Benefits

- Cryptosporidium control
- Solids removal down to sub micron levels
- 30% to 80% better performance than sand
- Lower THM levels
- Reduce or eliminate trichloramines
- AFM should never need to be changed
- Life cycle cost benefits, water & energy give a return in capital in under 24 months
- 100% environmentally sustainable

Application

- Drinking water
- Tertiary treatment of sewage effluent
- Industrial waste water and grey water
- Swimming pools
- Desalination pretreatment
- Cooling towers
- Public aquaria

A water filtration project for Life & the Environment
Support by the European Commission
LIFE 02 ENV/UK/000146 AFM

Dr. Howard Dryden
Dryden Aqua 2007
**AFM media replaces sand**

Sand filtration will be the principle means of treating drinking water for many years. The process has served us well, however with the increasing demands on our water resources and pressure to continue to improve water quality, we have perhaps reached the limit of sand filter performance. As a consequence Uvc, ozone, carbon filters and membrane systems are now becoming more common place. However there is a technique that can greatly improve the performance of Pressure and Rapid Gravity Filters without resorting to high capital cost systems. The WHO (World Health Organisation) estimate that 6% of the disease in Europe are water born, and the highest percentage of these is due to gastroenteritis caused by the 4 micron diameter oocysts of Cryptosporidium and Giardia.

Research conducted by Dryden Aqua with support from the European Commission under the Life Environment initiative, has confirmed that AFM (Active Filter Media) provides a much more effective barrier to the passage of oocysts than is possible for sand. Considering that the oocysts are resistant to chlorine, AFM filter media provides an opportunity to easily improve the performance of most drinking water treatment systems and reduce the incidence of disease. The public and environmental health implications are substantial.

Key areas of sand filter performance are as follows;

- Solids removal
- Removal of oocysts
- Reduce chlorine demand and reaction products; trichloramines and THM’s
- Reduce backwash water volume
- Generate Life Cycle Cost saving and employ sustainable procurement

Sand filters will remove particles down to around 10 microns, however when used in conjunction with good flocculation, it is possible to consistently remove solids down to micron and sub-micron levels. This performance can only be maintained if there is zero channelling of water through the filter bed.

**Channelling of water through sand filters**

It is impossible to prevent bacteria from growing on sand, indeed sand is an excellent substrate for the growth of bacteria. Even when a sand bed is continually fluidized at 50% expansion, the sand will become a very effective biofilter. No amount of air scouring or backwashing will remove the biofilm.

Alginates excreted by bacteria glue the bacteria on to the sand. The problem is the alginates also glue the sand grains together to form channels, and over a period of a few months to several years (depending on water quality and temperature), the alginates will become harder and more stable. With water temperatures over 15 deg C, the growth rate of heterotrophic bacteria can be as short as 15 minutes. The exponential growth and production of alginate will either form stable channels through the sand, or there will be a rapid increase in pressure differential across the filter. The consequences are either deterioration in water quality, or an increase in back wash frequency, or more likely a combination of both problems.

Bacteria are required in slow bed filters, but in rapid gravity and pressure sand filters, they are the main reason for poor water quality and filter failure. AFM active filter media solves this problem!
AFM filter media and solids removal.

AFM media is an active filter media manufactured by Dryden Aqua and designed to replace sand in all types of sand filter. AFM has surface catalytic properties and a high negative zeta potential. The surface active properties prevent colonization by bacteria so bacteria induced bed channelling is essentially eliminated. Coagulants and flocculent such as PAC have a positive charge, when added to water they reduce the zeta potential and impart a positive charge to the suspended solids. The high negative zeta potential on AFM attracts the particles and holds them within the filter bed. AFM filter media will remove at least 30% more particles from the water than a sand filter. This statement is supported by independent trials conducted by two UK water companies.

Dr. John Hargreaves (Chief Executive Scottish Water PLC) & Minister for the Environment Mr. Ross Finnie MSP visit our AFM system in Scottish Water
**Graph 1. Backwash performance of Sand and AFM**

Data provided by Suffolk & Essex Water (UK)

**Back-washing**

What goes into a filter must come back out, Graph 1 shows the backwash performance of sand and AFM. The graph clearly shows that more waste was removed from the AFM filter during a backwash in comparison to an identical filter bed containing sand. The backwash profile of AFM was also reproducible which indicates stable steady state conditions. In comparison the backwash performance of sand was not stable, and up to 30% less waste was eluted from the sand.

In sand filters, a proportion of the solids will be glued to the sand by alginites. Aggressive air scouring and extended backwash times are therefore required to try and keep the media clean. With AFM the solids are only held by a weak electrical charge that is broken during backwash to release all of the solids. A great deal less water is therefore required to backwash AFM.
The surface of AFM exhibits catalytic activity in the presence of oxygen. A proportion of the dissolved oxygen molecules are dissociated on the surface of AFM which increases the oxidation potential of the media. The surface of AFM is therefore self sterilizing.

The zeta potential generates a high charge density, which attracts positively charged particles, but at the same time the slip zone prevents the particles from reaching the surface of the media. AFM therefore attracts solids, and holds on to them, but they are prevented from bonding to the surface. The self cleaning properties mean that the media is just as effective in treating wastewater such as sewage effluent as it is in treating clean water because the media does not become biofouled.

**Chlorine reaction products.**

Chlorine is usually added after the sand filters, but in double filtration systems, chlorine may be used before the second sand filter, and under these conditions trichloramines will be produced. Trichloramines are formed by reaction between ammonium and chlorine at a pH less than 5. The biofilm on the sand grains is acidic and is the principle location for trichloramine production. AFM has no biofilm, and the surface is not acidic, so trichloramines can not be produced.

\[
\begin{align*}
NH_3 + HOCl & \rightarrow NH_2Cl + H_2O & pH = 6-8 & \text{ Mono-chloramine} \\
NH_2Cl + HOCl & \rightarrow NHCl_2 + H_2O & pH = 5-6 & \text{ Di-chloramine} \\
NHCl_2 + HOCl & \rightarrow NCl_3 + H_2O & pH = <5 & \text{ Tri-chloramine}
\end{align*}
\]

At the chlorine levels normally used before sand filters, the chlorine will not kill the biofilm, indeed it can actually promote the growth of bacteria species that produce copious quantities of alginates such as *Pseudomonas spp*. Bacteria excreted alginates as a defence mechanism, so the presence of low chlorine concentration can actually increase alginate production and make the situation worse.

Rapid gravity and pressure sand filters behave as biofilters, but the high water flowrates and backwash regime results in an unstable system. Bacteria cells are constantly being scoured off the media. If insufficient bacteria are eroded, the biofilm will become unstable, anaerobic zones develop, and methane and hydrogen sulphide are produced. The filters can then dump a slug of bacteria and waste trapped in the biofilm back into the product water.
Sand filters will remove organic matter and solids from the water, but by acting as biofilters they also convert soluble nutrients back into organic matter in the form of bacteria cell biomass, which is then discharged back into the water supply. The bacterial cell biomass, alginates and waste products are now available to react with chlorine to form THM’s.

Conclusion

The mechanical filtration performance of rapid gravity and pressure sand filters are inherently unstable because the bacteria cell biomass is in a state of flux. The biofilm is resistant to chlorine, indeed if chlorine were used before a filter, the levels of THM’s and trichloramine would be substantially increased. The bacteria also coagulate the sand grains, which increases the backwash frequency and volume of water required to keep the sand clean.

Eventually the bacteria will cause channelling of water through the filter bed providing a conduit for the passage of oocysts and at the same time the filter will discharge bacteria and organics back into the product water which increases the THM level. In around 25% of the water supplies in the UK ammonium is added to the water after the sand filters to form mono-chloramine in an effort to prevent the chlorine forming THM’s.

All of the inherent problems of sand filters could be eliminated if biofouling of the sand is prevented. Unfortunately, this is neither easy nor practical for municipal drinking water systems. One possible solution is to use an alternative filter media that actively rejects biofouling, AFM is the first active filter media certified for treating drinking water that meets this criteria.

AFM (Active Filter Media) was developed with support from the European Commission under Life Environment. The organisations that were partners in the project or provided Dryden Aqua with trial sites include.

Scottish Water
Northumbrian Water
Suffolk & Essex Water
United Utilities
Thames Water
Entec