



# AFM<sup>®</sup> Activated Filter Media

## Instructions For Use document:

IFU Title	AFM® activated filter media
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- Drinking water from all sources; surface water and ground water
- Pre-treatment prior to membranes; freshwater and marine
- Swimming pools, private & public
- Aquaculture and public aquaria marine or freshwater
- Industrial process water
- Tertiary treatment of waste water

**AFM® is a direct replacement for sand in any type of sand filter**

**Operate your sand filter with AFM®, in accordance with this IFU document to double filter performance.**

**Reduce Risk**

**Future proof installations**

**Stable, Predictable performance**

**Scalable from a house to a city, from domestic to industrial**

**Quick return on investment < 3years\***

\*Data analysis by;

The Carbon trust and Oakdene Hollins consulting engineers

## Research & Development

AFM® is the product of more than 30 years of research and development by Dr. Howard T Dryden. The research was based on a PhD on aluminosilicate zeolitic sand clinoptilolite for the selective ion exchange filtration of recycled water for intensive closed (RAS) aquaculture systems. Sand rapidly biofouls and coagulates, which results in bio-dynamic instability of the sand bed followed by transient channelling of un-filtered water passing into the product water. This happens in all sand filters, and in aquaculture it will lead to fish mortalities. In drinking water, it leads to disease. AFM® (an activated filter media) was developed as a means of resolving the deficiencies incumbent with all sand filters. The technology is perfectly adapted to any type of sand filter or application, ranging from; drinking water to industrial process water. AFM® will improve performance, reduce risk and stabilise the systems, by providing a predictable repeatable and sustainable performance.

## Dryden Aqua guarantee statement

The performance of AFM® has been independently verified by IFTS, Dryden Aqua guarantee that after 10 years the performance of AFM® will be within 10% of the “as new performance” measured under ISO standard conditions. AFM® must be used in accordance to Dryden Aqua specifications.

There will be no reduction of performance or AFM® properties when the media is back-washed at a rate that fluidises the bed by a minimum of 20% for a period of 5 minutes or until the water runs clear. AFM® installed on systems 20 years ago is still performing to specification.

*Nicola Sturgeon, first minister for Scotland and Howard Dryden CEO of Dryden Aqua, in the AFM® production facility in Edinburgh*



## Key Points about AFM®

### Technical key points

- AFM® can double the performance of a sand filter, up to 100 times better at removing sub-5 micron particles
- AFM® Grade 1 is verified to achieve log 3 reduction (1000 times) down to 4 microns with no coagulation or flocculation
- Stable and predictable performance, AFM® is not subject to biodynamic instability and will never allow untreated water to pass through to the product water.
- No biofouling means greatly reduced Legionella risk from the filter
- Product water will have at least 50% lower chlorine oxidation demand than an equivalent sand filter, so lower concentration of disinfection by products including THMs
- AFM® is expected to last for the life of the filtration systems.

### Quality and certification

- AFM® is an engineered product manufactured to a precise specification under ISO9001-2008 conditions
- Certified under Reg31, NSF50 & NSF61, Environmental standards, Singapore Green Tick, HCAAP approved

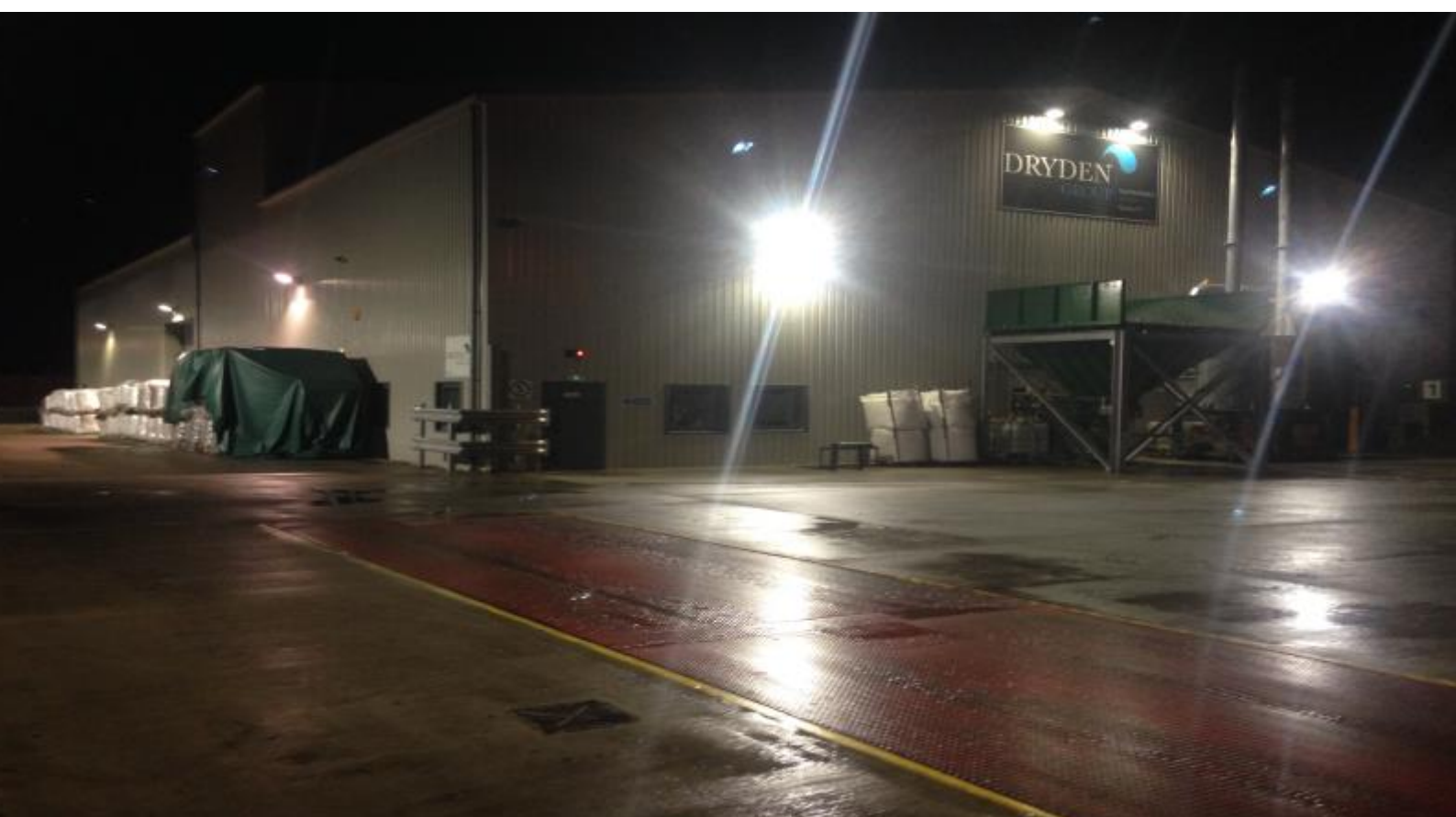


### Production facility and videos

Dryden Aqua has invested €8 million on a new AFM® production facility in 2014. View a video of our facility from our website at [www.DrydenAqua.com](http://www.DrydenAqua.com)

### Quote from Scottish Water

*Scottish Water tested AFM®, the results demonstrated significant performance advantage over sand in relation to suspended solids/iron removal and process efficiencies. I can also confirm that Scottish Water has been using AFM® for targeted effluent treatment for some 14 years with considerable success in the removal of solids and BOD reduction. Mark Haffey, R&D Technical Leader, Technology & Innovation Scottish Water*





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## 1. What is AFM®

AFM® is an amorphous alumino-silicate (glass) manufactured by up-cycling post-consumer green glass bottles in a dedicated factory designed and operated specifically for the production activated glass water filtration media.

The particle shape and size distribution are optimised for filtration. AFM® is not a passive filter media, the surface is activated by a SolGel like process, the surface structure of each grain of media is altered to control;

- surface area
- charge density
- catalytic properties
- molecular sieve properties

### Grades & Particle size distribution

The particle shape of AFM® is controlled to maximise surface area and to minimise pressure differential and bed lensing effects.

The particle size distribution is controlled to within very tight tolerances. We control the sphericity and uniformity coefficient of the grains to maximise particle filtration. While a high sphericity is beneficial for sand this is not necessarily the case for AFM®.

The higher the uniformity coefficient the better the filtration performance, but this increases the risk of bed compaction and lensing. AFM® is manufactured as opposed to quarried, the particle size distribution and shape can therefore be maximised to improve performance as a water filtration media.



## AFM® product specifications

Specification	grade 0	grade 1	grade 2	grade 3
<b>Particle size</b>	250 - 500 microns	0.4 to 1.0mm	1.0 to 2.0mm	2.0 to 4.0mm
<b>Undersized</b>	<5%	<5%	<10%	<10%
<b>Oversized</b>	<5%	<10%	<10%	<10%
<b>Effective size</b>	320 microns	0.46mm	1.3mm	2.6mm
<b>Hardness</b>	>7 mohs	>7 mohs	>7 mohs	>7mhos
<b>Sphericity</b>	>0.7	>0.7	>0.7	>0.7
<b>uniformity coefficient</b>	1.5 to 1.7	1.5 to 1.7	1.5 to 1.7	1.5 to 1.7
<b>aspect ratio</b>	2 – 2.4	2 - 2.4	2 - 2.4	2 - 2.4
<b>organics</b>	<50g/tonne	<50g/tonne	<50g/tonne	<50g/tonne
<b>Colour</b>	>95% green	>95% green	>95% green	>95% green
<b>specific gravity (grain)</b>	2.4kg/l	2.4 kg/l	2.4 kg/l	2.4 kg/l
<b>Embodied energy</b>	<72kw/tonne	<65kw/tonne	<50 kw/tonne	<50 kw/tonne
<b>Bulk bed density</b>	1.28 kg/l	1.25 kg/l	1.23 kg/l	1.22 kg/l
<b>Attrition, 50% bed expansion 100 hours backwash in water</b>	<1%	<1%	<1%	<1%

## Chemical Composition by % (all grades)

Composition (oxides)	Percentage +/- 10%	Composition (oxides)	Percentage +/- 10%
Silica	72	Calcium	11
Magnesium	2	Lanthanum	1
Sodium	13	Cobalt	0.016
Aluminium	1.5	Lead	<0.005
Antimony	<0.001	Mercury	<0.0005
Arsenic	<0.0001	Titanium	<0.1
Barium	0.02	Rubidium	<0.05
Cadmium	<0.0001	Iridium	<0.05
Chromium	0.15	Platinum	<0.0001
Inorganic undefined	<0.0005	Organic undefined	<0.0005

There will be no metal ion leaching between pH4 and pH10, indeed AFM® will adsorb heavy metals and release on back-wash, AFM® provides drinking water and food security.



## Chemical tolerance

### Oxidising agents

AFM® may be exposed to high concentration of oxidising agents

pH range	pH 4 to 10
Hypochlorous	10 g/l
Chlorine dioxide	10 g/l
Ozone	10mg/l
Hydrogen peroxide	10 g/l

### Acids and alkali

AFM® is stable over a wide range of pH conditions, but strong acids and caustic conditions should be avoided

pH range,	pH4 to pH10
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### Salinity & TDS

Salinity and high TDS concentrations have no chemical effect on AFM®. AFM® is used for marine applications with up to 40g/l salinity and for many systems up to 100 g/l.

Salinity / TDS range	0 to 100 g/l
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### Temperature

AFM® is not affected by temperature, as long as the water is liquid then AFM® may be used.

Temperature range	0 to 100 deg C
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### Water quality

AFM® is chemically resistant to all;

solvents  
oxidising agents  
hydrocarbons.

## 2. Product packaging and delivery

AFM® is packaged in a fully automated factory at Dryden Aqua. AFM® is packaged in sealed plastic sacks and printed with the appropriate product identification and tracking information.

### Packaging

AFM® is supplied in bags of the following size:

- a. 1000 kg bags with bottom discharge.
- b. 25 kg plastic bags & 21.5 kg sacks.
- c. 11.4 kg plastic bag.

### Delivery

AFM® is delivered in multiples of 1 tonne pallets, normally in full truck loads of 24 tonnes or in container loads of 20 tonnes

### AFM® robotic bagging system





## Bags and Labelling

Each bag is printed during packaging with the following information:

1. Lot batch number.
2. Size Grade.
3. Uniformity coefficient.
4. Effective particle size.

## Product codes

	Product order codes			
	Grade 0	Grade 1	Grade 2	Grade 3
	0.25 to 0.50mm	0.40 to 1.0mm	1.0 to 2.0mm	2.0 to 4.0mm
AFM® 11.4 kg sack	10020	10021	10022	10023
AFM® 21 kg sack	10030	10031	10032	10033
AFM® 25 kg sack	10000	10001	10002	10003
AFM® 1 tonne	10010	10011	10012	10013

When supplied in 1000kg tope bags, a label will be connected to each bag to provide the same information as the plastic bags.

The largest swimming pool in Scandinavia, on full AFM® system



### 3. Filling filters and commissioning

#### Disinfection of AFM®

During the manufacturing process of AFM® it is exposed on two occasions to temperatures over 1000°C. The product is cleaned and sterilised and heavy metals and organics are reduced to less than 50ppb (parts per billion). All production takes place in a secure building and the product is always protected.

#### Dust

AFM® has a very low dust content, however when a product is moved some dust may be generated. Silica sand contains free silica and a mineral called Tremolite, which is a form of Asbestos. The dust from silica sand can be harmful to health and exposure to dust must be avoided, it is for this reason that silica sand is not permitted for use in sand blasting.

All dust is dangerous; however, AFM® dust contains no “free silica” and it does not contain any toxic minerals. From a Health & Safety perspective, handling AFM® is much safer than sand. However, all the usual precautions should be taken when handling the material, especially in confined spaces. Appropriate breathing apparatus should be used.

#### Old packaging

AFM® is packaged in carbon neutral plastic bags; the used bags must be recycled or disposed of in a responsible manner. Plastic is dangerous and must not be allowed to pollute the environment and harm animals. For more information visit [www.GoesFoundation.com](http://www.GoesFoundation.com)

**At Dryden Aqua we are marine biologists, keeping marine mammals and fish alive and healthy defines the high standard and water quality of AFM® water treatment**





## Filter bed depth and type of filter

The depth of the filter bed is a function of the filter design; it is always best to use filters in compliance with the German DIN standards. However, this is not always the situation, especially with small filters or horizontal filters.

Filter bed depth may range from 300mm to 3000mm, if the filter complies to DIN will have a bed depth from 1200mm to 1400mm. AFM® may be used in any type of sand filter design including:

1. Vertical pressure filters.
2. Horizontal pressure filters.
3. RGF rapid gravity filters.
4. Moving bed sand filters with vertical up-flow or down-flow mode.

There will be a variation in quality and performance of different types and manufacturers of sand filters. It is always best to use filters in compliance to DIN standard or from a reputable manufacturer. Regarding performance, vertical filters are better than horizontal filters, and filters with a nozzle distribution plate are preferred over laterals.

**Squares Pharmaceuticals in Dhaka Bangladesh. AFM® treats all the water prior to the RO membranes. AFM® replaces, Sand filters, carbon filters & 5 micron and 1 micron cartridge filters**





## Transferring the AFM® to the filter

AFM® may be transferred manually to the filters by emptying the plastic bags, or 1 tonne big bags into the filter in accordance with the procedure below.

AFM® may alternatively be transferred to filters from a bulk tanker using water. Under no circumstances use compressed air or transfer the AFM® in a dry condition. Under high air pressure and at high velocities, the AFM® would damage the transfer hose which would cause contamination of the product.

## How to fill Pressure filters

In all cases, it is essential that the filters are on a level concrete pad or plinth, and that the valve manifold and pipework is supported to prevent any stress on the filter flanges.

Before the first layers of filter media are introduced via the top access port, it is best to half fill the filter with water. This helps to prevent damage to the laterals or the nozzle distribution plate by the falling media.

For filters with a side manhole, open the bags and gently empty the first layer onto the base of the filter bed. The larger grades are added first, grade 3 for filters over 1m in diameter, and grade 2 for filters 1m and smaller in diameter. See Table 1.

For horizontal filters, we also recommend grade 3 on the base of the filter up to a point that is level with the laterals.

After the addition of each layer it is important to make sure the media is evenly distributed and the bed is flat. Once all the media is in place, perform a backwash in accordance to Table 3.

After the back-wash, inspect the bed, there may be fines on top of the bed. Carefully skim the top off the filter bed to remove the fines and any other debris that may be present that could interfere with filtration performance. With AFM® this is rarely required, but with a new installation there could be debris such as plastic shavings from the pipework and filter installation.

Once the filter bed has been skimmed, refit the filter lid and backwash for a period of 5 minutes, or until the water runs clear. After the back-wash, place the filter on a rinse phase for 2 minutes. Once the rinse phase has completed and if there is sufficient water, repeat the backwash and rinse phase for a third time. The bed is now ready for service, however before going on-line with a drinking water network it is good practice to conduct an analysis of the water in accordance with Annexe 1.

## Anthracite and multi-layer beds

Anthracite or activated carbon may be used with AFM®, the choice of media depends upon the application of the AFM®. Table 1, provides details on the use of anthracite with AFM® grade 0 and grade 1.

Grade 0 AFM® provides an exceptional performance in mechanical filtration of water. Grade 0 can also be used to treat water with a heavy load of solids, or it can be combined with coagulation and flocculation. Under these conditions it is necessary to use a layer of anthracite on top of the AFM® grade 0 bed to protect the media and to provide a longer run phase cycle between back-washes

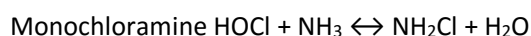
## Activated carbon

AFM® is used with activated carbon in combination with chlorine or other oxidising agents, the filter bed will usually be grade 1 AFM® with a 50mm to maximum 100mm layer of activated carbon. It is very important not to use any more than 100mm of activated carbon, to prevent the carbon from becoming a biofilter. A small amount of activated carbon works well as a catalyst, but any more than 100mm could start to cause issues resulting from biofouling of the carbon

The following reactions will take place on the surface of the activated carbon. In the first stage the hypochlorous will oxidise the surface of the carbon for form very active CO\* sites. By this mechanism, activate carbon will remove some of the hypochlorous from the water.



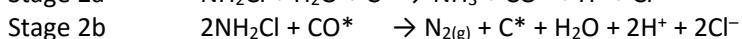
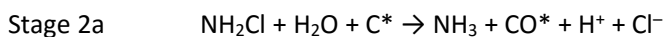
The chlorine will also react with chemicals in the water such as ammonium to form inorganic chloramines such as monochloramine, and organic matter to form organic chloramines.



In addition to monochloramine, other inorganic chloramines including;

- dichloramine and trichloramine, but this is a function of pH and water chemistry.
- Organic chloramines, formed by reaction with protein and amino acids.

The mechanism by which chloramines are catalytically oxidised by activated carbon in the presence of chlorine are as follows;



The end products will be nitrogen gas, hydrochloric acid and water as well as carbon dioxide with organic matter.

AFM® works very well as a support for activated carbon, and if any bacteria are released as floc, the AFM® will capture and prevent their release into the product water. AFM® is used in combination with carbon for indoor swimming pool water treatment to reduce the combined chlorine concentration and as a mechanical support with BACs drinking water systems to reduce the risk to the distribution network

### Notes.

*Filters from different manufacturers will have different dimensions. With regards to filters that have a lateral arrangement. In general, for filters under 1m in diameter, AFM® grade 2 is used to fill the space and cover the laterals to a depth of at least 50mm. In filters larger than 1m diameter, grade 3 should be used to fill the space below the laterals. The remainder of the bed is then made up with grade 2, 1 & 0 in accordance to the percentages given in the Table 1.*

## Vertical Pressure Filters, media ratios

The make-up of the pressure filter bed depends upon the size of the filter and configuration of the base, there are four options.

1. Filters under 1m diameter with laterals.
2. Filters under 1m diameter with nozzle plate.
3. Filters over 1m diameter with laterals.
4. Filters over 1m diameter with nozzle distribution plate.

Anthracite may be used on top of the AFM® to extend the run phase cycle and allow the AFM® to cope with high loadings of solids. Activated carbon may be used for dechloramination, removal or other applications discussed in next section.

**Table 1. Vertical pressure filters;** AFM® filter bed depths as a percentage for each grade for Vertical pressure and gravity flow Filters, bed depth may range from 600mm to 1400mm

	Grade 3	Grade 2	Grade 1	Grade 0	anthracite	Back-wash velocity
<b>With (or without) flocculation, Pressure &amp; RGF filters</b>						
<i>Pressure filters, under 1m Ø with laterals</i>	0%	20%	80%	0%		>45m/hr
<i>Pressure filters under 1m Ø with nozzle plate</i>	0%	10%	90%	0%		>45m/hr
<i>Pressure filters over 1m Ø and RGF filters with laterals.</i>	10%	10%	80%	0%		>45m/hr
<i>Pressure filters over 1m Ø with nozzle plate &amp; RGF filters with nozzles or screened floor</i>	0%	10%	90%	0%		>45m/hr
<b>AFM® grade 0 multi-layer with anthracite Back-wash at &gt;20m/hr velocity</b>						
<i>Pressure filters under 1m Ø with nozzle plate</i>	0%	10%	0%	70%	20% 0.6 to 1.18mm	>20m/hr
<i>Pressure filters over 1m Ø with nozzle plate &amp; RGF filters with nozzles or screened floor</i>	0%	10%	0%	70%	20% 0.6 to 1.18mm	>20m/hr
<b>AFM® grade 1 multi-layer with anthracite Backwash at &gt;45m/hr velocity</b>						
<i>Pressure filters under 1m Ø with nozzle plate</i>	0%	10%	70%	0%	20% 1.18 to 2.5mm	>45m/hr
<i>Pressure filters over 1m Ø with nozzle plate &amp; RGF filters with nozzles or screened floor</i>	0%	10%	70%	0%	20% 1.18 to 2.5mm	>45m/hr
<b>No flocculation, Pressure &amp; RGF filters</b>						
<i>Pressure filters, under 1m Ø with laterals</i>	0%	20%	60%	20%		>45m/hr
<i>Pressure filters under 1m Ø with nozzle plate</i>	0%	10%	70%	20%		>45m/hr
<i>Pressure filters over 1m Ø and RGF filters with laterals.</i>	10%	10%	60%	20%		>45m/hr
<i>Pressure filters over 1m Ø with nozzle plate &amp; RGF filters with nozzle plate</i>	0%	10%	70%	20%		>45m/hr
<b>AFM® grade 0 optimised filters</b>						
<i>Grade 0 optimised filters, pressure filters under 1m Ø with laterals</i>	0%	20%	10%	70%		>20m/hr
<i>Grade 0 optimised filters, pressure filters under 1m Ø with nozzle plate</i>	0%	10%	10%	80%		>20m/hr
<i>Grade 0 optimised filters, pressure filters over 1m Ø with laterals</i>	10%	10%	10%	70%		>20m/hr
<i>Grade 0 optimised filters, pressure filters over 1m Ø with nozzle plate and RGF filters</i>	0%	10%	10%	80%		>20m/hr

## Horizontal Pressure filter, media ratios

Horizontal pressure filters provide more filter bed surface area at a lower cost than vertical pressure filters. However the bed depth is usually lower, and because the bed depth varies across the diameter of the filter, there is a variable water pressure gradient across the bed. The distance water travels through the filter bed from the outside is greater than the distance from the centre of the filter to the under drains. The greater the distance the water travels, the greater the pressure drop. This means the flow rate down through the centre of the filter bed will be faster when compared to the side of the filter bed.

The differential flow of water through a horizontal filter leads to rapid biofouling of sand down the sides of the filter. When the filter is placed in backwash the same situation happens in reverse, preferentially most of the water goes up through the centre of the filter bed. This in turns means that more organic matter and food for bacteria remain in the sand bed down the sides, which servers to accelerate the rate of biofouling and bed compaction.

Horizontal sand filters have the advantage that you get a lower cost filter for the surface area, but when used with sand, performance may be seriously sacrificed. When AFM® is used in horizontal pressure filters, the biofouling, bed compaction and channelling problems are solved, because AFM® resists biofouling and is much easier to backwash than sand.

**Table 2. Horizontal pressure filters;** AFM® filter bed depths as a percentage for each grade for Horizontal Filters. Bed depth may range from 300mm to 1400mm

	<b>Grade 3</b>	<b>Grade 2</b>	<b>Grade 1</b>	<b>Grade 0</b>	<b>anthracite</b>	<b>Backwash velocity</b>
<b>With or without flocculation</b>						
<i>lateral under-drain filter</i>	20%	10%	70%	0%		>45m/hr
<i>with nozzle plate</i>	0%	10%	90%	0%		>45m/hr
<i>lateral under-drain filter</i>	20%	10%	10%	40%	20% 0.6 to 1.18mm	>20m/hr
<i>nozzle plate filters</i>	0%	10%	10%	50%	20% 0.6 to 1.18mm	>20m/hr
<i>lateral under-drain filter</i>	20%	10%	50%	0%	20% 1.18 to 2.5mm	>45m/hr
<i>nozzle plate filters</i>	0%	10%	60%	0%	20% 1.18 to 2.5mm	>45m/hr
<b>Without flocculation</b>						
<i>lateral under-drain filter.</i>	20%	10%	50%	20%		>45m/hr
<i>nozzle plate filters</i>	0%	10%	70%	20%		>45m/hr
<b>Grade 0 optimised filters</b>						
<i>lateral under-drain filter</i>	20%	10%	10%	60%		>20m/hr
<i>nozzle plate filters</i>	0%	10%	10%	80%		>20m/hr



## Horizontal pressure filters





## Rapid Gravity filters media ratios

### How to fill an RGF filter with AFM®

Prior to placement of the filter tests for water retention must have been completed satisfactorily. Backwash pump functional tests should have been completed. If this is not possible before one filter is operational then it is preferable that only one filter be charged with media. However, circumstances may not always permit such an ideal sequence.

The filter and associated filtered water ducts and channels, pipes and clean wash water tank must be physically clean and free from loose dirt and other extraneous matter especially polystyrene from form work and plastic wrapping materials. Ideally, the filter should be vacuum cleaned especially if the discharge arrangement from the filter has fine slots or nozzles.

The filter bed is prepared in the same way as if sand was being used as the filter and / or support material. However, less AFM® Grade 1 (by weight) is required compared to sand due to the lower bulk density of AFM® Grade 1.

AFM® Grade 1 (0.40 – 1.00mm) is used to replace 16/30 sand.

The walls of the filter should be marked with the levels of each layer and on larger filters suitable gauge sticks may be erected. The expected quantities of material for each layer should be calculated and included in the method statement. Table 3 provides the recommended percentages of the different grades of media. The various layers will be levelled off with levelling boards or raked level to levelling strings. The levels should be marked in a waterproof medium to withstand submergence during the first backwashes.

Each support layer should be protected after placing and walking boards used for access. Footprints cause compaction of the support layers and can cause mal-distribution during backwashing. Local humps act as trigger sites for boiling and spouting.

Support layers should preferably be lowered on to a board within the filter and then spread. They should not be tipped over the side, particularly on exposed lateral floors where the laterals can be displaced. Tipping over the side can also displace previously installed layers. The support layers do not expand during a back-wash and should be laid to design depth.

The working layer (grade 1 or grade 0) should also be placed carefully to avoid displacement of the top support layer. If the working layer is to be delivered by hose (only with water) the hose should be kept off the top of the previous layer. After this layer, has been placed the situation is less critical. Walking on the working layer after 150mm has been placed is of less concern if the bed is dry. The working layers need not be levelled accurately. The backwash procedure will perform this task. The working layers should be left short by 20% of the design depth to accommodate room for bed expansion during back-wash.

Do not charge second or third layers in multimedia filters until the lower layers have been washed and skimmed.

## RGF Bed Conditioning Procedures.

**Do not air scour AFM® rapid gravity filters!** Air will displace the support grades and will not be reclassified during a back-wash.

The first step, unless the material was placed into a flooded filter, is to gradually initiate a backwash. If the media shows signs of floating allow it to stand for a few hours or overnight with the water level below the wash out cill.

Raise the backwash rate to the maximum design value over a period of 60 to 90 seconds, and continue until the water clears. Skim off any extraneous material. The wash can then be repeated with air scour as per the intended procedure.

In cases where there is no water available until the first filter has been commissioned then the first filter in the freshly charged condition may be allowed to filter slowly before the first wash but this is a last resort dispensation and may cause some penetration of fines in to the under drain. Temporary arrangements to fill the clean wash water tanks are recommended in this case.

After 3 back washes, skim the surface of the filter to remove fines. The process should be repeated until no further accumulation occurs.

Only after this state has been reached should any additional layers be placed. The washing / skimming procedure will need to be repeated with the second (and third) layer.

After washing and skimming, the material level in the filter may require adjustment. It can be quicker to transfer washed material from another filter so that only one bed must be rewashed and skimmed after further topping up. The designated level of the material is attained after washing, when the filter is ready for service. The support layers do not expand and settle.

The final bed should be sampled in depth to ensure that the size grading is as intended. Surface layers will tend to be finer than deeper layers and a composite sample is necessary unless a combined air/water wash is used.

A filter should not be placed on-line within the network until the product water has been tested for compliance with water quality parameters detailed in annexe 1.

### Rapid gravity filter

**Table 3. Rapid Gravity Filters** AFM® filter bed depths as a percentage for each grade for Horizontal Filters, Bed depth may range from 300mm to 1400mm



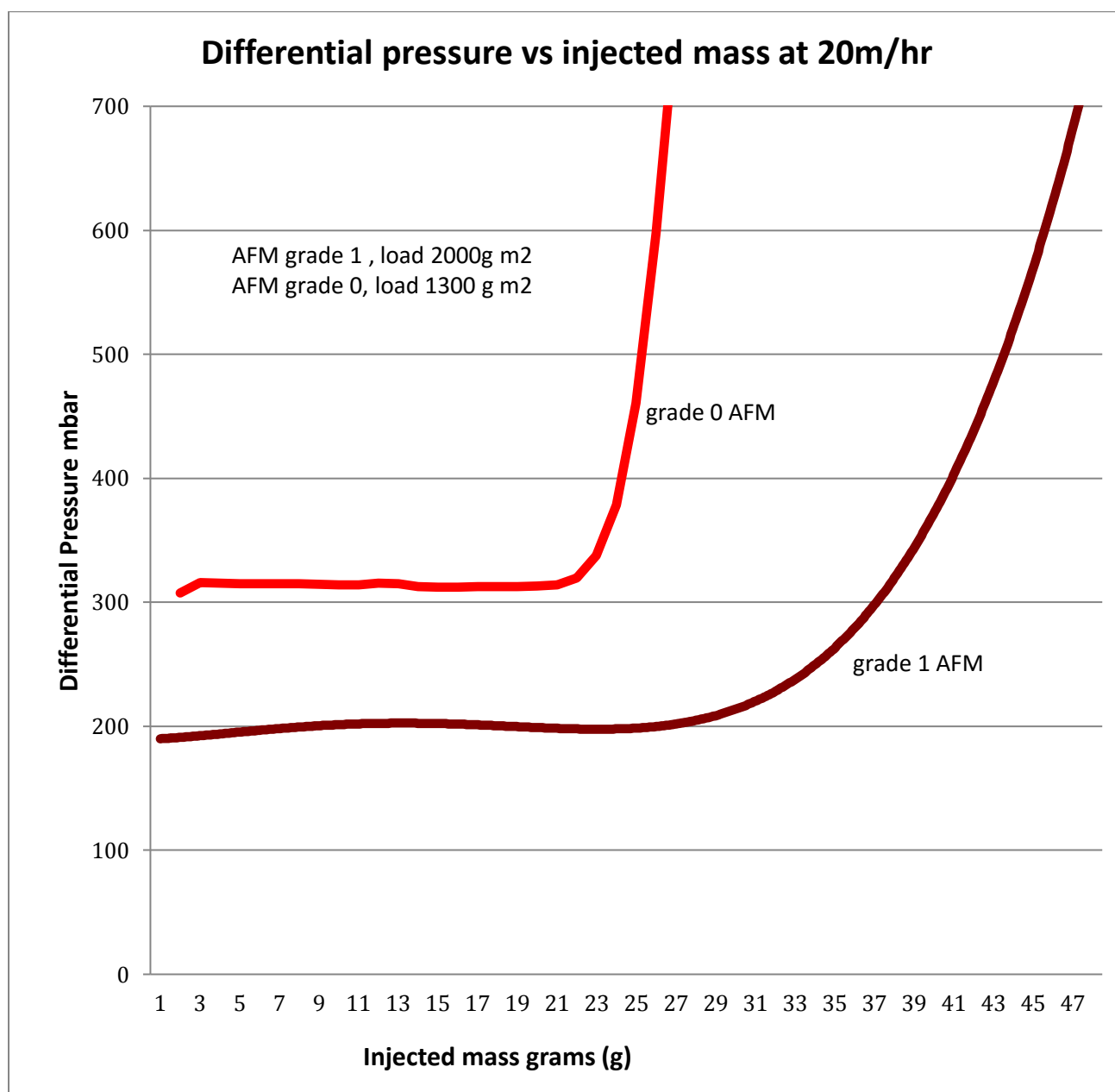
	Grade 3	Grade 2	Grade 1	Grade 0	anthracite	Backwash velocity
<b>With or without flocculation</b>						
<i>lateral under-drain filter</i>	10%	10%	80%	0%		>45m/hr
<i>with nozzle plate</i>	0%	10%	90%	0%		>45m/hr
<i>lateral under-drain filter</i>	10%	10%	10%	50%	20% 0.6 to 1.18mm	>20m/hr
<i>nozzle plate filters</i>	0%	10%	10%	50%	20% 0.6 to 1.18mm	>20m/hr
<i>lateral under-drain filter</i>	10%	10%	60%	0%	20% 1.18 to 2.5mm	>45m/hr
<i>nozzle plate filters</i>	0%	10%	60%	0%	20% 1.18 to 2.5mm	>45m/hr
<b>Without flocculation</b>						
<i>lateral under-drain filter.</i>	10%	10%	60%	20%		>45m/hr
<i>nozzle plate filters</i>	0%	20%	60%	20%		>45m/hr
<b>Grade 0 optimised filters</b>						
<i>lateral under-drain filter</i>	10%	10%	10%	70%		>20m/hr
<i>nozzle plate filters</i>	0%	10%	10%	80%		>20m/hr

## 5. Run phase differential pressure

AFM® is a mechanical filter; the primary function is to remove solid particles from the water. AFM® gives exceptional performance and can remove 99.93% of all particles down to 3 microns using grade 0 AFM® at 2m/hr filtration velocity (IFTS verified). AFM® can be used to treat potable clean water as well as municipal waste water or industrial water.

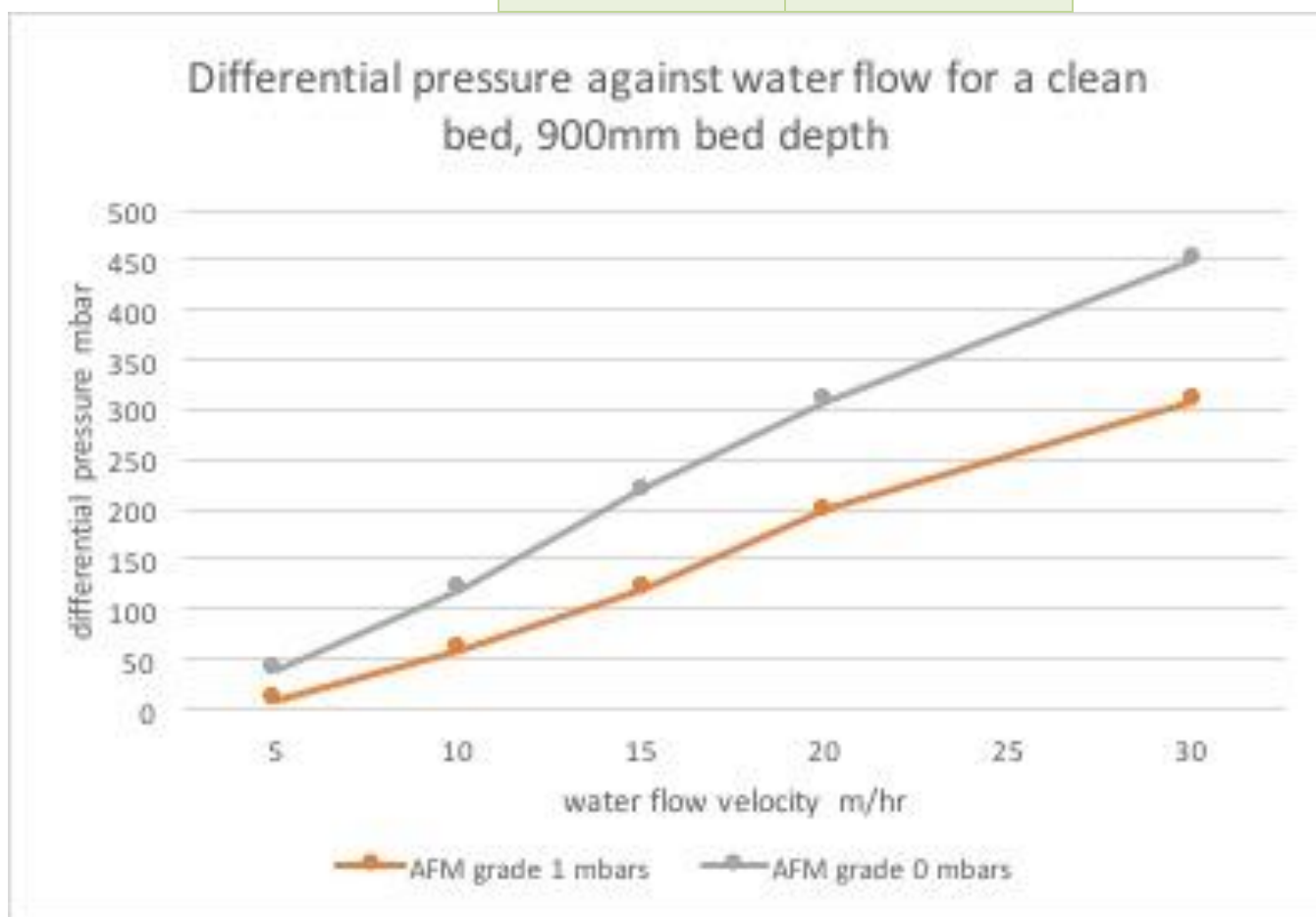
AFM® will be exposed to high concentrations of solids; the limitation is related to rate of change of pressure and the back-wash frequency. AFM® should be back-washed when the pressure differential reaches 0.5 bar, or after a period of 1 week. The run phase should not be continued for more than 1 week, without a back-wash.

The following graphs presents the run phase delta P across the bed at 20m/hr, and the mass of solids removed by the AFM®. The loadings relate to engineered particles; in practical applications, the loading rate may be greater or less than 2 kg and 1.3kg for grade 1 and grade 0 respectively. The loading capacity will relate to the size of the particles and their mechanical properties



**Differential pressure against water flow for a clean bed,  
900mm bed depth**

m/hr	AFM® grade 1	AFM® grade 0
	mbars	mbars
5	10	40
10	60	120
15	120	220
20	200	310
25		
30	310	450





## 6. Suspended solids loading capacity

In practical terms the shortest back-wash frequency for grossly polluted waste water, industrial water or for a river in spate conditions is likely to be in the region of 4 hours. Taking 4 hours as the shortest back-wash frequency the maximum solids load capacity is given in the following table.

**Maximum SSmg/l suspended solids concentration for AFM® filtration**

<b>Water flow velocity m/hr</b>	<b>grade 1</b>		<b>grade 0</b>	
	<b>AFM®</b>	<b>AFM® + 300mm anthracite</b>	<b>AFM®</b>	<b>AFM® + 300mm anthracite</b>
	<b>mg/l SS</b>	<b>mg/l SS</b>	<b>mg/l SS</b>	<b>mg/l SS</b>
<b>5</b>	100	400	65	250
<b>10</b>	50	200	32	120
<b>15</b>	33	120	22	80
<b>20</b>	25	100	16	60
<b>25</b>	20	80	13	50
<b>30</b>	16	60	10	40

### Anthracite depth filtration

Anthracite may be used on top of the filter bed to increase solids load or run phase duration. AFM® is a fine polishing filter media perfect for the removal of sub 20 micron particles. For heavy loads of solids above 20 microns, then a 100mm to 300mm layer of anthracite is a good solution.

Grade 1 AFM®            1.18 to 2.5mm anthracite  
Grade 0 AFM®         0.6 to 1.18mm anthracite

The anthracite may increase the loading

### Turning off and starting up a media bed filter

AFM® media bed filters should be operated continuously; they must never be stopped or allowed to go anaerobic. If the filters must be turned off for a protracted period, the following procedure should be used prior to start up.

### Decommissioning and commissioning a filter

Prior to turning off an AFM® filter it should be given a standard backwash with clean water. After the backwash as much water should be drained off from the filter as possible.

Prior to going back-online, backwash the filter for a period of 5 minutes at a water flow rate that gives a 20% bed expansion followed by a rinse phase for 10 minutes. Repeat the backwash and rinse phase for a 2<sup>nd</sup> and 3<sup>rd</sup> time prior to going back on-line.

## 7. Run phase filtering water, performance of AFM® & sand

The fine particle retention performance of any media bed is inversely proportional to the velocity of water passed through the filter. It is always best to operate the filter at the slowest possible flow rate to maximise performance. This is particularly important for drinking water, especially when there may be a high concentration of cryptosporidium oocysts.

Different filtration media and sand from different countries / deposits will have a different performance. This is a function of particle size distribution, sphericity, chemical composition and uniformity coefficient. Typically, RGF filters operate at 6m/hr and pressure filters at 12m/hr. AFM® filters should be operated under the same conditions, however when possible, slow the flow rate down to the slowest practical rate.

The flow rate for an AFM® filter depends upon the design of the filter and the application. For most RGF and pressure filters the filtration velocity should be below 12m/hr. This equates to a water flow rate of 12m<sup>3</sup>/hr of water, for every 1m<sup>2</sup> of filter bed surface area. RGF filters will be operated at a slower flow rate due to pressure head limitations, typically the water flow velocity should be 6m/hr.

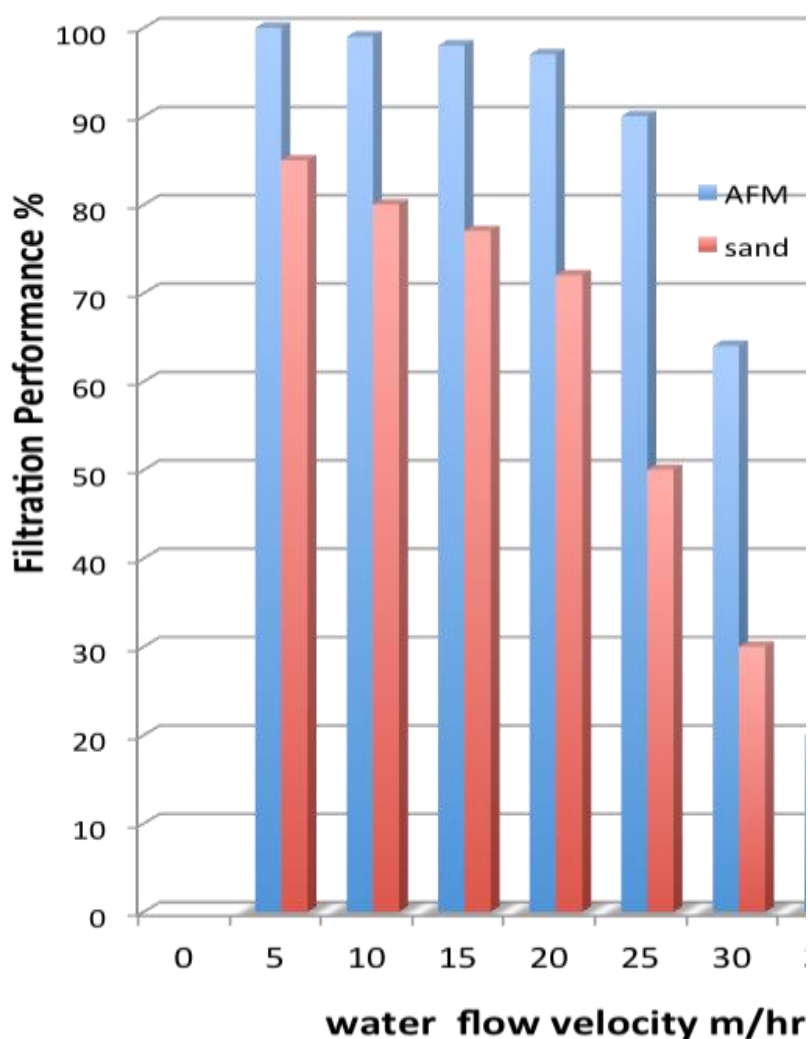
### AFM® an Activated Filter Media



The following graph demonstrates the relationship between 16 x 30 grade sand and grade 1 AFM® at different flow velocities. By way of example, if we take a water flow velocity at 30m/hr, sand will remove 30% of all particles down to 5 microns. The sand used was Leighton Buzzard sand from England, which is an exceptionally high quality sand. Other types of sand are likely to have an inferior performance.

If the flowrate is reduced from 30m/hr to 20m/hr, the 30% reduction in water flow results in more than 100% improvement in the performance. It is therefore a false economy to operate filters at too high a water flow.

#### Filtration performance in removal of 5 micron particles at different filtration velocities



## Recommended and maximum run phase water flow for different applications using AFM®

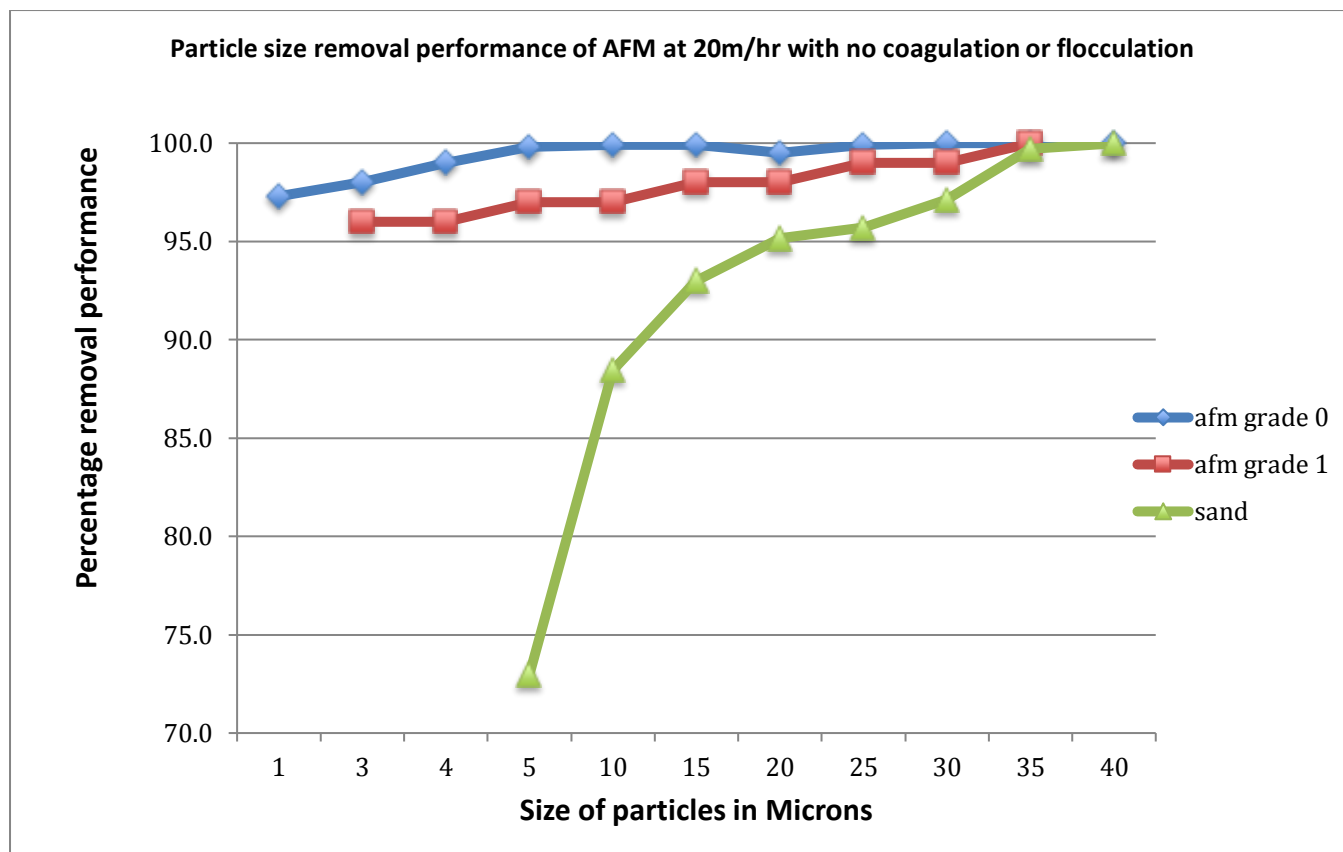
**Table 3. Run phase water flows for different applications**

	Recommended Run phase water flow m/hr	
	Pressure	Gravity flow & Moving bed
<b>Drinking water</b>		
Recommended water flow	<10	<5
Maximum water flow	<20	<15
<b>Municipal wastewater</b>		
Recommended water flow	<5	<5
Maximum water flow	<15	<10
<b>Aquaculture and Aquaria</b>		
Recommended water flow	<20	<5
Maximum water flow	<30	<10
<b>Swimming pools</b>		
Recommended water flow	<20	<10
Maximum water flow	<30	<20
<b>Process water (examples)</b>		
Borehole water treatment for ferric, manganese and arsenic	<10	<5
Treatment prior to membranes	<15	<10
Cooling towers	<20	<10

## Filtration performance and grade of filter media

The standard grade of filter media used in most pressure and RGF filter is a sand of 16 x 30 mesh size, AFM® grade 1 is equivalent to this grade of sand. However, because AFM® does not biofoul this gives the opportunity to use a much finer grade of media, grade 0 which has a particle size distribution 0.25 to 0.50mm. This is half the size of 16 x 30 sand and grade 1 AFM®.

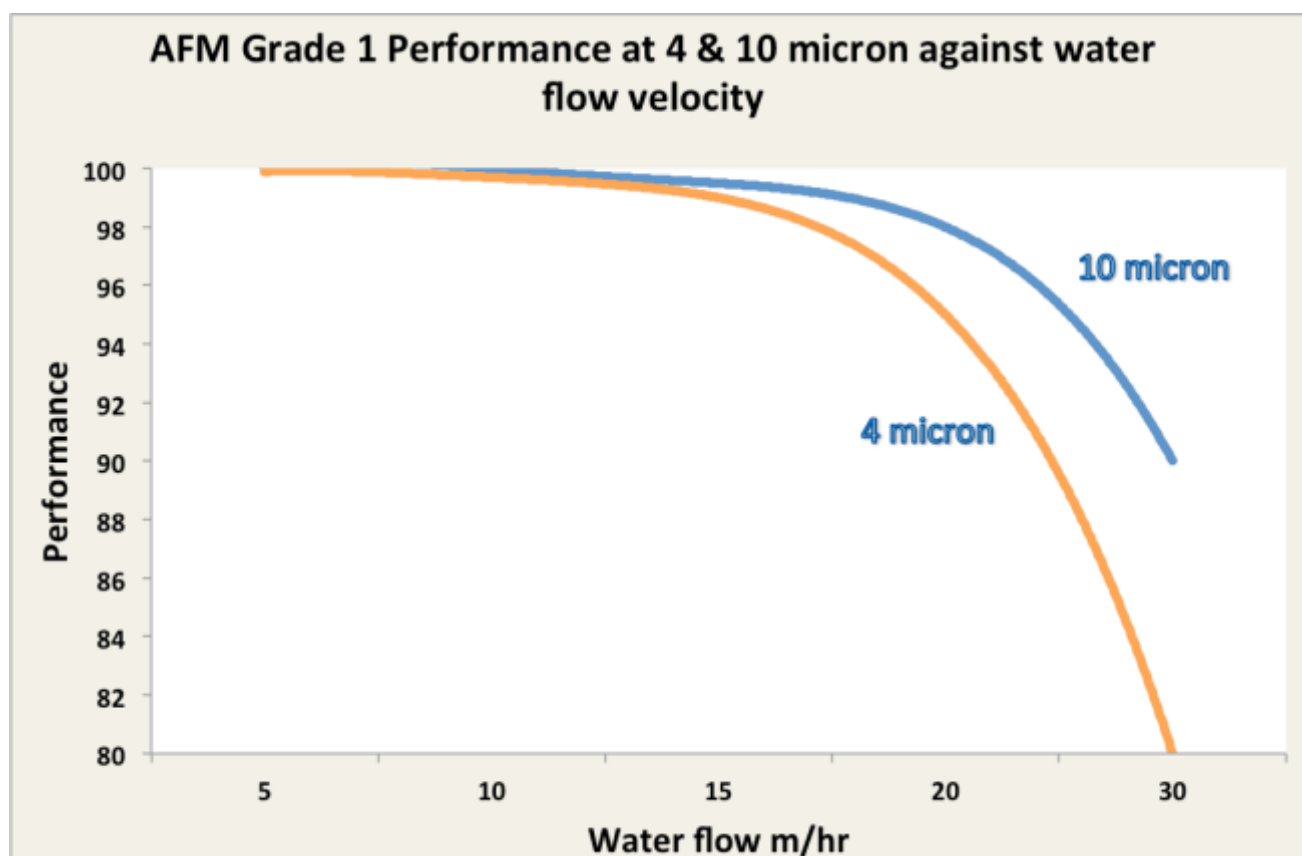
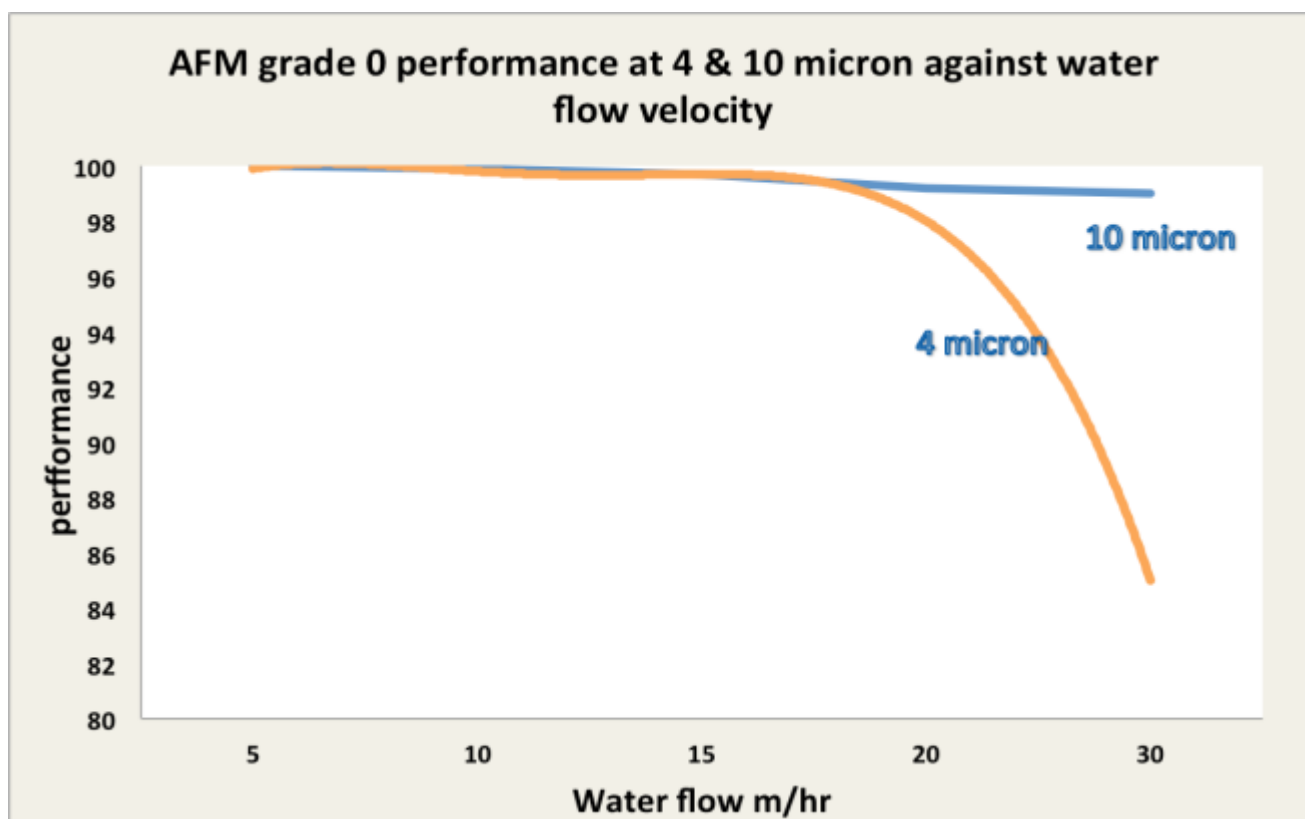
At a flow velocity of 20m/hr, sand removed 73% of all 5 micron particles. Grade 1 AFM® removed 97% and grade 0 removed more than >99.9%

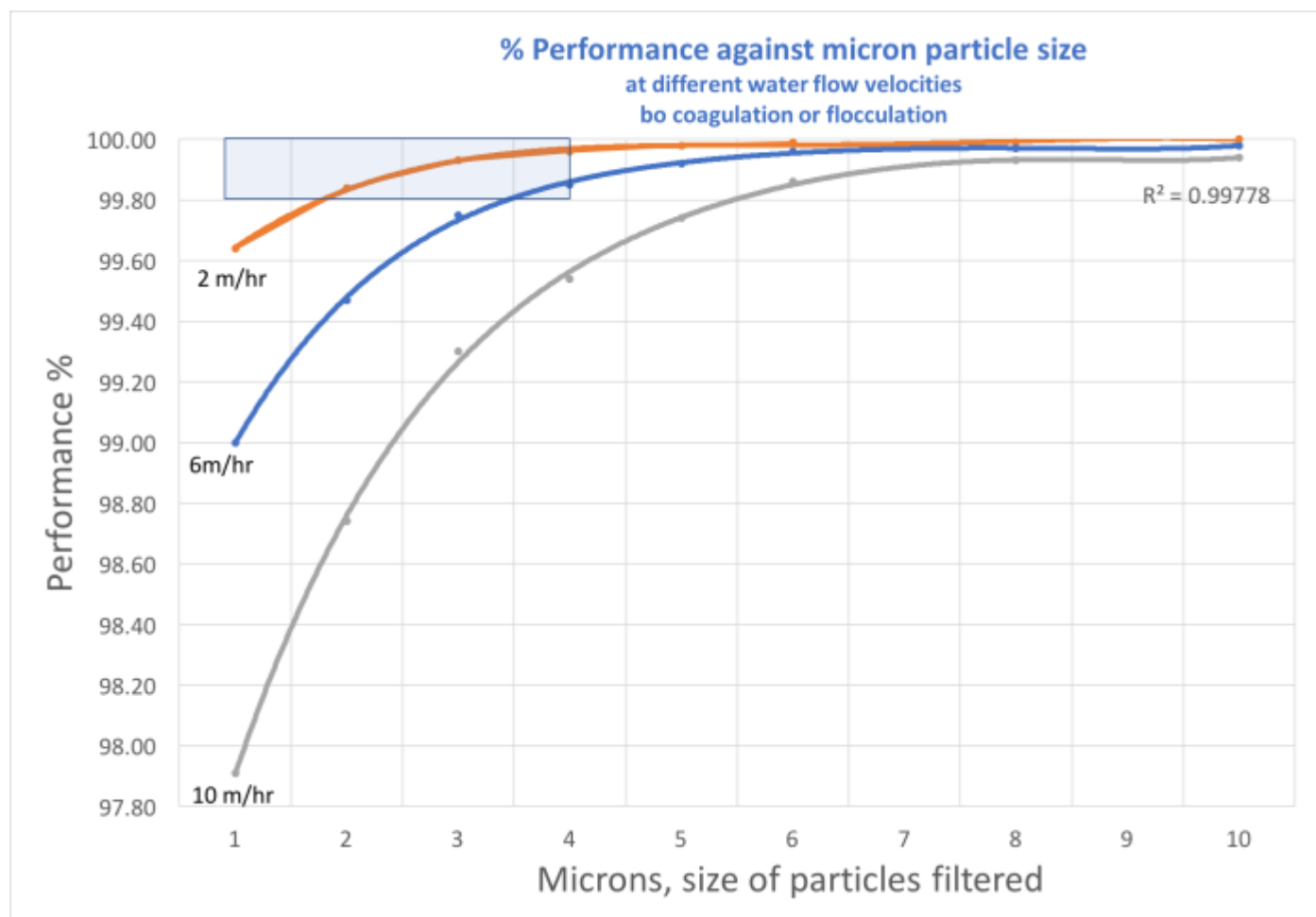
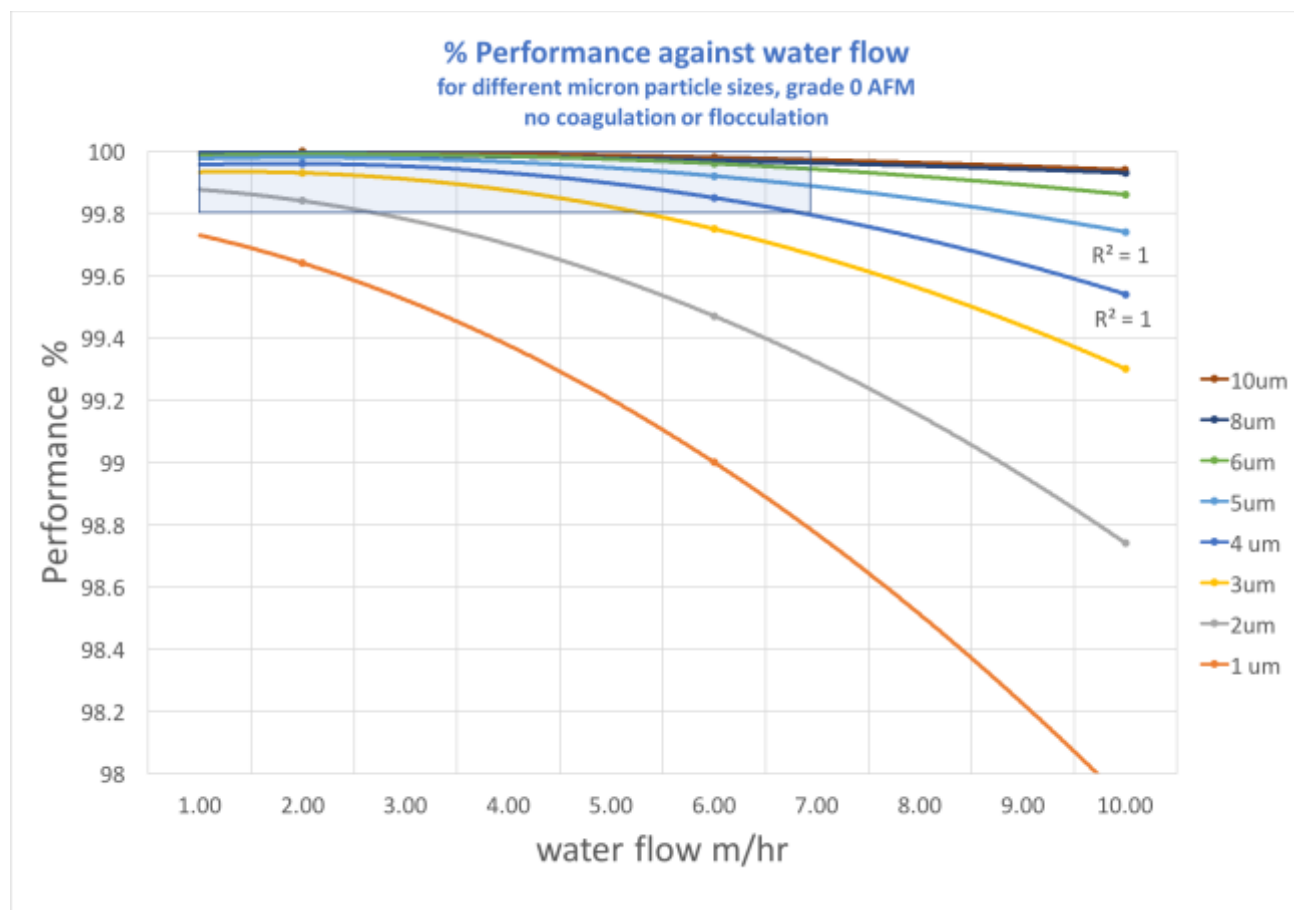




## AFM® grade 0 and grade 1 filtration performance at different water flow for 4 and 10 micron particles.

The following two graphs show the performance of grade 0 and grade 1 AFM® and the influence of water flowrate on filtration performance over the range 5 to 30m/hr filtration velocity. The performance is then examined in more detail for velocities between 2m/hr and 10m/hr with grade 0.





## AFM® grade 0 Performance.

All the data for AFM® has been established without the application of coagulants or flocculants. It is important to note that AFM® grade 0 can be used as an effective Cryptosporidium oocysts barrier at water flows of 2m/hr with a 900mm bed depth.

When AFM® is combined with coagulation and flocculation using PAC (polyaluminium chloride) or Polyamide cationic flocculants, the performance and ability to remove cryptosporidium oocysts at 5 microns and sub 1 micron is greatly enhanced. The performance data presented is without the application of flocculants.

### **4 micron particle filtration performance**

Filtration performance %	Water flow
99.96%	2m/hr
99.89%	5m/hr
99.85%	6m/hr
99.75%	7m/hr
99.54%	10 m/hr

### **3 micron particle filtration performance**

Filtration performance %	Water flow
99.93%	2m/hr
99.80%	5m/hr
99.75%	6m/hr
99.61%	7m/hr
99.30%	10 m/hr

### **filtration performance at a water flow of 2m/hr**

Filtration performance %	Micron rating
99.96%	4um
99.93%	3um
99.80%	2um
99.60%	1um

## 8. How to back-wash a filter

Back-washing an RGF (rapid gravity filter) or a pressure sand filter is a very simple procedure, however it must be conducted properly to ensure that the filter will have optimal performance during the run phase. This applies to all media bed filters, irrespective of the media contained within the filter vessel.

The process has 6 stages.

1. Air purge
2. At the start of water back-wash, slowly wind-up water flow to 100%
3. Back-wash water flow to achieve 10% to 20% bed expansion for single bed and multi media beds
4. Back-wash duration to insure completion of the back-wash process
5. Rinse phase to prevent solids entering the product water
6. Run phase

### Air purge

Air purging a filter bed will help to scrub and clean the filter media. This is particularly important for filter media that provide a good substrate for bacterial growth such as;

- Sand
- Most mineral based filter media
- Zeolites
- Activated carbon

Air purging was developed as a means of minimising the amount of back-wash water. For example, in the water industry a typical 16 x 30 grade Rapid Gravity sand filter, will normally be air purged at an air flow of approx; 60m<sup>3</sup>/hr of air per 1 m<sup>2</sup> of filter bed surface area for a period of 5 to 10 minutes. The filter will then be back-washed at a flow velocity of 30m/hr (30m<sup>3</sup>/hr per 1 m<sup>2</sup> of filter bed surface area) for up to 10 minutes.

A flow velocity of 30m/hr is insufficient to expand the bed, but it is sufficient to remove **most** of the solids that were trapped in the sand and lifted to the surface of the sand bed by the air purge. The operative word is “most”, but not all the solids will be removed from the sand bed, some will remain and act as a food source for bacteria. Also, if the filter bed has a graded size range of media, then the air purge will serve to mix the grades, and because the water flow does not expand the bed, the grades will not re-classify. The net results, is that all the grades get mixed together in a filter bed that is not back-washed properly. Performance of the filter will therefore be compromised.

It is our opinion that an air purge should only be applied when filter media can be backwashed at a water flow that can expand the bed by at least 15%, which is sufficient to re-classify the media.

***An air purge is neither required nor recommended for AFM®***

### At the start of a water back-wash, slowly wind-up to 100% water flow

If 100% water flow is immediately applied to a filter, there may be a water-hammer which could damage the pipework or the filter internals. The fluid hydraulics are never perfect, especially with filters using laterals in the “spokes of wheel, radial” configuration, or with most horizontal filters.

Taking horizontal filters; at the start of a back-wash, water will rush into the filter towards the back-end and proportionally there will be a slightly greater flow velocity at the end of the filter and laterals. The water will therefore kick up the media at the end of the filter and at the edges. The pressure drop is reduced and more water will pass through the ends and sides of the filter vessel.

The filter now goes onto the run phase, and most of the water will initially go through the ends and sides of the filter, because it has been back-washed more effectively due to the high flow velocity. As the sides and ends block the water flow moves towards the centre of the filter. Next time the filter is back-washed slightly less water will go through the sides and ends, because there was more bio-coagulation due to earlier solids/organic penetration at the start of the run-phase. Gradually the flow pattern will shift towards the centre of the filter and the ends and edges will become compacted, coagulated and eventually blocked.

The above is a generalisation, the flow hydraulics, bio-coagulation and compaction will vary between different filter designs. However, for all filter designs and types of media, if the filter is not back-washed properly filter performance will always be compromised. It is important to use a high-quality filter media such as AFM®. It is equally important to use a properly designed filter vessel and to operate the equipment properly.

#### Time in seconds to 100%, maximum back-wash water flow

##### Type of filter

German DIN standard vertical filter  
with nozzle plate  
Vertical filter with standard lateral  
arrangement  
Horizontal filters with nozzle plates  
or laterals

30

60

90

#### Back-wash water flow to achieve 10% to 20% bed expansion

The minimum back-wash velocity should expand the bed by 10%, but 20% or more bed expansion is recommended especially for multimedia beds. If activated carbon is used, because it has a lower density than sand, the 20% bed expansion may result in a lower flowrate than the figures given below which equate with 20% expansion for a single media.

The back-wash velocity depends on several factors, including;

- Particle size distribution
- Uniformity coefficient
- Density of the media
- Water temperature
- TDS / salinity of the water

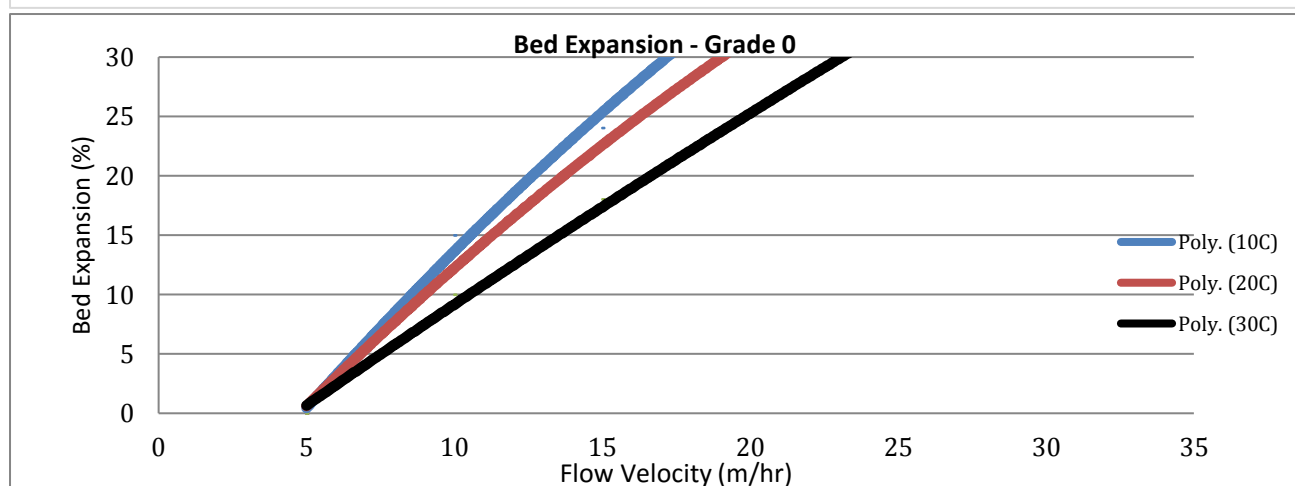
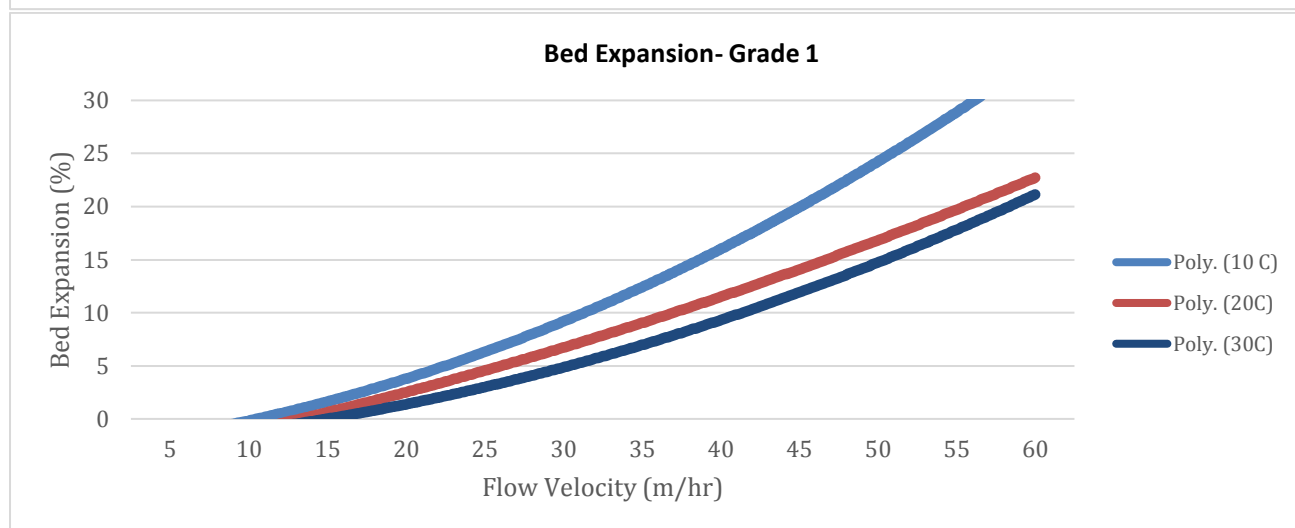
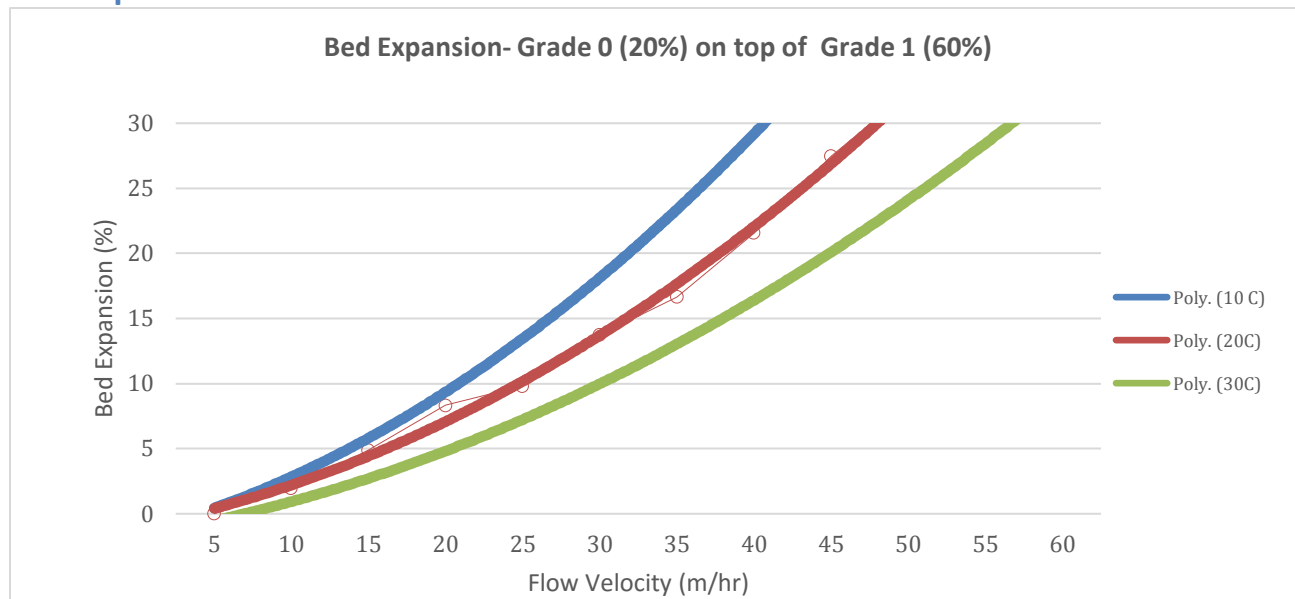
##### Filter media

#### Water flow velocity m/hr for 10% and 20% bed expansion at different water temperature

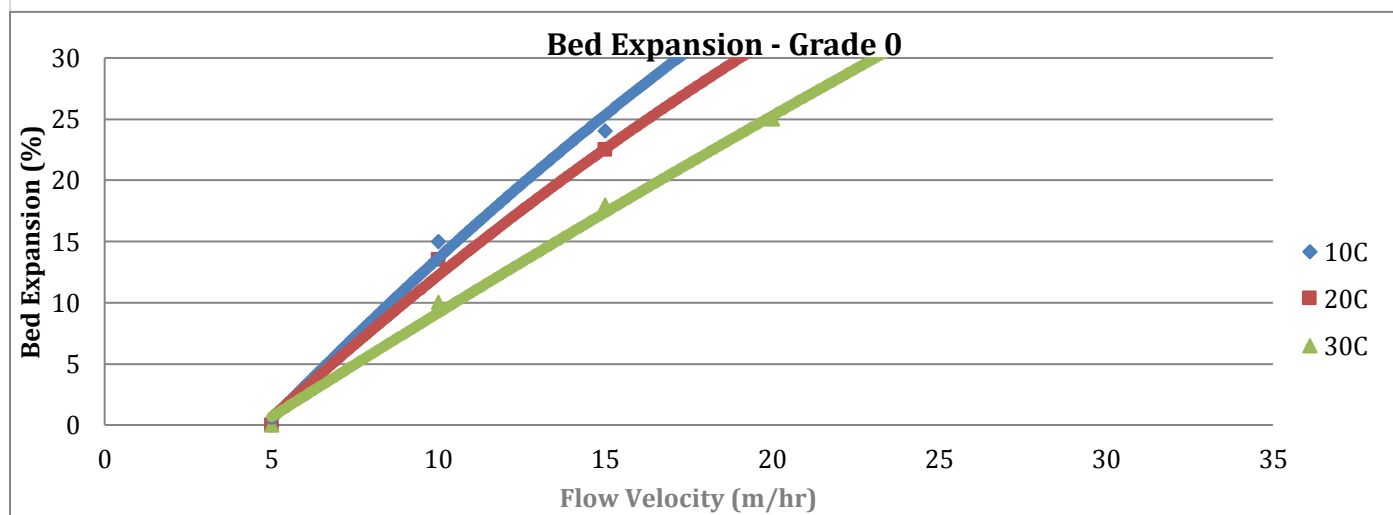
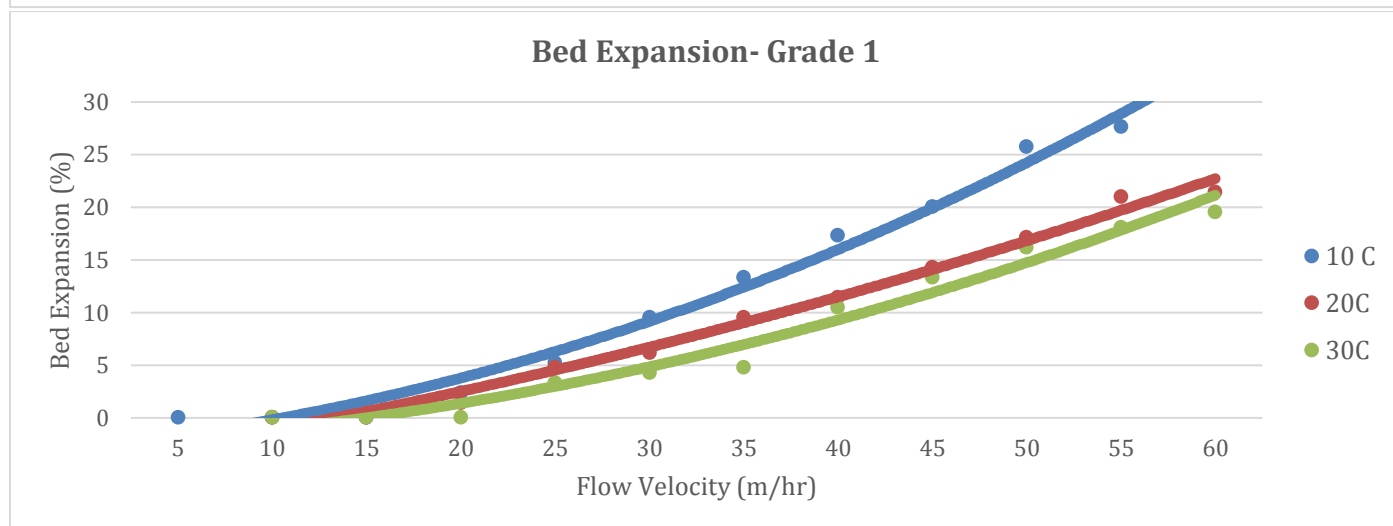
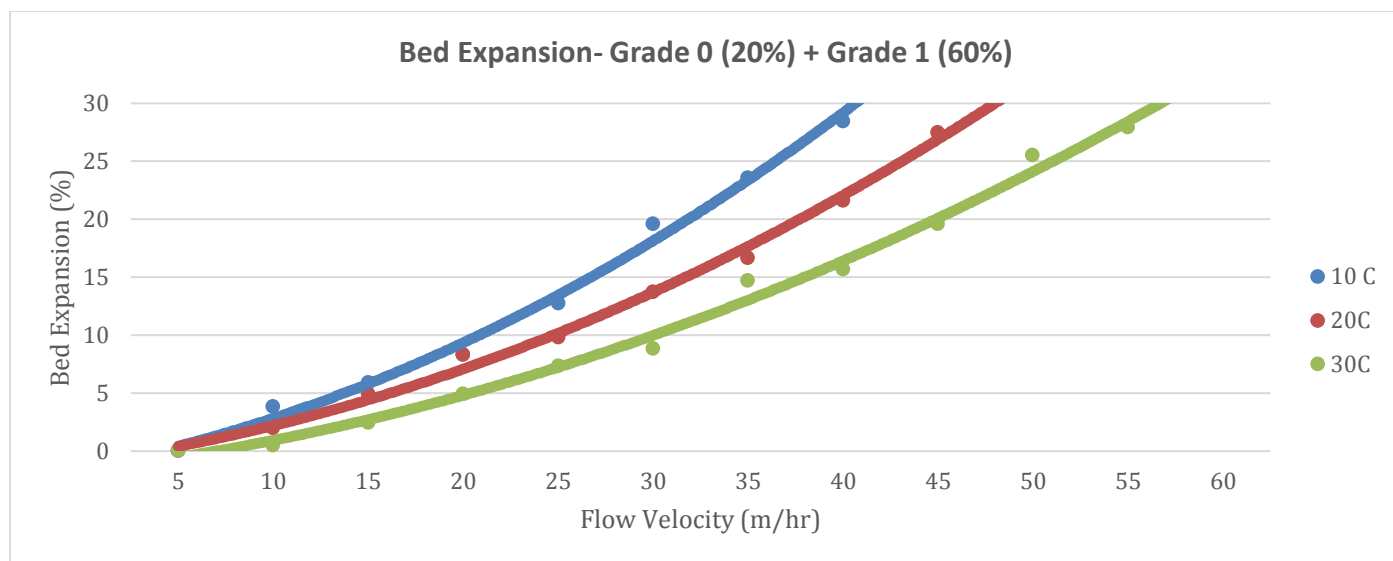
	10 deg C		20 deg C		30 deg c	
	10%	20%	10%	20%	10%	20%
AFM® grade 0 (0.25 to 0.50mm)	8	12	9	14	10	16
AFM® grade 1 (0.4 to 1.0mm)	31	45	36	55	42	57
Silica Sand 16 x 30 grade	39	50	46	58	53	66



## Bed Expansion freshwater



## Bed Expansion Seawater at 35ppt

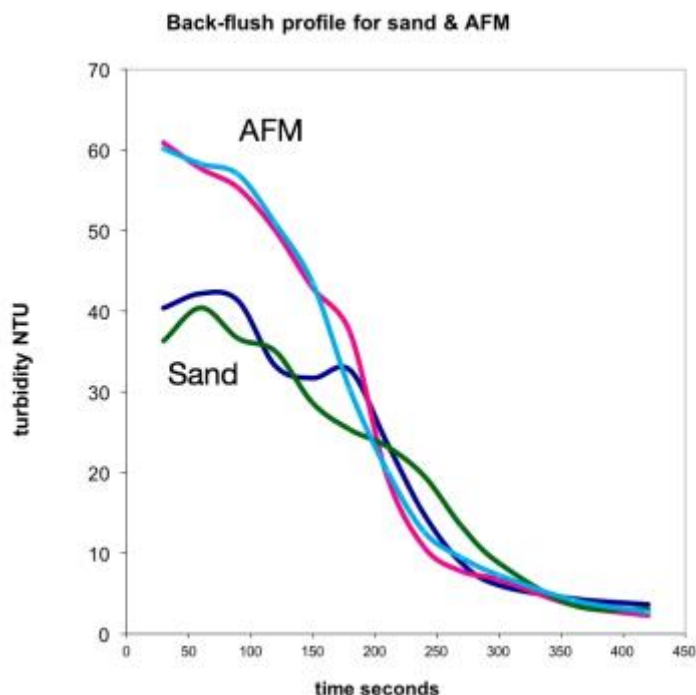


## Back-wash duration to ensure completion of the back-wash process

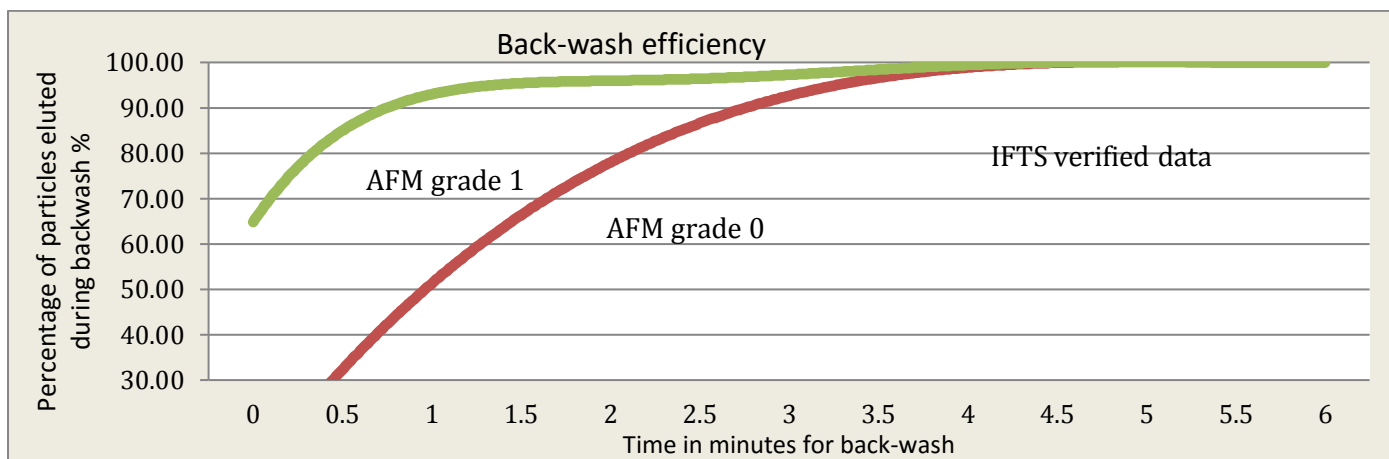
The back-wash must progress until the solids are removed from the filter bed, and evacuated from the water above the filter bed. To achieve this task, the bed must be expanded by at least 15% to release the solids, if this is not achieved, the filter bed will never be cleaned, irrespective of how long the bed is back-washed.

A useful technique to evaluate backwash performance is to measure the back-wash profile. This is achieved by taking a sample of water at the very start of a back-wash, and then every 15 seconds until completion of the back-wash.

If the filter media is stable and not subjected to compaction, or coagulation by bacterium or chemicals in the water, the back-wash profile will be a smooth curve. If the filter is not stable, as in the sand backwash profile (see right) there will be an irregular back-wash profile that can be attributed to coagulated lumps of media breaking up during the back-wash process. The area under the curve can be measured and is proportional to the total mass of solids discharged in backwash for each media tested; the greater the area, the more solids are discharged. This means that more solids were removed by AFM® than by sand during the run phase in the above tests.



In most cases the back-wash will be complete within 300 seconds, however if the bed is not fluidised, the curve will be flat and very protracted. If there is deep solids penetration into the bed, or if there is a large head space above the media, then a longer back-wash will be required, not only to clean the media but also to evacuate all the water above the bed.



## Rinse phase to prevent solids entering the product water, and back to Run phase

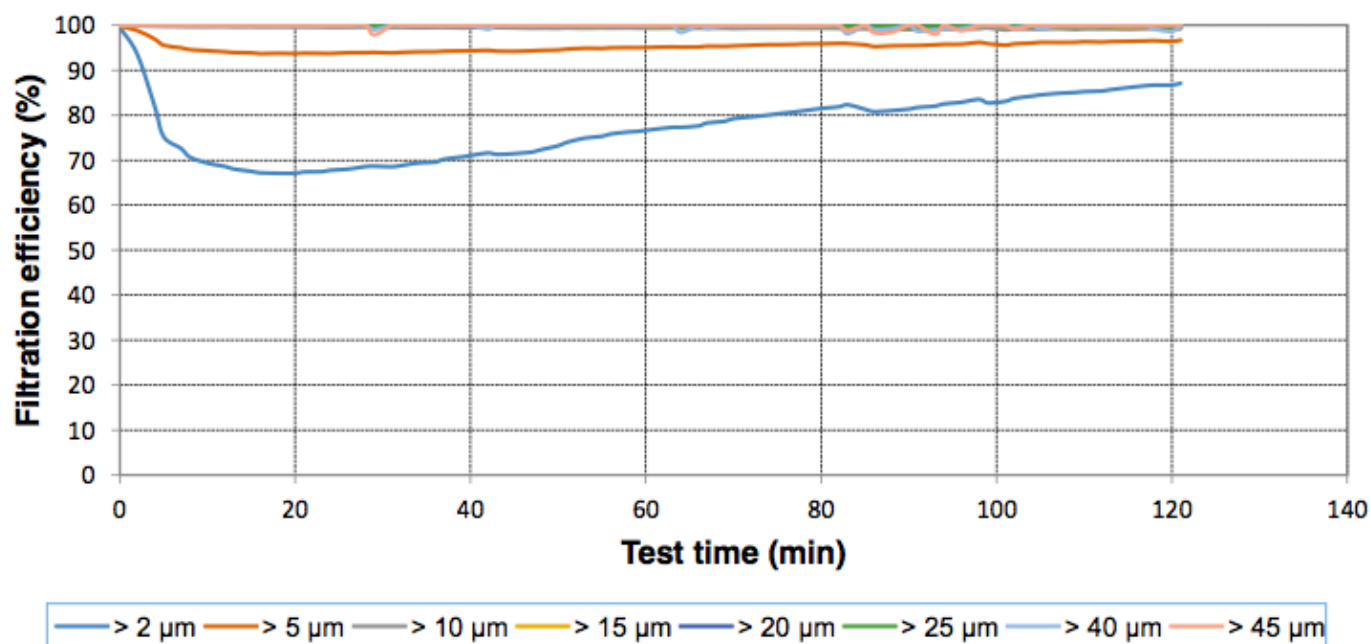
After the back-wash the filter bed needs to settle and compact slightly. Any dislodged solids near the base of the filter bed also need to be discharged to waste. Normally the rinse phase lasts only a few minutes however for, drinking water treatment to reduce the risk of solids such as Cryptosporidium parasites passing into the product water, or for discharge of solids that might foul or block a membrane, the water from an unstable sand filter needs to be sent to waste for up to 30 minutes before the filter can be placed back online.

If the back-wash profile defines the bed as unstable, then the rinse phase will need to up to 30 minutes in duration. The instantaneous filtration performance can also be measured. The following data from IFTS (Institute of Technical separation), presents measurements for AFM® grade running at 20m/hr and sand at 20m/hr.

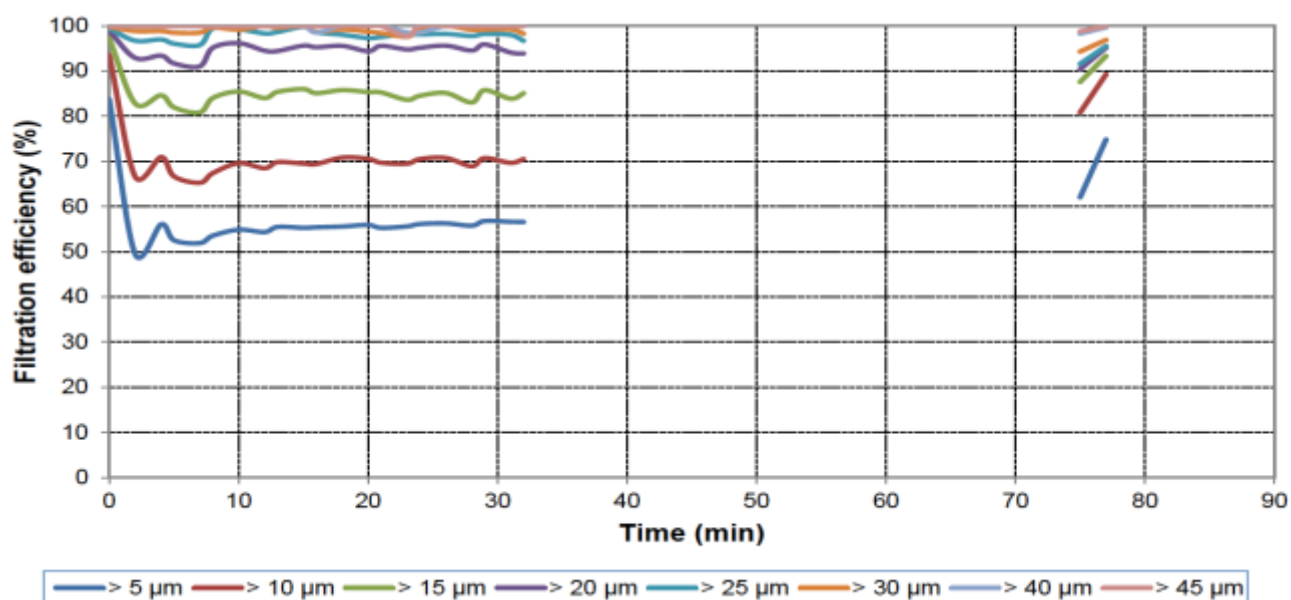
In the following two graphs, note the much higher performance of AFM® in terms of percentage removal of 5 micron particles. Also note that the smallest particles measured with AFM® was 2 microns compared to 5 microns with sand.

## Instantaneous filtration performance after a back-wash

AFM® grade 1 Instantaneous filtration performance at a water flow at 20m/hr no flocculation down to 2 microns



Sand instantaneous filtration performance at a water flow velocity of 20m/hr 16 x 30 grade (Leighton Buzzard deposit England) at 20m/hr, no flocculation, down to 5 microns



Taking 5 µm particle size, there was a gradual decrease in performance of AFM® which stabilised at approx 92% removal efficiency. Sand experience a rapid drop in performance to 50% efficiency then stabilised at approx 55%. At 5 µm and a water flow of 20m/hr, AFM® remove 6 times more effective than sand.

In relation to a water treatment risk analysis, the results confirm the greater security afforded by AFM® over sand.



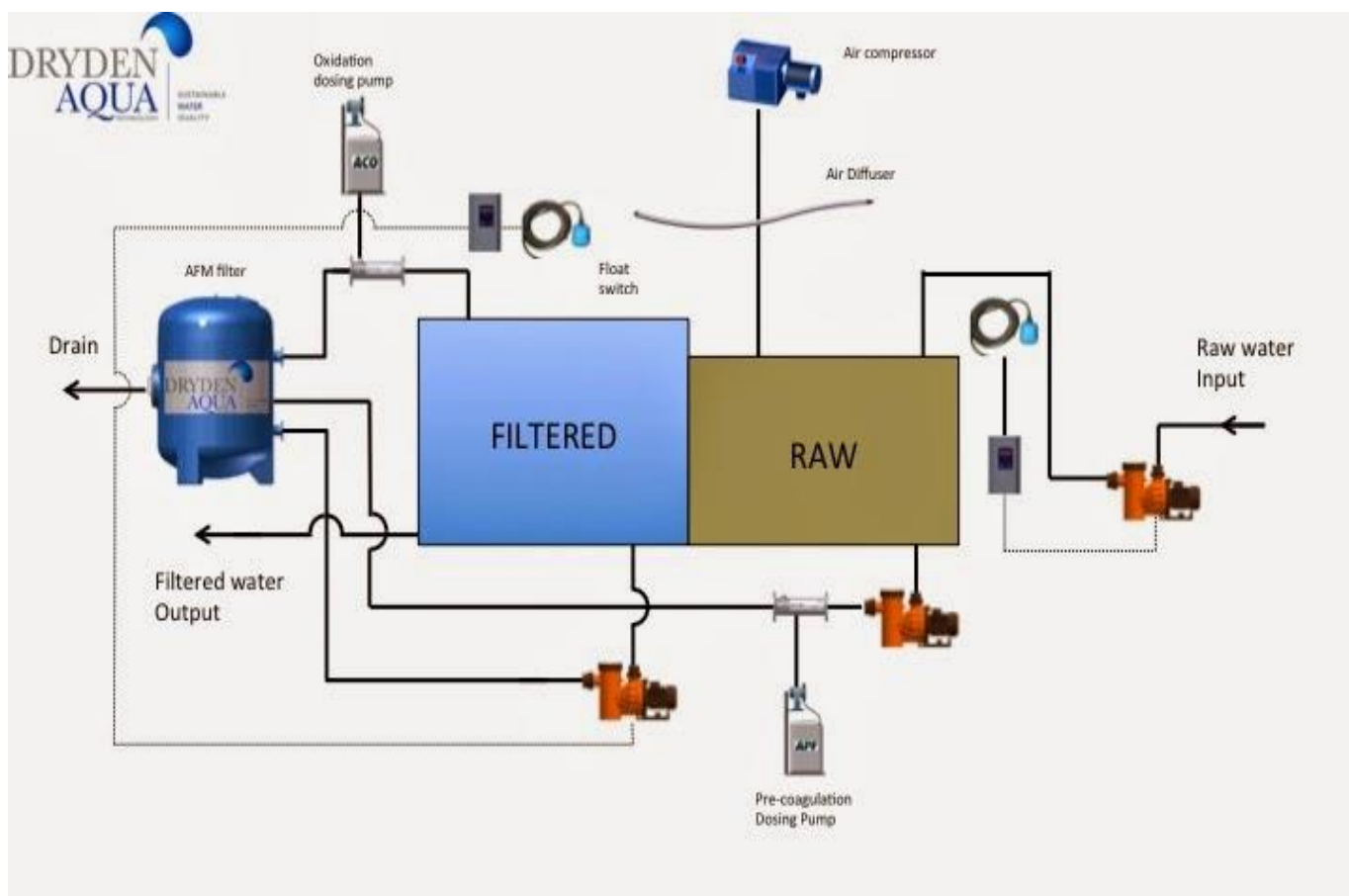
## Run Phase

Once the rinse phase has completed the filter may be placed back into service mode. The transition should be slow; a minimum time of 30 to 60 seconds should be taken to avoid any disturbance of the bed.

The water flow through media bed filters should never be turned off to avoid the development of anoxic conditions. By way of example, if a filter was removing arsenic from the water, the arsenic is in the form of  $As_5^+$  which is insoluble. If the filter flow was stopped, organic matter and bacterium growing on the media and in the filter, would consume the oxygen, the redox potential would drop and the arsenic would be reduced to  $As_3^+$  which is soluble. When the filter goes back-on-line the arsenic would be released into the product water. The issues are not as serious for media that do not biofoul. however, it is good practice never to turn off the water flow. The schematic below displays a possible configuration for a filtration systems that runs continuously but delivers a variable flow.

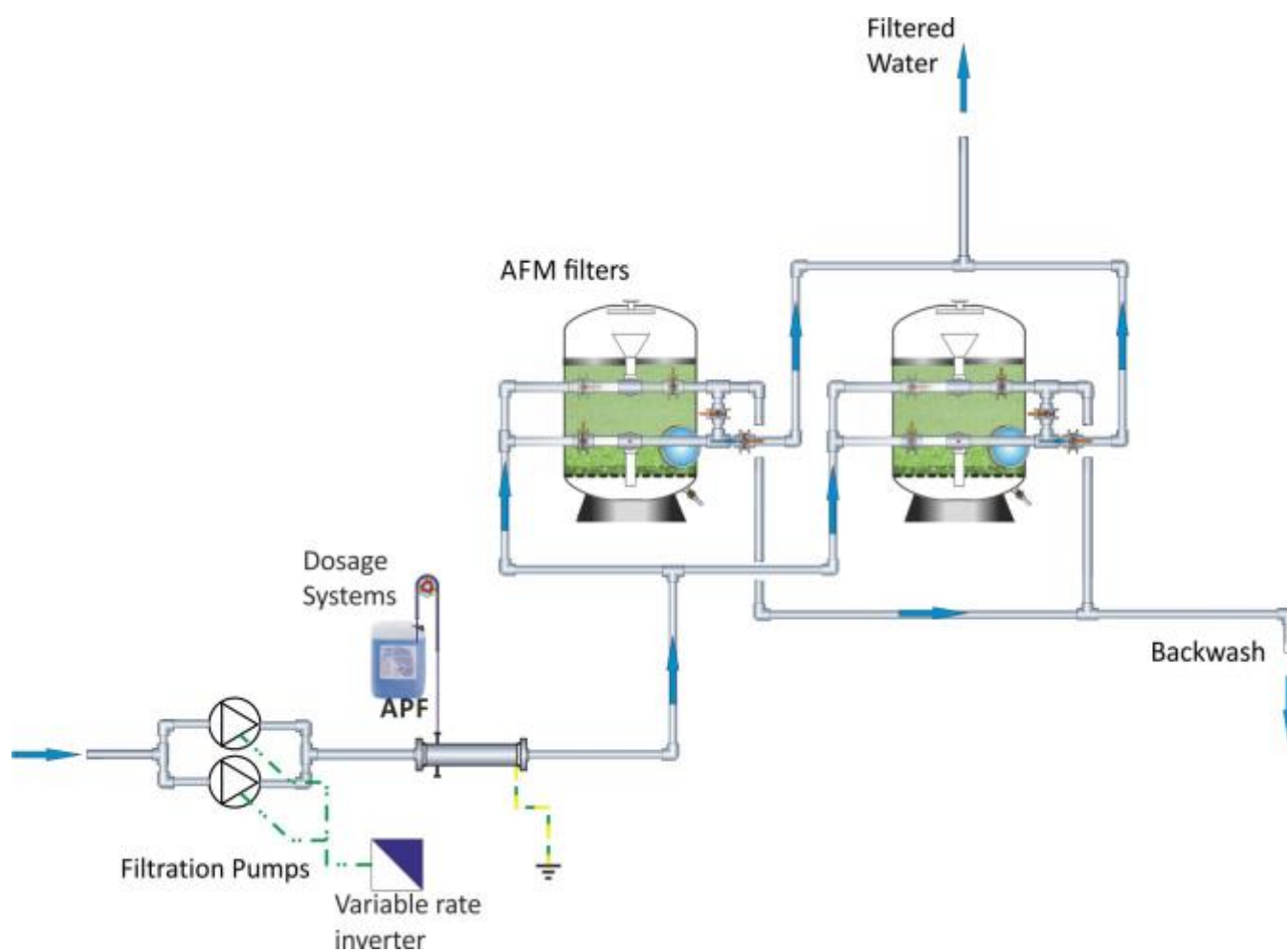
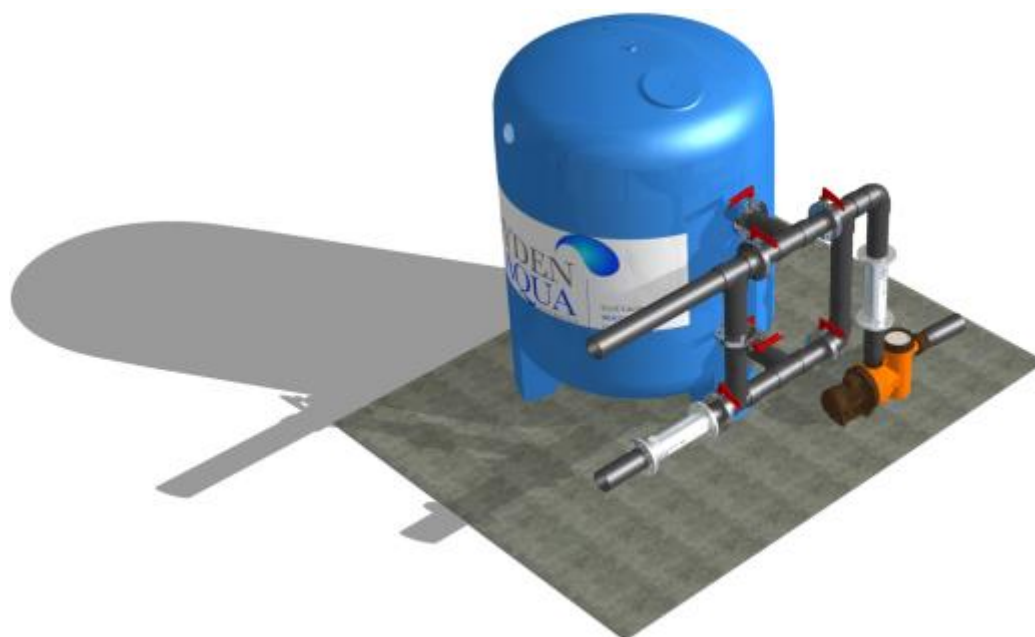
If the filters are turned off for a long period, it is best to backwash before they are turned off and/or when they are turned back on again.

Water flow through the filters should be smooth and constant, if a change of flow is required, then take at least 30 seconds to regulate the flow down or up.



## 9. Pressure filter System Schematics

5 Valve – Single Filter layout and multi filter configuration



## 10. Storage

### Precautions for safe handling

No special precautions should be necessary. Avoid the generation of airborne dust. Provide sufficient ventilation at places where airborne dust is generated and wear a prescribed dust mask. The appropriate precautions as detailed in the SDS data sheet for AFM® must be observed.

### Conditions for safe storage

Store in a cool (room temperature), dry place. AFM® may be stored outside immediately prior to filling the filters. However, if it is stored outside for a protracted period it should be protected from the elements by covering with a tarpaulin. The AFM® should also be stored in a secure location and protected from any intruder interference and contamination by any animals. Sunlight will not affect AFM®, however the polythene bags may suffer UV damage and the plastic will degrade, avoid storage out-side for long period of time unless protected from UV radiation.

## 11. Disposal of waste and spillage

AFM® is inert and may be sent to an approved solid waste disposal or landfill site for disposal. AFM® is a circular economy product and should ideally not be sent to landfill.

AFM® will last for the life of the filtration system and should never need to be replaced. However, if AFM® is removed from the filters due to decommissioning of the filter, it may be returned to Dryden Aqua. The media should be analysed prior to returning to Dryden Aqua to ensure there has been no contamination.



## 12. Annex Index

Annex 1. Applications for AFM®

Annex 2 AFM® for the tertiary treatment of Waste water

Annex 3. The removal of Arsenic, Ferric and Manganese

[Annex 4 Removal of Phosphate from water](#)

Annex 5, Parasitic nematode egg removal from waste water, and second use of water for irrigation

Annex 6. Water quality standards...**Standards European and WHO drinking water quality**

Annex 7. Using AFM® with activated carbon and anthracite



## Annex 1. Applications for AFM®

Application	Water source	Advantages
<b>Municipal Wastewater</b> <ul style="list-style-type: none"> <li>Municipal wastewater</li> </ul>	Tertiary treatment after activated sludge.	<ul style="list-style-type: none"> <li>Will more easily comply with discharge legislation</li> <li>Product water of a higher quality more suitable for second use applications</li> <li>No chlorine or less required when the water is used for class 1 irrigation</li> <li>Return in capital from revenue is always under 2 years and often under 1 year.</li> </ul>
<b>Process Wastewater</b> <ul style="list-style-type: none"> <li>Textiles</li> <li>Leather</li> <li>Oil in water</li> <li>Food washing</li> <li>Cooling towers</li> <li>Steel process water</li> </ul>	The wastewater will be from a variety of sources. AFM® is usually used as part of the water treatment process located after activated sludge or MBR membrane bio-reactors.	<p><b>Textiles.</b> AFM® applied after the fluidised bed bio filtration or MBR. Advanced coagulation and flocculation systems have been developed and optimised for AFM® to remove dyes and facilitate recirculation of the water.</p> <p><b>Leather.</b> The industry generation a hexavalent chromium wastewater, with pre-reduction of the water and conversion of Cr5+ to Cr3+ gives good performance with AFM®</p> <p><b>Oil in water.</b> AFM® can filter oil in water up to 100mg/l and remove &gt;99% of the oil in a sustainable manner. Higher concentrations require an alginate flocculent. Permits AFM® to be used up to 2000mg/l and achieve &gt;99% removal.</p>
<b>Drinking water &amp; Clean water</b> <ul style="list-style-type: none"> <li>Drinking water               <ul style="list-style-type: none"> <li>Ground water</li> <li>Surface water</li> </ul> </li> <li>Process feed water</li> <li>Drinks industries</li> <li>Food processing</li> <li>Pharmaceuticals</li> <li>Hospitals feed water &amp; dialysis recycle</li> <li>Electronics,</li> <li>Boiler feed</li> </ul>	Ground water	AFM® offers a continuous and sustainable solution for the removal of metals and metaloids, such as ferric, manganese and arsenic to a concentration in accordance to the European directive and WHO
	Surface water	Will remove 100 times more sub 5 micron solids from the water than sand. Not subject to biofouling and transient wormhole channelling. High security against the passage of copepods, oocysts and other parasites. Perfect for removing cyanobacteria, diatoms and most freshwater phytoplankton as well as zooplankton without any blockage issues.
	Municipal drinking water supplies	AFM® is used to treat municipal water prior to use in Hospitals, and food industries to minimise the risk from Pseudomonas. Already used in hospitals in the UK and Asia. Example, Belfast maternity hospital when tragically several babies succumbed from Pseudomonas, problem solved with AFM®
	Ultrapure water, pre-treatment. Water from a variety of sources	Ultrapure water treatment usually involves a 3-stage process. 1.sand filtration, 2. Carbon filtration, 3. one micron cartridge filtration. AFM® can replace all three stages as a single one-pass stage prior to the reverse osmosis membranes. Water flow is usually under 10m/hr velocity
<b>Pre-treatment prior to membrane desalination</b>  <b>Marine and brackish water</b> <ul style="list-style-type: none"> <li>Drinking water</li> <li>Drinks industry</li> </ul>	Seawater, brackish water or ground water with a high TDS.  Water supply for reverse osmosis	One of the problems with membrane filtration is fouling from the coagulants and flocculants. The use of grade 0 AFM® gives a very high performance and negates the need to use chemicals. If coagulants and flocculants are used, then grade 1 AFM® is applied. AFM® does not coagulate, or allow channelling so as long as the chemicals are dosed properly in accordance to turbidity they will never reach the membranes. System performance is superior to UF because AFM® grade 1 with controlled flocculation will give nominal filtration better than 0.1 microns and will remove chemicals from solution such as soluble reactive silica, phosphate and dissolved organics that would otherwise foul the membranes
<b>Aquaculture &amp; Aquaria</b> <ul style="list-style-type: none"> <li>Aquaculture</li> <li>Aquaria</li> </ul>		<p><b>Aquaculture and Aquaria,</b> require the best possible water quality. AFM® provides at least double the performance of sand and reduces the viral parasitic and bacteria risk.</p> <p>AFM® will physical remove all parasites from the influent water, such as crypto carryon, amoeba and even fungal spores</p>
<b>Swimming pools &amp; Water features</b> <ul style="list-style-type: none"> <li>Swimming pools</li> <li>Fountains</li> <li>Water features</li> </ul>	Recycled water around a process. This is one of the main applications for AFM® with over 100,000 systems currently running in Europe.	<p><b>Swimming pools, water features fountains and marine mammal systems</b> can use AFM® as part of the DAISY system (Dryden Aqua Integrated System). DAISY provides the ultimate in water treatment with a visibility through the water more than 25m and turbidity usually less than 0.1NTU.</p> <p><b>Water features,</b> AFM® provides a much better quality and reduces the nutrient load and bacterial cell biomass as measure by ATP in the circuit. The result is reduced cost, reduced corrosion and lower risk from Legionella.</p>

## Annex 2 AFM® for the tertiary treatment of Waste water

AFM® is used for the tertiary treatment of wastewater in gravity flow or pressure filters. AFM® has many benefits over sand filtration, which include the following;

- AFM® does not biofoul, coagulate or experience transient channelling
- Predictable and repeatable performance
- Turbidity and TSS reduction better than 90%
- Perfect for ferric removal as such AFM® is also very good at removing phosphate and arsenic
- Many priority chemicals such as herbicides are hydrophobic and are adsorbed onto sub 10 micron particles. AFM® will remove 97% of all particles down to 4 microns, independent confirmation by IFTS
- Should never need to be replaced

<i>Operational criteria</i>	<i>range</i>		<i>notes</i>
<b>Bed depth AFM®</b>	500mm	2000mm	Typical bed depth is 1200mm with 200mm of 1 to 2mm anthracite on top of the bed
<b>Run phase water flow</b>	1 m/hr	20 m/hr	The slower the flow rate the better the performance
<b>Running pressures (differential)</b>	0.1	0.5	Do not exceed 0.5 bar differential
<b>Back-wash water flow</b>	>50m/hr	60m/hr	Back-wash for 5 minutes, or until the water runs clear. Air purge not required
<b>Rinse phase duration</b>	5 minutes	Or until water runs clear	It takes a few minutes for the bed to stabilize after a back-wash
<b>Back-wash frequency / hours</b>	4	40	Depends upon solids load in wastewater
<b>Water quality</b>			Ideally the dissolved oxygen level should be above 2mg/l or redox potential above 300mv entering the AFM® filter bed

TYPE OF FILTER	SS. (mg/l)		Performance %	Turbidity ntu		Performance %	bacteria		Performance %	Filtration Velocity m3/m2/h
	inlet	outlet		inlet	outlet		inlet	outlet		
RGF sand filter with sand	7.14	2.2	69	3.5	2.23	36	23120.0	12300.0	46	1.2
Pressure filter with sand	8.18	3.82	53	5.87	4.76	18	22311	18023	19	4.96
Moving bed sand filter with sand	7.08	3.82	46	2.13	1.79	16	14067	10307	26	5.4
Drum filter 10 micron	14.66	7.33	50	7.16	3.88	45	56712	38460	32	3.23
Disc Filter 10 micron	5.6	3.1	44	2.22	2.06	7	30450	21138	30	2.12
Ring Filter 10 micron	7.41	3.98	46	3.01	3.17		9447	7761	17	2.5
AFM® Pressure filter	10.60	0.89	96%	2.98	0.24	92 %	23000	10000	58 %	3.59

## Municipal wastewater

The following is published data by a Spanish Water Utility on the treatment of wastewater for second use. The data shows the backwash profile from the gravity flow sand filter and then the AFM® grade 1 filter media. The data confirms the stability and high performance of AFM® in comparison to sand.

The sand filter was unstable and the large interval between the back-wash peaks confirms channelling of water through the sand bed.

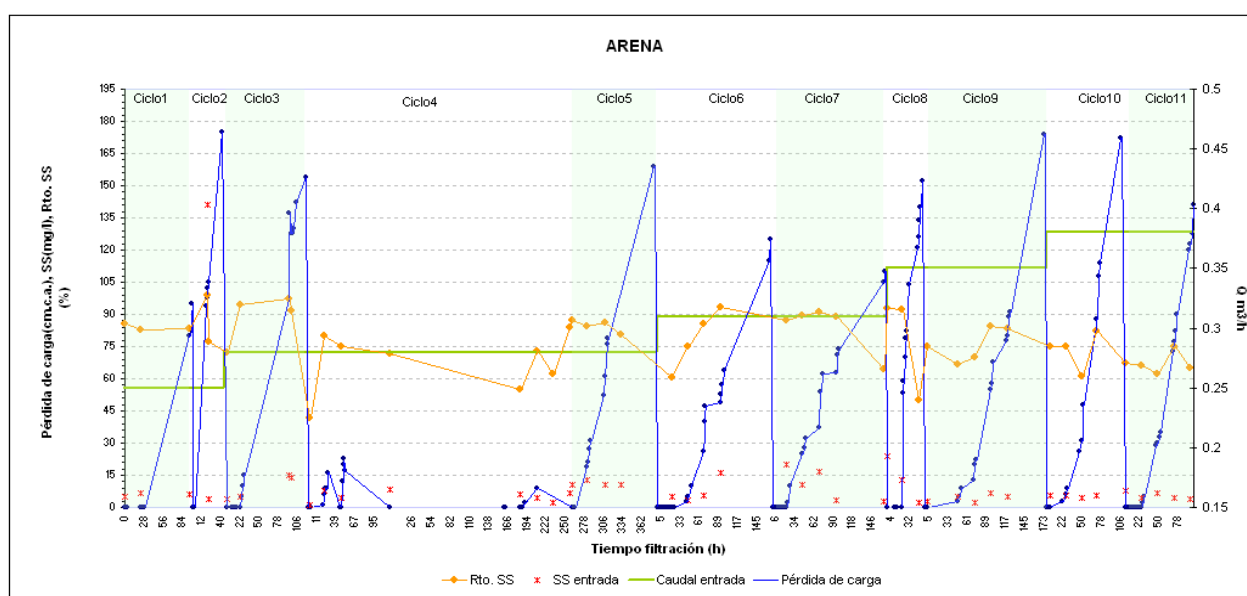
The AFM® filter was like clock-work, each run phase and every back-wash was the same. The data confirms the stability of AFM® and the high quality of product water that may be achieved.

Data published

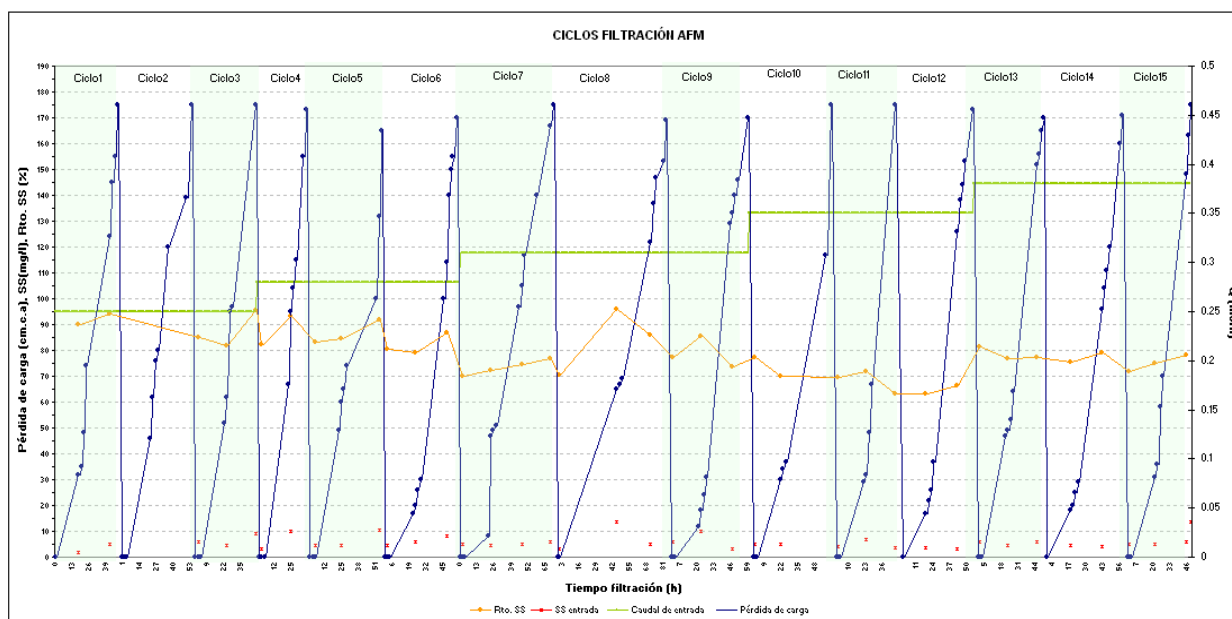
Technologie del Agua, No 334 November 2011, I.S.S.N. 211/8173

Independent tests conducted by Spanish Water Company and reported in Technologie del Agua , December 2009, page 47.

### Sand filter tertiary treatment, using 16 x 30 sand



### AFM® grade 1 Filter tertiary treatment



## Waste water treatment, results for AFM®

Wastewater	Typical Performance advantage
Suspended solids	>90% reduction
COD/BOD/TOC	
Turbidity	>90% reduction
Ammonium	No change with AFM®
Bacteria TTC	50% reduction
THMs	50% to 90% reduction
Back-wash profile	Used to check performance

Water quality before and after AFM®, tertiary treatment of municipal waste water





## Annex 3. The removal of Arsenic, Ferric and Manganese

<i>Chemical parameter</i>	<i>Soluble fraction</i>	<i>Insoluble</i>	<i>Drinking water standard</i>	<i>AFM® performance</i>
<i>Manganese</i>	Mn <sup>2+</sup>	Mn <sup>4+</sup>	50 ug/l	>80%
<i>Ferric</i>	Fe <sup>2+</sup>	Fe <sup>3+</sup>	200 ug/l	>95%
<i>Arsenic</i>	As <sup>3+</sup>	As <sup>5+</sup>	10 ug/l	>95%

Iron, manganese and arsenic are often found in borehole / tube wells and ground-water at varying concentrations depending upon the geology of the ground. The process used by Dryden Aqua to remove the chemicals is as follows;

### Process

1. Oxidation reactions to convert metals from soluble ionic form to insoluble oxidized precipitate, pH correction
2. Decantation may be required if the concentrations are above 5 mg/l, if not proceed to AFM® filtration
3. AFM® filtration to remove the suspended metal oxide solids, there will also be adsorption reactions and surface oxidation reactions.

### Oxidation;

Manganese and Arsenic are removed by co-precipitation and catalytic oxidation by Ferric. For the process to work the ferric needs to be at least 5 times higher concentration than either the arsenic or the manganese. If the concentration of ferric is sufficient, then simple aeration of the water for a period of up to 30 minutes, with co-precipitate the arsenic and manganese and the AFM® will remove from solution.

The process is very simple and easy to reduce the arsenic concentration to less than 10ppb in a sustainable system. If the water is deficient in ferric, it may be compensated for by dosage of ferric chloride.

If ferric is not used for catalytic oxidation of Manganese or Arsenic, then an oxidising agent such as chlorine dioxide needs to be added to the water to raise the redox potential to 500mv.

### Aeration

This is achieved through aeration of the water. The water is aerated for a period of no less than 30 minutes. If water flow is 50 m<sup>3</sup>/hr the aeration level is 50m<sup>3</sup>/hr of air and tank volume is 25m<sup>3</sup> of water. Dryden Aqua manufacture fine bubble drop in air diffusers for this application.



	<i>range</i>		<i>notes</i>
<i>Bed depth AFM®</i>	900mm	1400mm	Bulk bed density 1.25 to 1
<i>Run phase water flow</i>	5 m/hr	10 m/hr	The slower the flow rate the better the performance
<i>Running pressures (differential)</i>	0.1	0.5	Do not exceed 0.4 bar differential
<i>Back-wash water flow</i>	>45m/hr	60m/hr	Back-wash for 5 minutes, or until the water runs clear. Air purge not required
<i>Rinse phase duration</i>	5 minutes	Or until water runs clear	It takes a few minutes for the bed to stabilize after a back-wash
<i>Back-wash frequency / per week</i>	1	7	Reduce back-washing to a minimum.

## Annex 4 Removal of Phosphate from water

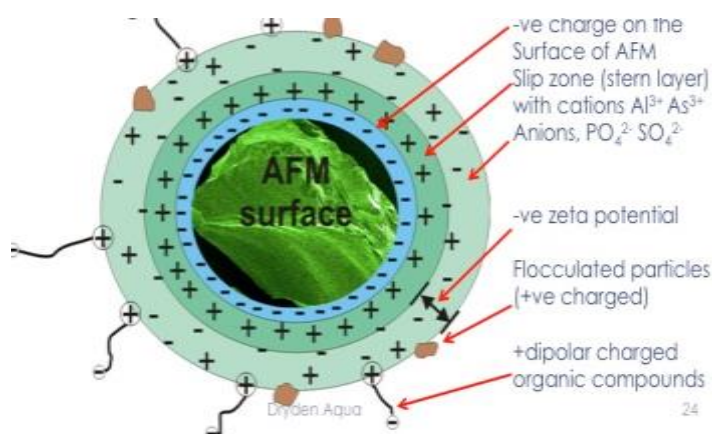
Total phosphate includes three forms of phosphate;

1. Organic phosphate is found in plankton, algae and bacterial cell biomass,
2. inorganic phosphate such as struvite, and soluble reactive phosphate is referred to as ortho-phosphate.

AFM® will mechanically filter the water down to less than 1 micron when coupled with pre-coagulation and flocculation. The removal rate of organic and inorganic particulate phosphate will be more than >95%.

AFM® will directly adsorb soluble reactive orthophosphate

$\text{PO}_4^{2-}$  in the AFM® stern layer, the capacity for adsorption is low, but sufficient to make an impact on concentrations remaining after coagulation with ferric, lanthanum or magnesium.



## Water & Wastewater treatment to remove phosphate

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

There are three main approaches, all of which involve the precipitation of phosphate to form an insoluble salt by the addition of;

- (i) ferric to form ferric phosphate
- (ii) magnesium to form struvite.
- (iii) lanthanum to form lanthanum phosphate

At Dryden Aqua we have been using (iii) Lanthanum salts (NoPhos) to remove phosphate in the aquarium and aquaculture industry for over 20 years. Lanthanum is injected into the water at a 1:1 stoichiometric ratio to reduce organic phosphates down to concentrations below 0.05 mg/l. NoPhos must be injected into the water before AFM® using an aggressive static mixer such as our ZPM to ensure efficient use of NoPhos and removal of ortho-phosphate.

The process is simple, reliable and sustainable when Lanthanum chloride (NoPhos) is used. The performance of ferric is not quite as good as lanthanum, in order to compensate for the reduced performance; typically, a 2: 4 excess molar ratio is applied. More ferric may be required if there is a higher concentration of suspended solids or dissolved organics in the water to be treated.

Ferric chloride is injected into the water via a ZPM or aggressive static mixer. Ideally there should be a 10-minute aerated contact tank. The dissolved oxygen content must be kept above 2 mg/l or redox potential above 300mv. AFM® is highly effective for the removal of ferric, arsenic and manganese and a good solution for the removal of the ferric phosphate salt.

Chemical parameter	Soluble fraction	Insoluble	Drinking water standard	Performance
Phosphate Soluble reactive	$\text{PO}_4^{2-}$	$(\text{Fe}^{3+})_2(\text{PO}_4^{2-})_3$ $\text{Mg}^{2+}\text{NH}_4^+\text{PO}_4^{2-}$	No limit	>95% usually less than 0.1mg/l $\text{PO}_4\text{-P}$

The details below provide a list of phosphate minerals that will form insoluble precipitates

<ul style="list-style-type: none"> <li>• <a href="#">triphyllite</a> <math>\text{Li}(\text{Fe}, \text{Mn})\text{PO}_4</math></li> <li>• <a href="#">monazite</a> <math>(\text{Ce}, \text{La}, \text{Y}, \text{Th})\text{PO}_4</math></li> <li>• <a href="#">hinsdalite</a> <math>\text{PbAl}_3(\text{PO}_4)(\text{SO}_4)(\text{OH})_6</math></li> <li>• <a href="#">pyromorphite</a> <math>\text{Pb}_5(\text{PO}_4)_3\text{Cl}</math></li> <li>• <a href="#">vanadinite</a> <math>\text{Pb}_5(\text{V}_2\text{O}_7)_3\text{Cl}</math></li> <li>• <a href="#">erythrite</a> <math>\text{Co}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}</math></li> <li>• <a href="#">amblygonite</a> <math>\text{LiAlP}_2\text{O}_6</math></li> <li>• <a href="#">lazulite</a> <math>(\text{Mg}, \text{Fe})\text{Al}_2(\text{PO}_4)_2(\text{OH})_2</math></li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">wavellite</a> <math>\text{Al}_3(\text{PO}_4)_2(\text{OH})_3 \cdot 5\text{H}_2\text{O}</math></li> <li>• <a href="#">turquoise</a> <math>\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 5\text{H}_2\text{O}</math></li> <li>• <a href="#">autunite</a> <math>\text{Ca}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 10\text{-}12\text{H}_2\text{O}</math></li> <li>• <a href="#">carnotite</a> <math>\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 3\text{H}_2\text{O}</math></li> <li>• <a href="#">phosphophyllite</a> <math>\text{Zn}_2(\text{Fe}, \text{Mn})(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}</math></li> <li>• <a href="#">struvite</a> <math>(\text{NH}_4)\text{MgPO}_4 \cdot 6\text{H}_2\text{O}</math></li> <li>• <a href="#">Xenotime</a> <math>\text{Y}(\text{PO}_4)_3</math></li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Apatite</a> group <math>\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH})</math></li> <li>• <a href="#">hydroxylapatite</a> <math>\text{Ca}_5(\text{PO}_4)_3\text{OH}</math></li> <li>• <a href="#">fluorapatite</a> <math>\text{Ca}_5(\text{PO}_4)_3\text{F}</math></li> <li>• <a href="#">chlorapatite</a> <math>\text{Ca}_5(\text{PO}_4)_3\text{Cl}</math></li> <li>• <a href="#">bromapatite</a></li> </ul>	<ul style="list-style-type: none"> <li>• Mitridatite group:</li> <li>• <a href="#">Arseniosiderite-mitridatite</a> series <math>(\text{Ca}_2(\text{Fe}^{3+})_3[(\text{O})_2](\text{AsO}_4)_3] \cdot 3\text{H}_2\text{O})</math><sup>1</sup></li> <li>• Arseniosiderite-<a href="#">robertsite</a> series <math>(\text{Ca}_2(\text{Fe}^{3+})_3[(\text{O})_2](\text{AsO}_4)_3] \cdot 3\text{H}_2\text{O})</math><sup>2</sup></li> </ul>
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## Process

There are three approaches; ortho-phosphate is removed by forming an insoluble precipitate with Lanthanum, ferric, or magnesium. AFM® is highly effective for this application because the precipitates formed are efficiently removed without solidifying the filtration bed.

1. The precipitating salts must be added via an aggressive static mixer, **after** the pump but **before** the filter
2. Lanthanum addition is stoichiometric at a molar ration of 1:1
3. Ferric addition should be at a ratio of 2-4 to 1 molar Ferric to Phosphate. This will give a surplus of ferric for coagulation and other flocculation reactions. The optimum concentration should be determined on a case-by-case basis because water with a high concentration of suspended solids, or other chemicals will influence the concentration of ferric required.
4. Struvite. The molar ratio  $\text{NH}_3\text{:Mg:PO}_4$  equates with 1:8:3, this is not stoichiometric but it has been found in different water types to give good results. There will be a requirement to adjust the injection of magnesium to determine the optimum ratio.
5. The chemical reactions are rapid, and a period of 15 minutes is sufficient. Dryden Aqua air diffusers are designed to perform the mixing action. It is important to ensure that the dissolved oxygen concentration is above 2mg/l or the redox potential exceeds 300mv. Our air diffusers are easy to remove for cleaning and descaling.
6. Decantation may be required if the concentration of phosphate is above 5 mg/l as  $\text{PO}_4\text{-P}$ , if not, it is a matter of just proceeding to AFM® filtration
7. The AFM® filtration process to remove the phosphate suspended solids will result in adsorption reactions of phosphate  $\text{PO}_4^{2-}$  directly onto the AFM®. (N.B. An activated form of AFM® designed to be even more selective with higher capacity for orthophosphate is in development.)

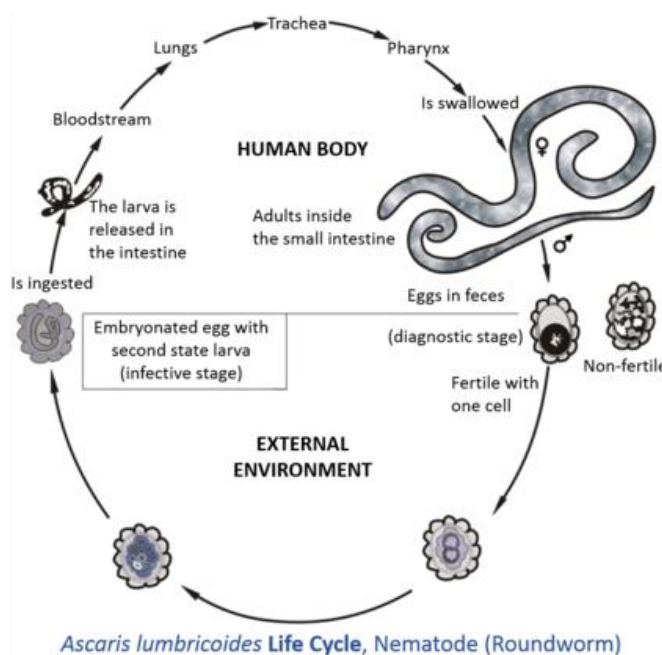
## Annex 5, Parasitic nematode egg removal from waste water, and second use of water for irrigation

Water can often contain parasites such as *Cryptosporidium* in drinking water, or nematodes including the human parasite *Ascaris lumbricoides* in wastewater.

*Ascaris* infects more than 2 billion people in the world, and is particularly acute and dangerous in the developing world among people that are weakened through poor nutrition or chronic illness. One of the main vectors for the spread of the parasite is the use of wastewater for irrigation that contains the parasitic eggs.

The parasite egg is large at 40 microns and easy to remove by AFM® tertiary treatment. Sand will also remove the egg, but because sand suffers from biodynamic instability and transient wormhole channelling, the infections eggs will break through the filter. This may explain why almost 1% of the population in Europe and North America, also have the nematode infection.

The parasite larvae infect your blood, internal organs and lungs, and then end up back in your intestine where they can grow up to 35cm in size.



### Case Study

**Kaipara District Council Location: Mangawhai, New Zealand**

We have been monitoring water quality in Kaipara district in New Zealand since 2009. The municipal wastewater is treated by AFM® pressure filters operating at 20m/hr. There are *Ascaris* eggs in the wastewater, but none have been detected in the product water. The predictable high performance of AFM® has allowed the wastewater to be used for irrigation.

In addition to human parasitic nematodes, there are also nematodes that will infect plants.

Waste water will contain heavy metals and metaloids such as hexavalent chromium and arsenic. AFM® is very good at removing these components. We have also shown that priority toxic chemicals tend to hydrophobic and are adsorbed onto particles. AFM® is up to 10 times more efficient at removing these particles. It is essential that the water is of the highest standard to avoid accumulation of toxins in the plants and in the aquifer. AFM® provides a solution to these issues.



## Annex 6 Analysis of product water prior to connection of drinking water filtration system to a network

General Chemistry	required	Method of water analysis
pH	Yes	Auto analyser
Conductivity (@20°C)	Yes	Auto analyser
Alkalinity	Yes	Auto analyser
Total dissolved solids	Yes	gravimetry
		Calculation
Suspended Solids	Yes	gravimetry
Colour	Yes	Auto analyser
Nitrate	Yes	Calculation
Nitrite	Yes	Colorimetry
Oxidised nitrogen	Yes	Colorimetry
Phosphate (Soluble reactive)	Yes	Colorimetry
Sulphate	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Chloride	Yes	Ion Chromatography
		Ion Chromatography
Bromate	Yes	Ion Chromatography
Bromide	Yes	Ion Chromatography
Fluoride	Yes	Ion Chromatography
		Auto analyser
Turbidity	Yes	Auto analyser
Total organic carbon (TOC)	Yes	TOC Analyser
<b>Metals</b>		
Aluminium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Antimony	Yes	Inductively coupled plasma with mass spectroscopy (ICP/MS)
Arsenic	Yes	Inductively coupled plasma with mass spectroscopy (ICP/MS)
Boron	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Cadmium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Calcium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Chromium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Copper	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Iron	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Lead	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Magnesium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Manganese	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)



Mercury	Yes	Inductively coupled plasma with mass spectroscopy (ICP/MS)
Nickel	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Potassium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Selenium	Yes	Inductively coupled plasma with mass spectroscopy (ICP/MS)
Silica	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Sodium	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
Zinc	Yes	Inductively coupled plasma with mass spectroscopy or optical emission spectroscopy (ICP/MS or ICP/OES)
<b>Microbiology</b>		
Total Viable Count (TVC) @ 22°C	Yes	Pour plate method
Total Viable Count (TVC) @ 37°C	Yes	Pour plate method
Coliforms	Yes	Membrane filtration using membrane lactose glucuronide agar (MLGA)
E.Coli	Yes	Membrane filtration using membrane lactose glucuronide agar (MLGA)
Cryptosporidium	Optional	Immunomagnetic separation and microscopy
<b>Organic Chemistry</b>		
Solvent extractable Organic compounds	Yes	Gas Chromatography with Mass Spectroscopy
Volatile Organic Compounds (VOC)	Yes	Head Space, Gas Chromatography with Mass Spectroscopy
Trihalomethane	Yes	Gas Chromatography with Mass Spectroscopy
<b>Radio-activity</b>		
Gross Alpha and Beta	Optional	Proportional counting
Tritium	Optional	Distillation and scintillation counting

## Annex 6. Water quality standards...Standards European and WHO drinking water quality

	WHO standards	EU standards
	1993	1998
<i>Suspended solids</i>	***	***
<i>COD</i>	***	***
<i>BOD</i>	***	***
<i>Oxidisability</i>		5.0 mg/l O <sub>2</sub>
<i>Grease/oil</i>	***	***
<i>Turbidity</i>	***	<5
<i>pH</i>	***	6.5 – 8.5
<i>Conductivity</i>	250 microS/cm	250 microS/cm
<i>Color Pt-Co</i>	***	15
<i>Dissolved oxygen</i>	***	>75% sat
<i>Hardness CaCO<sub>3</sub></i>	***	150 – 500
<i>TDS</i>	***	***
<i>cations</i>		
<i>(positive ions)</i>		
<i>Aluminium (Al)</i>	0.2 mg/l	0.2 mg/l
<i>Ammonia (NH<sub>4</sub>)</i>	***	0.50 mg/l
<i>Antimony (Sb)</i>	0.005 mg/l	0.005 mg/l
<i>Arsenic (As)</i>	0.01 mg/l	0.01 mg/l
<i>Barium (Ba)</i>	0.3 mg/l	***
<i>Berillium (Be)</i>	***	***
<i>Boron (B)</i>	0.3 mg/l	1.00 mg/l
<i>Bromate (Br)</i>	***	0.01 mg/l
<i>Cadmium (Cd)</i>	0.003 mg/l	0.005 mg/l
<i>Chromium (Cr)</i>	0.05 mg/l	0.05 mg/l
<i>Copper (Cu)</i>	2 mg/l	2.0 mg/l
<i>Iron (Fe)</i>	No guideline(6)	0.2
<i>Lead (Pb)</i>	0.01 mg/l	0.01 mg/l
<i>Manganese (Mn)</i>	0.5 mg/l	0.05 mg/l
<i>Mercury (Hg)</i>	0.001 mg/l	0.001 mg/l
<i>Molibdenum (Mo)</i>	0.07 mg/l	***
<i>Nickel (Ni)</i>	0.02 mg/l	0.02 mg/l
<i>Nitrogen (total N)</i>	50 mg/l	***
<i>Selenium (Se)</i>	0.01 mg/l	0.01 mg/l
<i>Silver (Ag)</i>	No guideline	***
<i>Sodium (Na)</i>	200 mg/l	200 mg/l
<i>Tin (Sn) inorganic</i>	No guideline	***
<i>Uranium (U)</i>	1.4 mg/l	***
<i>Zinc (Zn)</i>	3 mg/l	***
<i>anions</i>		
<i>(negative ions)</i>		
<i>Chloride (Cl)</i>	250 mg/l	250 mg/l
<i>Cyanide (CN)</i>	0.07 mg/l	0.05 mg/l
<i>Fluoride (F)</i>	1.5 mg/l	1.5 mg/l
<i>Sulfate (SO<sub>4</sub>)</i>	500 mg/l	250 mg/l
<i>Nitrate (NO<sub>3</sub>)</i>	(See Nitrogen)	50 mg/l
<i>Nitrite (NO<sub>2</sub>)</i>	(See Nitrogen)	0.50 mg/l
<i>microbiological</i>		
<i>parameters</i>		
<i>Escherichia coli</i>	***	<1 in 250 ml

<i>Enterococci</i>	***	<1 in 250 ml
<i>Pseudomonas aeruginosa</i>	***	<1 in 250 ml
<i>Clostridium perfringens</i>	***	<1 in 100 ml
<i>Coliform bacteria</i>	***	<1 in 100 ml
<i>Colony count 22oC</i>	***	<100 in 1 ml
<i>Colony count 37oC</i>	***	<20 in 1ml
<i>other parameters</i>		
<i>Acrylamide</i>	***	0.0001 mg/l
<i>Benzene (C6H6)</i>	***	0.001 mg/l
<i>Benzo(a)pyrene</i>	***	0.00001 mg/l
<i>Chlorine dioxide (ClO2)</i>	0.4 mg/l	
<i>1,2-dichloroethane</i>	***	0.003 mg/l
<i>Epichlorohydrin</i>	***	0.0001 mg/l
<i>Pesticides</i>	***	0.0001 mg/l
<i>Pesticides – Total</i>	***	0.0005 mg/l
<i>PAHs</i>	***	0.0001 mg/l
<i>Tetrachloroethene</i>	***	0.01 mg/l
<i>Trichloroethene</i>	***	0.01 mg/l
<i>Trihalomethanes</i>	***	0.1 mg/l
<i>Tritium (H3)</i>	***	100 Bq/l
<i>Vinyl chloride</i>	***	0.0005 mg/l

#### Drinking water Standards

- (1) Desirable: Less than 5 NTU
  - (2) Desirable: 6.5-8.5
  - (3) Desirable: 15 mg/l Pt-Co
  - (4) Desirable: less than 75 % of the saturation concentration
  - (5) Desirable: 150-500 mg/l
  - (6) Desirable: 0.3 mg/l
- \*\*\* required but parameters have not been set