



# DAISY

## 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 (CO<sub>3</sub>). 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.

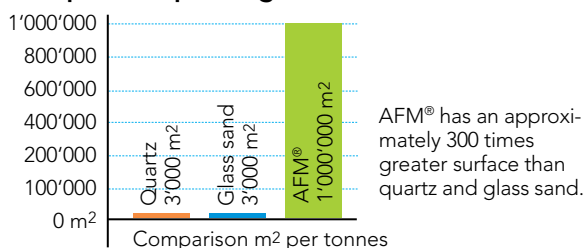
**5. Filter function remains good with AFM® for many years:** All sand filters will suffer from bio fouling; this always leads to bio-coagulation of the sand grain and worm-hole channelling. As soon as you have channelling there will be unfiltered water reaching the pool. AFM® does not bio foul and does 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 m<sup>2</sup> per m<sup>3</sup> of media but activated AFM® has a surface area of over 1'000'000 m<sup>2</sup> per m<sup>3</sup> 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

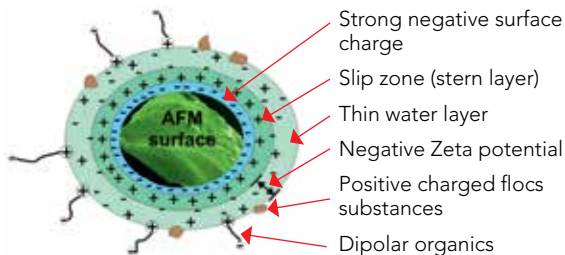
Glass beads are promoted as a good filtration media for swimming pools. Glass beads are certainly very clean and safe to use, however a sphere has the lowest possible surface area and largest space between the particles than any other shape. Also as solids build up on the bed the pressure differential 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/m<sup>3</sup> – AFM® has a bulk bed density of 1'250 kg/m<sup>3</sup>. 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

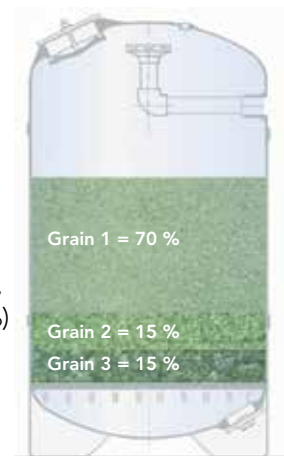
= 0.40 to 1.0 mm in the upper filter bed (70 %)

### AFM® grain 2

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

### AFM® grain 3

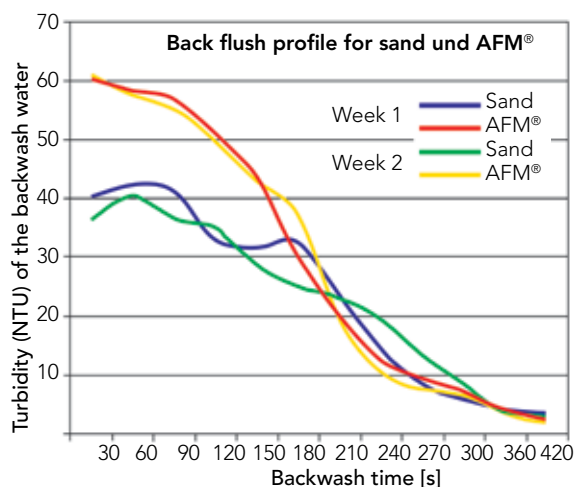
= 2.0 to 4.0 mm particle size, on the base of the filter (15 %)



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 m<sup>3</sup> of water passed through the filters. The water quality will affect the coagulation and flocculation reactions. For best results, alkalinity as CaCO<sub>3</sub> 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

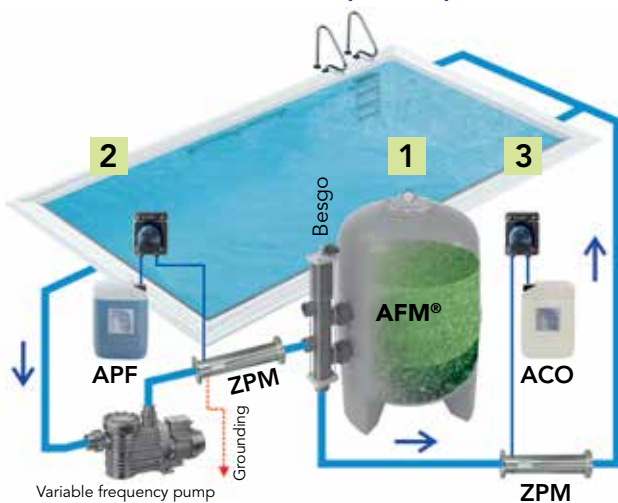
ZPM stands for Zeta Potential Mixer. They are manufactured from 316 grade stainless steel for freshwater and a combination of plastic and titanium for marine applications. The ZPM is flanged into the pipework and as the water passes through the ZPM, it is violently mixed and cavitates.

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:

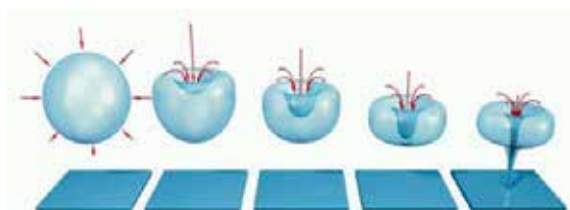
### Enhanced oxidation with ACO and ZPM after AFM® filtration

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.

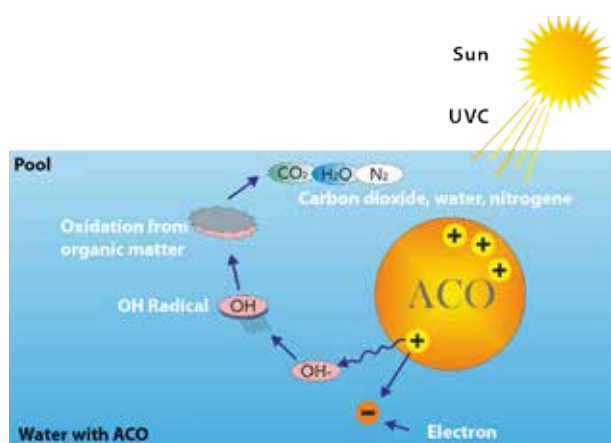
### ACO has three primary functions:

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 ( $\text{CO}_2$ ), water ( $\text{H}_2\text{O}$ ) and nitrogen ( $\text{N}_2$ ), 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<sup>3</sup> of water filtered. ACO can also be dosed manually; the dosage is 1 l per 100 m<sup>3</sup> 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.

