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technical article

Document Ref:	0411001-ROPT-text-RevG
Status:	Re-Issued to Amiad
Company:	Amiad Filtration Systems Limited
Issue Date:	7 June 2006
Copy Date:	to be advised
Publication:	to be advised
Issue:	to be advised
Word Count:	2060 words

AMIAD's Filtomat Microfiber for RO Pre-Treatment

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In this feature article, we outline the effectiveness of Amiad Filtomat Microfiber automatic self cleaning filter technology when used in reverse osmosis (RO) pre-treatment for the production of potable water. The Filtomat provides effective pre-filtration of various water sources prior to RO. We examine how the pre-filtration technology operates and how it can be integrated into a RO system. We include details on a project developed and installed by Veolia-OTVB at Folkestone and Dover Water Services' (FDWS) Denge Water Treatment works, UK, in 2004. We evaluate the effectiveness of the Filtomat units on site for filtering groundwater sources and draw on FDWS's operational experiences since commissioning.

Amiad (www.amiad.com) has developed a comprehensive range of compact automatic and manual self-cleaning filters over the last 40 years, incorporating innovative technology characterised by low operating cost and short capital payback. Filtomat units are typically installed in potable water applications, including RO pre-treatment (where they can protect against Cryptosporidium oocyst) and nanofiltration pre-treatment where membranes are used to primarily remove colour. Other applications include use in effluent treatment processes, recirculation-water filtration systems, cooling tower main and side-stream filtration applications, and off-shore water injection projects.

Amiad's filtration technology has been evaluated by the UK Drinking Water Inspectorate (DWI) and approved by the UK Secretary of State for use in UK public water supplies. The units are marketed in the UK by water filtration specialists Atkins Fulford (www.atkins-fulford.co.uk) who provide a comprehensive service from initial evaluation and feasibility studies through to commissioning and ongoing servicing.

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Pre-Filtration Options

Alternatives to the Filtomat for RO pre-treatment include self cleaning conventional strainers or gravity sand filters to remove the main solids loading, followed by cartridge filters rated at 5 µm. The combined capital cost of these processes is generally higher than a Filtomat system, which would typically have a lower comparative operational cost. This is because the replacement cost of cartridge filters required downstream of the preliminary filtration process would be high due to residual solids loading. This is especially the case with self cleaning strainers. These generally only filter to a level of 15 µm, and their low filtration area results in particular vulnerability where higher solids loadings are present.

Because the Filtomat filtration medium is constructed of fine thread fibers wound in layers, the technology combines the advantages of surface and depth filtration in a compact design, which can be rated down to 2 µm. The main advantage of the system is the large filtration area. The largest unit (model MTG – see Figure 1) has a small footprint of 4m x 1m, is capable of handling flows up to 300 m^3/h, and has a filtration area of 36 m^2 compared to 1m^2 for conventional strainers. The high filtration area results in reduced flushing frequency and low wastewater production, which is less than 3 m^3 per flushing cycle.

Figure: 1 – Filtomat Microfiber construction

The fine Filtomat threads are wound in layers around a grooved plastic spool cassette. Raw water enters and is filtered through the thread cassettes before passing to a collecting outlet pipe. When particles accumulate within the thread layers, differential pressure increases. At a preset level or time interval, an automatic controller activates the backwash control sequence. After inlet and outlet valves close, and the drain and backwash valves open, the backwash pump delivers pressurised water to a shuttle pipe and from there to nozzles that spray the cassette surfaces. To maximise backwash efficiency, the backwash jet is strong enough to penetrate the thread layer, hit a plastic support and return, forming the reject stream which carries particles out of the cassette, into the filter housing, and through the drain valve to waste.

A piston assembly creates an axial movement of the nozzles. A special synchronised indexing mechanism rotates the cassette carousel to a new position when axial movement is completed. When the cassette carousels have completed a full turn, the filter is clean. The drain and backwash valves close, the pump stops, inlet and outlet valves open, and the filter is put back into service.

RO Technology

So we can understand the benefits of the Filtomat technology as applied in RO systems we now explain how RO works, starting with osmosis, a natural process involving water flow across an ideal semi-permeable membrane. Water passes through the membrane at a faster rate than dissolved solids. The difference of passage rate results in separation of solids from water. The direction of water flow is determined by the chemical potential: a function of pressure, temperature and dissolved solids concentration.

When pure water is in contact with both sides of the membrane there is no flow because the chemical potential is equal on both sides of the membrane. If salt is added to one side of the membrane, the chemical potential of the resulting solution is reduced and osmotic flow from the pure water across the membrane occurs until equilibrium is reached. Equilibrium results when the hydrostatic pressure differential resulting from volume changes on both sides of the membrane is equal to the osmotic pressure of the salt solution.

If we apply an external pressure to the salt solution side of the membrane greater than the osmotic pressure we raise the chemical potential of the water and cause solvent flow in the reverse direction to the pure water side.

This is RO, a cross-flow membrane separation process providing a level of filtration down to ionic levels for removal of dissolved salts. Permeate is produced from the membrane with the majority of the dissolved content of the feed transferred to the waste concentrate stream. RO fundamentals can be summarised into the following main points:

- RO membrane permeate production is proportional to net driving pressure (NDP) across the membrane;
- salt flow is proportional to concentration differential across the membrane and is independent of applied pressure;
- permeate salinity depends on relative mass transfer rates of water and salt through the membrane;
- chemical and physical membrane properties determine its ability to allow preferential transport of water over salt.

The fact that water and salt have different mass transfer rates through a given membrane results in the phenomenon of salt rejection.

There are various factors that contribute to the operating cost of an RO system. These include power requirement, power cost, membrane life and replacement cost, membrane cleaning costs and scale inhibition costs.

RO membrane suppliers specify that 5 µm absolute rated filtration should be placed upstream of their membranes as part of their process guarantee conditions. As Filtomat units are capable of effectively removing 98% of suspended solids above 3 µm, they are used extensively in RO membrane pre-filtration applications. This lower 3 µm filtration rating achievable can reduce the chemical cleaning requirement of RO membranes by a factor of four compared to using 5 µm rated cartridge filtration. Reduction in cleaning frequency has a number of benefits including reduced chemical costs and extended membrane life, as each time a RO membrane is cleaned, membrane integrity is slightly reduced.

A limitation on the achievable NDP is the degree of fouling expected at the membrane surface, and to a large extent this is determined by the level of pre-filtration provided. By using Filtomat units, which can be supplied rated at 3 µm, in lieu of 5 µm cartridge filters, the design NDP can be increased to a higher optimum level thus increasing the permeate production per unit membrane area. The result is a requirement for less membrane area, which means potentially lower RO capital costs. Also, less membrane area in RO systems means less chemical is required to clean the membranes, also reducing costs.

Case Study – Folkestone and Dover Water

In 2004, Atkins Fulford installed two 5 µm rated Filtomat MTG units as pre-treatment to a new RO system provided by Veolia Water to FDWS at Denge Water Treatment Works in the Southern UK.

The RO plant was required to treat one-third of the flow abstracted from local boreholes so that, when the permeate was blended with the other two-thirds of the flow, the arsenic level in the potable water produced could be reduced to well below the DWI prescribed concentration limit of 10 µg/l As, and the chloride level to less than 250 µg/l Cl. Some Seawater ingress into the groundwater source had resulted in high sodium and chloride levels in the boreholes.

Figure 2 – RO membrane system at Denge

Photo by John Leech

The RO plant (Figure 2) was designed to treat one-third of the 12 MLD system requirement, and to ensure efficient use of RO membrane area, three skids were provided each rated to produce 2.2 MLD permeate. Two skids operate in service with standby capacity provided by the third skid – this reserve unit is rotated into service every 24 hours. The RO systems incorporate DWI approved KOCH Fluid Systems TFC (thin film composite) 8821 ULP (ultra low pressure) membranes.

Feed water is filtered by the Filtomat units before entering 5 µm cartridge ‘police’ filters, installed as a failsafe backup, and further processing through high pressure feed pumps (Figure 3). The pumps raise the pressure to 8-9 bar for the RO process, which operates at a permeate recovery of 85%. Contaminants are concentrated into the remaining 15% concentrate stream. Figure 4 shows the two Filtomat units at Denge, and Figure 5 shows the piston assembly, used as part of the flushing sequence.

The option exists to upgrade the Filtomat units to 3 µm rated filters in the future, thus making the process requirement for cartridge filters obsolete. Filtomat units are now supplied with a 3 µm rating for RO pre-treatment as standard.

Figure 3 – RO High Pressure Pumps at Denge

Photo by John Leech

Following blending with non-RO-treated water, pH is adjusted and chlorine is dosed prior to potable water distribution. .The concentrate is discharged to sea via a sea outfall.

The system design was specified following an extensive feasibility study undertaken for FDWS by Veolia Water Partnership. This study concluded that Filtomat pre-filtration should be included. The purchasing recommendations made in the Study were investigated and supported by the design and build contractors Veolia-OTVB, before final ratification jointly by FDWS and Veolia Water.

We asked Gavin McHale, Head of Operations at FDWS, why the Filtomat units were chosen. He highlighted the following main reasons:

- the design was proven and this simplified the installation process;
- the system had DWI approval;
- a successful pilot trial had been undertaken on site.

Mr McHale said, *"The success of the pilot trial with a scaled down version of the Filtomat filter supplied by Atkins Fulford, provided confidence to take this option forward into design development, instead of the more expensive and time consuming option of design and construction of a conventional settlement and filtration pre-treatment stage, which may not have achieved such good quality filtrate."*

The Filtomat unit was considered as an alternative to constructing sand silt trap or settlement structures. These would have involved considerable testing and design development to ensure that they produced the necessary feed water quality for the RO plant, and may have involved two or more stages of settlement and filtration.

Figure 4 – Filtomat Microfiber MTG pre-filters at Denge

Photo by John Leech

In addition to this design uncertainty, construction of the building to house the Amiad and other mechanical and electrical equipment proceeded in parallel with their manufacture, which minimised the overall construction programme. This would have not been the case with constructing sand silt traps or settlement structures, unless on-site resources and costs were increased.

When asked how FDWS rated the Amiad installation, Mr McHale told us that the units, *"...have provided trouble free operation and given good protection to the RO membranes*."

He added, "*We would probably use them again in a similar situation, if proving trials confirmed their suitability*."

Figure 5 – Filtomat Microfiber MTG backwash piston at Denge

Photo by John Leech

Conclusions

The Filtomat Microfiber self-cleaning filter provides a highly effective pre-filtration solution for RO membrane systems. In our particular FDWS case study the technology was chosen following successful pilot trials and because of DWI approval status and simplified installation processes. Because the Filtomat technology is rated at 3 µm, chemical cleaning requirements for RO membrane systems are generally lower and NDP can be higher often resulting in less membrane area required.

Acknowledgements

Thanks to Mr John Leech for his assistance in researching this article and providing images.

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