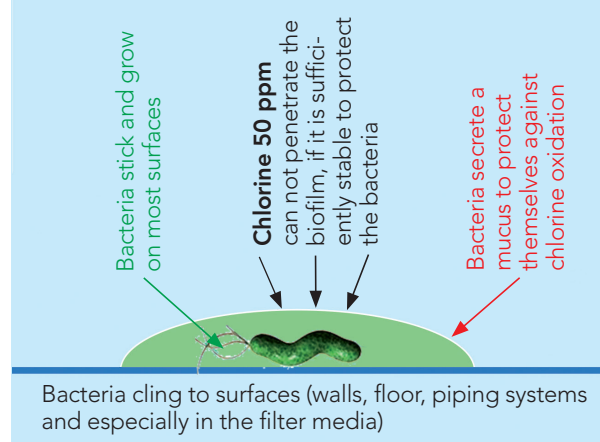
Sand filters are mechanical as well as biological filters. One m³ of sand has a surface area of 3'000 m². Individual planktonic bacteria floating in the water are oxidised by low concentrations of chlorine in less than 30 seconds. Nevertheless, we will still find bacteria growing in any swimming pool. How is that possible? When bacteria colonise a surface in contact with water, they immediately produce an alginate coat that protects them from chlorine. Every grain of sand in a sand filter will be colonised by heterotrophic bacteria (bacteria that feed on organic matter) after a few days. This bacteria layer is called biofilm and makes the sand sticky. On tiles the biofilm is identified as a slippery surface often incorrectly referred to as body fat.

Heterotrophic bacteria grow at an incredible speed. Under favourable conditions they will double in biomass every 15 - 30 minutes. They are the first to colonise a sand filter and every wetted surface in

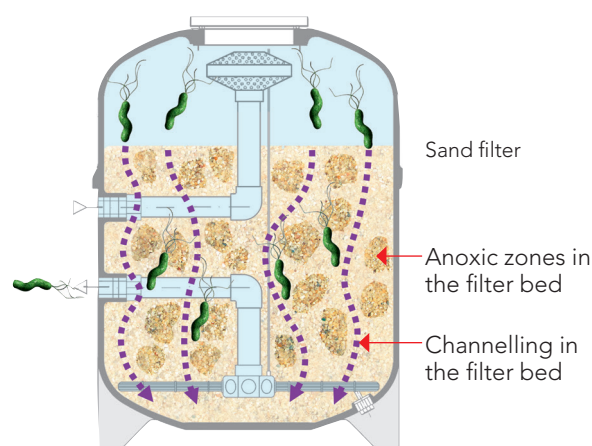
the pool circuit. The heterotrophic bacteria develop a biofilm which is then colonised by a diverse range of other species of bacteria, viruses and protozoa. The growth of the biofilm is not affected by the concentration of chlorine but by the availability of food. If there is no food bacteria can't multiply.

After about 6 - 12 months autotrophic bacteria colonise the biofilm as well. These bacteria grow much slower than heterotrophic bacteria (double approximately every 10 days).

How bacteria survive in a swimming pool?



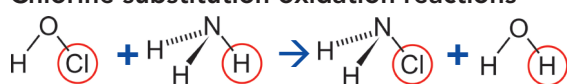
They produce organic matter which in turn serves as a food source for the heterotrophic bacteria. As a consequence the biofilm develops even faster and becomes more stable. The alginate acts like a glue and sticks the grains together leading to the formation of channels and lumps in the filter bed. The filter function is considerably reduced which increases the chlorine demand and the formation of toxic disinfection by-products. The chlorine demand of the sand filter will now be in excess of the chlorine demand attributed to the bathers. Even if there are no bathers there will still be a chlorine demand and disinfection by-products will be produced.



Chemical-biological: formation of chloramine

- **Volatility:** The most dangerous chlorine disinfection by-products are those that are volatile because they will escape the water as a gas. The chlorine smell in swimming pools is not chlorine but a volatile gas called trichloramine (NCl_3). This gas causes skin and eye irritation and is most hazardous to the lungs. The human lung is very efficient for gas exchange with over 70 m^2 surface area. Trichloramine causes irritation and strips the protective mucous lining from the lung. Trichloramine will cause skin, eye and lung irritation but it does not enter the blood stream. Other by-products produced by chlorine and short wave UVC light will pass through skin and lung tissue to enter the blood stream. These chemicals include chloroform (CHCl_3) and cyanogen chloride (ClCN). Both are much more toxic than trichloramine. That is why we are against the use of medium pressure UVC irradiation to reduce combined chlorine from public and private pool water. It is well known that UVC will convert organo-chlorine into chloroform and cyanide. For existing installations we recommend the use of ACO (see page 11).
- **Mono-, di- and trichloramine:** When ammonia and chlorine mix in water, inorganic chloramines are formed by a chlorine substitution oxidation reaction. The first stage is the formation of monochloramine, then dichloramine followed by trichloramine; especially under acidic conditions. Trichloramine is very volatile.

Chlorine substitution oxidation reactions

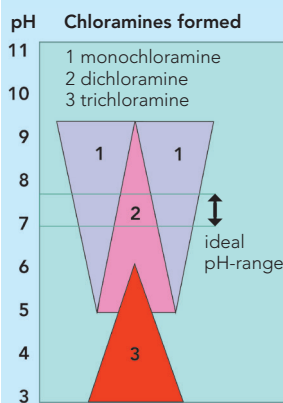


Hypochlorous + ammonia = monochloramine + water

Formation of mono-, di- und trichloramine

- | | | |
|--|---|-----------------------|
| (1) $\text{HOCl} + \text{NH}_3$ | $\text{NH}_2\text{Cl} + \text{H}_2\text{O}$ | monochloramine |
| (2) $\text{HOCl} + \text{NH}_2\text{Cl}$ | $\text{NHCl}_2 + \text{H}_2\text{O}$ | dichloramine |
| (3) $\text{HOCl} + \text{NHCl}_2$ | $\text{NH}_3 + \text{H}_2\text{O}$ | trichloramine |

Biochemical relationships



- Ammonia and chlorine forms inorganic chloramines (mono- > di- > trichloramine). Converts at low pH values, monochloramine to di- and trichloramine.
- Trichloramine are responsible for the characteristic smell of chlorine. They cause eye irritation and may cause damage to the protective film of the lungs.
- The formation of Trichloramine occurs mainly at pH values below 5.5.
- The primary environment in a swimming pool where we have acidic conditions, the biofilm.

- **Biological conversion:** Humans excrete nitrogen through sweat and urine. About 10 % of urine will be ammonia but the majority of the nitrogen (approximately 85 %) will be in the form of urea. Urea reacts with chlorine to form the organic chloramine, chlorourea. This is a non-hazardous substance because it is a stable, non-volatile molecule.

Bacteria growing on the sand convert urea into ammonia; the ammonia then reacts with chlorine to form inorganic chloramines. AFM® does not support the growth of bacteria and with no bacteria present, urea cannot be converted into ammonium and no inorganic combined chlorine is formed. For example sand filters work well for a few weeks but once the biofilm develops they start to produce combined chlorine. This can be avoided by using AFM®.

No biofilm = no bacteria = much less inorganic chloramine



- **No acidic environment:** Even without bacteriological activity, sweat and urine are still responsible for the formation of some inorganic chloramines in an AFM® system because 10 % of urine is ammonia. Monochloramine will always form but it is non-toxic and non-volatile. Monochloramine will then form dichloramine and harmful trichloramine. However, the reaction is time dependent upon concentration of monochloramine and pH of the water. The key driver for pushing the formation of trichloramine is a low pH: The more acidic the conditions the higher the concentration of trichloramine.

Pools are always maintained at a pH close to 7.0. So how is it possible to have a low pH? The explanation is the low pH of the biofilm because bacteria produce acids. The greatest surface area in the pool is the sand in the filter. Every m^3 of sand has an area of $3'000 \text{ m}^2$ for biofilm to grow and this is where monochloramine is converted to harmful trichloramine.

New sand filters work well for a few weeks until the acidic biofilm becomes established, then they start to produce trichloramine. AFM® rejects biofilm growth so there is never an acidic surface, trichloramines are not formed and AFM® pools do not smell of trichloramine. Dryden Aqua AFM® pools are therefore much cleaner and safer, especially for the sensitive lungs of young children.

No biofilm = no acidic environment = no trichloramine = no chlorine smell

Dryden Aqua integrated system for crystal clear and healthy swimming pool water

Dryden Aqua has developed an integrated pool water treatment system in which all of the components work together to provide a system in which the performance is far greater than the sum of the parts. As a marine biological company working in the pool industry, we have a unique knowledge of both water chemistry and biology. This knowledge combination has allowed us to design a fully integrated system that provides the best possible water quality with the lowest compliment of bacteria. The result is very clean water, so less chlorine is required to keep the water safe. The less chlorine used, the lower the concentration of chlorine disinfection by-products.

DAISY consists of three integrated steps:

Step 1:

Filtration with AFM®

What is AFM®?

AFM® stands for Activated Filter Material, a revolutionary filter media made from clean green glass, developed and manufactured by Dryden Aqua. AFM® exceeds the performance of quartz and glass sand by filtering at least 30 % more organics. AFM® is bio-resistant and self-sterilising which means no biofilm is formed in the filter bed. This important feature makes the pool system healthier, ecological and more economical.

AFM® has successfully been used in over 100'000 public and private swimming pools worldwide. AFM® is manufactured under ISO 9001-2008 standards and is a filter material certified under European standards for drinking water. AFM® is a registered trademark and is exclusively made by Dryden Aqua.

AFM® exceeds the performance of quartz and glass sand by far

1. Crystal clear water: AFM® filters much finer than quartz or glass sand. At 20 m/hr filtration speed, a nominal filtration of 5 microns is achieved without flocculation – AFM® filters at least 30 % more organic substances than fresh quartz or glass sand. With optimised coagulation and flocculation with APF and ZPM, a nominal filtration of less than 0.1 microns can be achieved.

2. Lower chlorine consumption means less secondary chlorine reaction products: chlorine is an excellent disinfectant. But in reaction with organic and inorganic substances it also produces undesirable, harmful reaction by-products such as trichloramine and THM's. The more chlorine is consumed the more secondary reaction by-products are produced. With AFM® we can remove far more substances than with sand or glass sand. This applies particularly in connection with coagulation and flocculation. Everything that can be filtered out and removed in the backwash process doesn't have to be oxidised. The better the filtration, the lower the chlorine consumption and the disinfection by-product production.

3. Bioresistent – no home for bacteria, viruses and other pathogens: sand is a good mechanical filter, but it's also an ideal breeding ground for bacteria. Within just a few days, every grain of sand is colonized by bacteria. They immediately form a mucus to protect themselves against the disinfectant. In this so-called «biofilm» live entire communities of bacteria and other pathogens – including Legionella. If you have no organic film in your filter, there are also no Legionella.

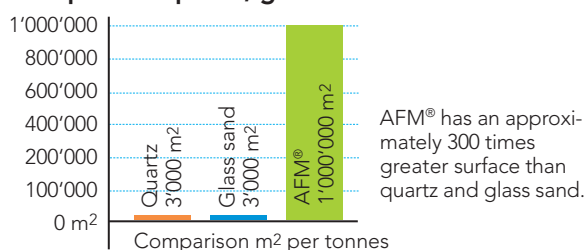
4. No trichloramine – no chlorine smell: The biofilm converts urea to ammonium and provides the acidic conditions required for the formation of toxic combined chlorine in the form of trichloramine. After about 6 months autotrophic bacteria move in the biofilm. They produce organic matter from carbonates (CO₃). Organic matter production by the sand filters can be greater than the load exerted by the bathers. AFM® does not support biofilm, organic load and chlorine demand will be at least 30 % lower and because there is no acidic biofilm, inorganic combined chlorine is 90 % lower. So with AFM® as part of a DAISY system there is no chlorine smell, no sore eyes just perfect water and air quality.

5. Filter function remains good with AFM® for many years: All sand filters will suffer from bio fouling; this always leads to bio-coagulation of the sand grain and worm-hole channelling. As soon as you have channelling there will be unfiltered water reaching the pool. AFM® does not bio foul and does not channel, so there is no possibility of unfiltered water reaching the bathers. The pool water quality is therefore much safer. Due to filter contamination, the performance of a sand filter worsens dramatically after 6 - 12 months despite frequent backwashing. The performance of AFM® remains consistently high for many years.

What makes AFM® as effective?

- 1. Clean Green glass:** For AFM®, we only use green glass bottle banks and surplus glass from glass kilns as our raw material in order to insure purity and traceability. AFM® is manufactured from pure green glass because only green glass has the chemical and physical properties required by AFM®.
- 2. Ideal hydraulic properties:** The raw material is cleaned, washed, sterilised and then reduced in size to a precise particle size, shape and particle size distribution. The correct shape is crucial for the outstanding hydraulic characteristics of AFM®. Glass beads or pearls, as well as plates are not suitable for clean water applications. Glass beads are not suitable because solids can push their way through beads. Filter media needs to lock to provide a barrier. Flat glass or clear glass form plates which is not suitable because the plates over-lap to cause a lensing effect in the filter which promotes channelling down to the outside edges of the filter bed. For safety reasons no dangerous glass splinters are allowed to be present in the filter material. Our ISO2001-2008 certified manufacturing process together with quality control of each produced batch in our laboratory ensures that this is not the case.
- 3. Activation:** AFM® activation process creates a meso-porous structure with a huge catalytic surface area. Typically crushed glass or sand has a surface area of 3'000 m² per m³ of media but activated AFM® has a surface area of over 1'000'000 m² per m³ which is over 300 times greater surface area for adsorption and catalytic reactions. Hydroxyl groups on the surface give AFM® a strong negative charge known as the zeta potential that attracts heavy metals and organic molecules. In the presence of oxygen or oxidising agents the catalytic surface generates free radicals that oxidise pollutants and disinfects the surface of AFM®.

Comparison quartz, glass sand and AFM®



Bottom line:

The chemistry of the glass, the particle shape and especially the activation process give AFM® these important properties to clearly outperform and outlast sand and glass sand filters. The large surface has a strong negative charge to adsorb organics and small particles. The surface also has metal oxide catalysts which produce free radicals and thus a high redox potential. Therefore AFM® is self-disinfecting. AFM® prevents bacteria from settling to make it a unique, bio-resistant filter material.

A word about glass sand...

AFM® has matured over a period of 30 years of research and developed into a highly engineered and safe product, certified under European Drinking Water regulations and tested under Environmental Technology Verification and validated to out-perform sand or crushed glass by up to 30 %. AFM® is also manufactured in one of the most sophisticated, computer controlled glass processing factories in the world.

Like all great ideas and products others try to follow. Unfortunately, in this case there are some serious human health and safety issues at risk. AFM® is a highly engineered product that is safe to use but most crushed glass products on the market are just waste mixed glass from refuse. Often the glass smells of decaying organic matter, and may contain contaminants as well as a higher percentage of fine shards of glass that will get through the laterals or nozzle of any filter used in swimming pools.

...and Glass beads

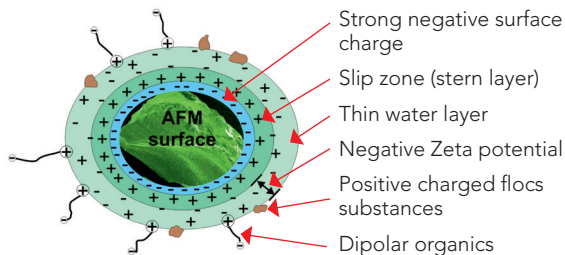
Glass beads are promoted as a good filtration media for swimming pools. Glass beads are certainly very clean and safe to use, however a sphere has the lowest possible surface area and largest space between the particles than any other shape. Also as solids build up on the bed the pressure differential can push them through the bed. For example it is very easy to push your hand through a glass bead bed but you can only penetrate a few millimetres of an AFM® or sand bed.

Dryden Aqua has been using glass beads for water filtration for the last 20 years. They make a good filtration media for grossly contaminated water because they are easy to back-wash and clean, but this property makes it a poor filter media for clean water applications such as swimming pools.

AFM® operating criteria:

Recommended filtration speed: 15 - 30 m/hr

AFM® operates over a wide range of water flows but like any filtration media, performance improves as you reduce the flow rate. For swimming pool water filtration the flow should be between 15 - 30 m/hr however we recommend flows less than 22 m/hr for best results. AFM® is a mechanical filtration media and will remove particles down to 5 microns at a water flow of 20 m/h. However in addition to acting as a mechanical filter media, AFM® also adsorbs micron and sub-micron particles as well as heavy metals and dissolved organics, even at slow flow rates. At high flow rates such as 50 m/hr AFM® will also perform much better than sand because sand filters become bio filters after 6 months which reduces the filtration performance.



Backwashing:

What goes into a filter must come back out during the backwashing stage, because any organic matter remaining in the filter acts as a food source and substrate to support the growth of bacteria. All sand filters and crushed glass filters will support a biofilm. The biofilm is an alginate jelly 50 microns thick which protects the bacteria from chlorine leaving them free to multiply. The alginate forms a sticky layer which makes it difficult to remove all of the fine solids that have been filtered from the water. For this reason, sand requires high water flow rates of 60 m/hr (From German DIN standard) for an effective backwash. However, bacteria and biofilms will continue to develop, so even these high flow rates are not effective at completely cleaning the sand during a back-wash. When AFM® is compared against sand and crushed glass, up to 30 % more solids are removed from an AFM® filter operating in the same water under identical conditions. This means less chlorine is required, chlorine by-products are reduced and you have a much safer water and air quality for bathers and pool staff.

The recommend operational criteria for an AFM® filter are as following:

- Air purge: 60 m/hr (optional not essential for AFM®)
- Backwash /water): 40 - 50 m/hr at a temperature between 25 and 32 °C of freshwater. With a bed expansion of 15 % of the filter bed you have a good backwash process

Recommended layering of AFM®?

Quartz sand has a bulk bed density of 1'450 kg/m³ – AFM® has a bulk bed density of 1'250 kg/m³. This means that you require 15 % less AFM® by weight in comparison to sand. For example if your filter takes 150 kg of sand, it requires only 125 kg AFM®.

AFM® is supplied in 3 different grain sizes and should be used in swimming pool filters as follows:

AFM® grain 1

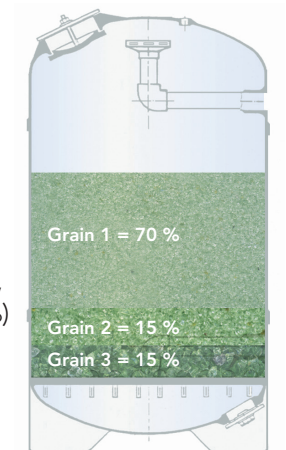
= 0.40 to 1.0 mm in the upper filter bed (70 %)

AFM® grain 2

= 1.0 to 2.0 mm support on top of grade 3 (15 %)

AFM® grain 3

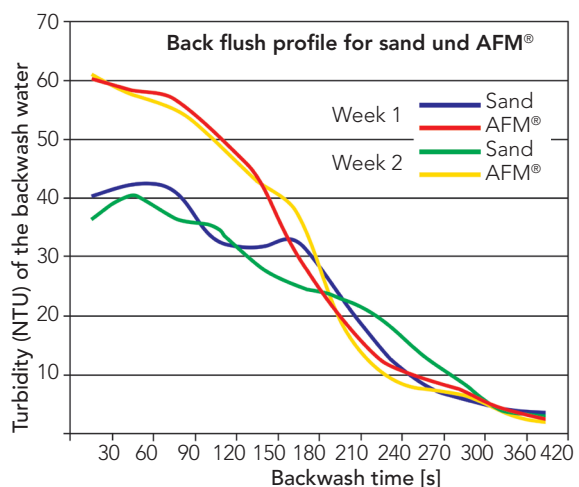
= 2.0 to 4.0 mm particle size, on the base of the filter (15 %)



If the filter is less than 1'000 mm in diameter then just grade 1 and 2 may be used (70 % grade 1 and 30 % grade 2). If the filter has a nozzle plate then irrespective of the filter diameter only 2 grades are required (85 % grade 1 and 15 % grade 2).

AFM® is supplied in 21 kg (46 lbs) bags or 1'000 kg (2200 lbs) big bags.

AFM® and sand back flush curve:



The back flush curve compares the backwash of a sandfilter with an AFM® filter. With the AFM® filter, 30 % more particles were washed out .

Step 2:

Optimal coagulation and flocculation with APF and ZPM

AFM® will remove most particles down to 5 microns and many micron and sub-micron particles as well as dissolved organic components. When AFM® is combined with a cavitating ZPM static mixer using APF (All Poly Floc), the performance is greatly enhanced. The combined system now gives nominal filtration down to 0.1 microns that is a 50 times better filtration. In addition, it removes most of the dissolved organic matter and reduces chlorine oxidation demand by up to 80 %. Why is this so important?

Less consumption of chlorine = less disinfection by-products (DBP): Chlorine must be used in all public pools. Chlorine is an excellent disinfectant that will kill most bacteria in less than 30 seconds. No other disinfectant comes close, which means chlorine is the only oxidising agent that protects the bathers from horizontal transmission of disease. However, a major disadvantage of chlorine is that it forms toxic disinfection by-products (DBP). This is why it is so important to treat the water to the highest possible standard in order to minimise the concentration of these disinfection by-products. This is the whole reason behind DAISY to make pools safe but it also makes good economic and environmental sense to minimise the amount of energy and chemicals.

APF: All-poly Floc

APF is the most sophisticated and powerful coagulation and flocculation product available to the swimming pool industry. Most of the chlorine demand is not from particles in suspension but from chemicals in solution. APF contains different electrolytes that drag dissolved chemicals out of solution to form small particles.

In addition to electrolytes, APF also contains poly-electrolytes to flocculate small particles to make larger particles that can then be removed by AFM® filter media. APF imparts a positive charge on the particles that are then adsorbed onto the negative charged surface of AFM®.

How does APF work?

- **Coagulation** is the process involving the destabilisation of dissolved chemicals to form a precipitate. In order to make coagulation work, APF must be mixed instantly and aggressively with the water – this is why we designed the ZPM. If a ZPM is not used, the coagulation stage is missed and APF jumps to flocculation.

- **Flocculation** is the process of bringing the colloidal suspensions of small particles (skin cells, bacteria and parasites) together to form larger particles or flocs that can be easily removed by AFM®. APF imparts a positive charge to the particles that are now attracted to the negative charge surface of AFM®. Flocculation takes several minutes and the particles are very fragile, which means the water must not be subjected to aggressive agitation. Use DIN standard filters because they give more head space above the filter bed and hence more time for the flocculation reactions to develop.

How to inject APF?

APF should be injected into the water using a peristaltic pump (for example a Dryden Aqua floccdos pump) on a continuous basis via a ZPM before the AFM® filter. Diaphragm dosing pumps should not be used because they do not provide a continuous flow. The dose rate is 1 ml per m³ of water passed through the filters. The water quality will affect the coagulation and flocculation reactions. For best results, alkalinity as CaCO₃ should be greater 60 mg/l and the hardness above 100 mg/l.

NoPhos is one of the electrolytes in APF; every 20 litres of APF contain 0.5 litres of NoPhos and is responsible for phosphate control in pool water. If 100 % of the phosphate is removed, then bacteria and algae simply cannot grow. APF contains sufficient NoPhos for most pools. If for any reasons (heavy bather load or water companies adding phosphate to municipal supplies) the NoPhos in the APF is not enough, we recommend to add 1 l of NoPhos in APF or directly to the pool water.



Swimming pool with strong algae attack – not with NoPhos

ZPM: Zeta potential mixer

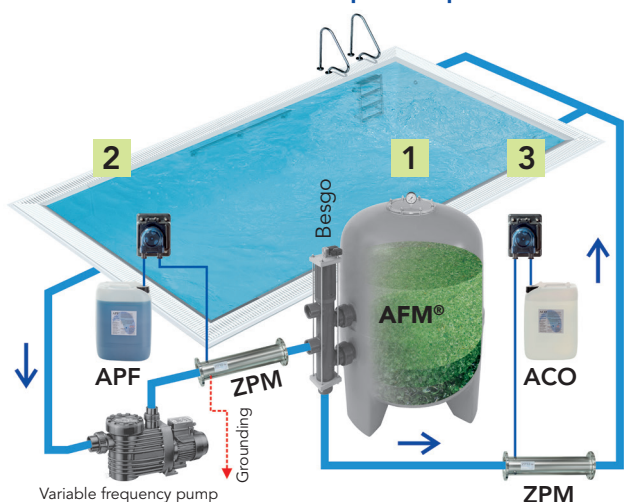
ZPM stands for Zeta Potential Mixer. They are manufactured from 316 grade stainless steel for freshwater and a combination of plastic and titanium for marine applications. The ZPM is flanged into the pipework and as the water passes through the ZPM, it is violently mixed and cavitates.

A ZPM is essential for the APF coagulation reactions but it also has other benefits. The ZPM splits the water molecule as well as dissolved oxygen to generate free radicals and to increase the redox potential. The Dryden Aqua ZPM therefore increases the oxidation potential and drops the zeta potential of the water. The net effect is that it promotes coagulation and disinfection. The violent mixing action also stresses cryptosporidium oocysts and renders them susceptible to oxidation by chlorine or it simply kills them directly. All of the above benefits make the Dryden Aqua ZPM an essential part of the DAISY system.

How does a ZPM work?

Installed upstream of the filter, the ZPM amplifies the coagulation and flocculation reactions for the conversion and precipitation of dissolved components into small particles. The cavitation reactions provide the perfect mixing and turbulent environment necessary for coagulation using APF. The ZPM neutralises the electrical charge (Zeta Potential) on dissolved chemicals and small particles to make some positively and some negatively charged. The opposite charges attract and this causes coagulation and flocculation. As the electrical potential drops to neutral, the redox oxidation potential of the water increases.

DAISY filter circulation for private pools



- 1 Filtration with **AFM®**
- 2 Coagulation and flocculation with **APF** and **ZPM**
- 3 Catalytic oxidation with **ACO** and **ZPM**

Step 3:

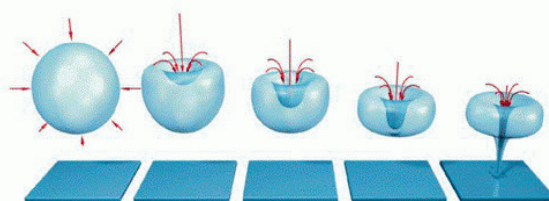
Enhanced oxidation with ACO and ZPM after AFM® filtration

Sand filters incubate and generate colonies of bacteria called bacteria floc. Indeed the primary source of bacteria in a swimming pool is actually the sand filter as opposed to the bathers. Just like biofilm, bacterial floc are large colonies of several million bacteria held together by an alginate glue. The alginate protects the bacteria from chlorine for several minutes to several hours. AFM® does not incubate bacteria but bacteria can still grow on the inside of the filter shell, nozzles and in the pipework. A ZPM after the filters will smash bacteria floc into individual bacteria which then allows the chlorine to kill the bacteria before the water reaches the pool.

ZPM for disinfection and cryptosporidium control

The ZPM downstream of the filter is installed for mechanical disinfection and barrier against bacteria. The Nano bubbles created by the cavitation are of most use here. They will be attracted to the surface of solids such as bacteria, viruses, spores and protozoa. Nano bubbles adhere to the surface where they then implode. The energy released blows a hole through the cell membrane of the pathogen. The bacteria or parasite will be killed or the hole formed allows chlorine to enter.

Bacteria and other pathogens are incubated on the surface of sand in the sand filters, on the walls of the balance tank and any surface in contact with the water. The slippery surface on tiles is not body-fat but a thin invisible film of bacteria. Some pathogens (e.g. Cryptosporidium) as well as biofilm protected colonies of bacteria are extremely resistant to chlorine. The ZPM breaks these colonies apart and allows chlorine to disinfect the water before the water reaches the pool. Bacterial floc can survive for a few minutes to several hours, bacteria from ZPM shattered floc can only survive for about 30 seconds.



Nano-bubble implosion process

ACO – active catalytic oxidation into the ZPM after the filters

ACO stands for Active Catalytic Oxidation and is unique to Dryden Aqua. ACO contains several components, one of which is a catalyst supporting the natural photo oxidation from UV light. The energy of the sun or UV light is catalysed by ACO to form free radicals to disinfect pool water. The radicals work just like chlorine to remove pollutants but they do not form combined chlorine.

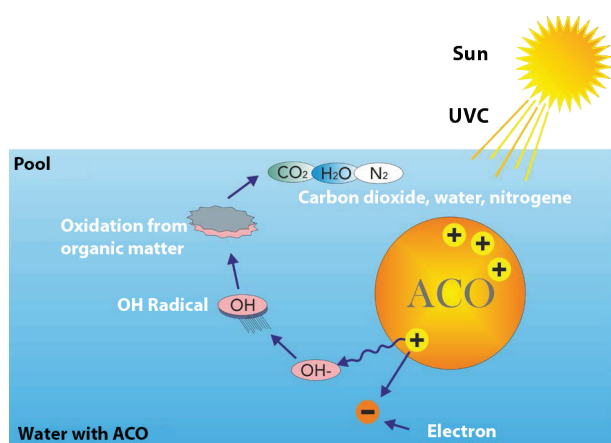
ACO has three primary functions:

1. Oxidation enhancer, makes chlorine and other oxidising agents work better
2. Protect chlorine from photolysis
3. Cationic flocculant works synergistically with APF

ACO is a catalyst and it is there for not consumed by the process. It gradually builds up in the water over a period of 8 weeks until it reaches equilibrium.

How does ACO work?

ACO consists of a mixture of poly silicates and metal oxides. The short-wavelength, energyintensive ultraviolet rays from the sun are converted by ACO into longer wavelengths. When this energy is released, it splits water molecules producing free radicals (hydroxyl radicals and oxygen radicals). They are even more powerful than ozone and can oxidize pollutants such as urea and chloramines completely back to carbon dioxide (CO_2), water (H_2O) and nitrogen (N_2), so no combined chlorine or toxic disinfection by-products, just clean, safe water. So whenever there is strong sunlight, ACO will help to disinfect the water but it will not be consumed and it will not form reaction by-products.



By the conversion of the short-wavelength UV light to longer wavelength light, chlorine is protected from photolysis (decomposition by the sun). The half-life of chlorine increases by over 300 %. In contrast to traditional chlorine stabilisers such as cyanuric acid, ACO amplifies the performance of chlorine to kill bacteria and provides you with cleaner, safer water for both private as well as public pools.

UV is used for dechloramination (reduction of combined chlorine), however medium pressure UV will double the chlorine demand. Also, some of the combined chlorine is converted to chemicals such as chloroform and cyanogen chloride that are hundreds of times more harmful than combined chlorine. When ACO is dosed into the water before UV, it helps to reduce chlorine demand and reduces the formation of harmful by-products.

ACO is a cationic flocculant that removes positive charged particles. In combination with APF which removes negative charged particles, we will get a double stage flocculation of both positively and negatively charged particles in the water.

How to use ACO?

ACO is best dosed continually into a ZPM after the AFM® filter, using a peristaltic dosing pump. The application rate is the same as APF and should be used at a continuous flow rate of 1 ml per m^3 of water filtered. ACO can also be dosed manually; the dosage is 1 l per 100 m^3 pool volume per week. We recommend the first dosage be double this amount. ACO takes around six to eight weeks before the full effects are visible.



Treat yourself and your family to the best.

We are marine biologists specialising in swimming pool water treatment. Our mission is to eliminate toxic chlorine by-products and provide the best air and water quality on the market. For over 30 years we have been working with chlorinated systems for dolphins and other aquatic mammals. In captivity, these animals often have to live in chlorinated water. The chlorine makes the water look nice and clean, but hidden are the high concentrations of chlorine reaction by-products that can cause the skin, eye, and lung damage. Indeed the primary cause of mortality among the animals is pneumonia as a consequence of lung damage caused by chlorine disinfection by-products. Dryden Aqua has solved this problem, so zoological animals now have much healthier conditions.

After introducing the Dryden Aqua integrated water treatment technology to the pool industry a few years ago, there are now over 100'000 swimming pools using our products worldwide.

The Dryden Aqua Integrated water treatment system (DAISY) is the only integrated system in which all of the component parts work together to provide a very efficient, environmentally sustainable low cost water treatment process. However the best news is that you will have the safest atmosphere above the water, brilliant water quality and the perfect swimming pool water quality for everyone, especially children.



For little money you get the best for many years.

Innovative technology in harmony with nature



Who is Dryden Aqua?

We are a marine biological company specializing in water quality and innovative, sustainable treatment technologies. Our unique knowledge combination and detailed understanding of the biological as well as physio-chemical reactions has enabled us to develop a highly innovative range of products for aquaria and swimming pools. Therefore we became leader in water treatment for public and private swimming pools.

Our mission is: crystal clear and healthy water without any smell of chlorine. Today more than 100'000 pools worldwide using our system.

www.drydenaqua.com