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Amiad's AMF² pre-treatment technology ensures efficient and reliable nanofiltration of Scottish Highland loch water

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In this feature article we report on the effectiveness of Amiad's AMF² automatic self cleaning filter technology as a pre-treatment for membrane systems. We focus on high and variable suspended solids and colour removal applications where potable quality water is required from nanofiltration (NF) systems. We show how the AMF² units provide effective pre-filtration of Scottish Highland loch water and examine how the technology operates, and how it can be integrated into an overall membrane-based solution. We include details on a project installed at Scottish Water's Mallaig Water Treatment Works (WTW), UK, in 2001, and evaluate the effectiveness of the AMF² units operating on-site. We draw on Scottish Water's operational experiences since the commissioning of their NF plant.

Technical Expertise

Over the last 40 years Amiad Filtration Systems Limited (*www.amiad.com*) has developed a range of compact automatic and manual self-cleaning filters incorporating innovative technology characterised by low operating cost and short capital payback. In addition to membrane pre-filtration protection, Amiad's automatic AMF² units are typically installed in drinking water applications (where they can protect against *Cryptosporidium*), effluent treatment processes, recirculation-water filtration systems, cooling tower main and side-stream filtration applications, and off-shore water injection projects.

Amiad's AMF² filters have been evaluated by the UK Drinking Water Inspectorate 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 Limited (*www.atkins-*

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fulford.co.uk) who provide a comprehensive service from initial evaluation and feasibility studies through to commissioning and ongoing servicing.

Membrane Pre-Filtration

NF membrane suppliers typically specify that 5 µm absolute rated filtration should be placed upstream of their membranes as part of their process guarantee conditions. As AMF² units are capable of effectively removing 98% of suspended solids above 3 µm, they are used extensively as NF membrane pre-filtration protection.

Alternatives to the AMF² typically include sand filtration followed by cartridge filters or the use of self cleaning strainers and cartridges.

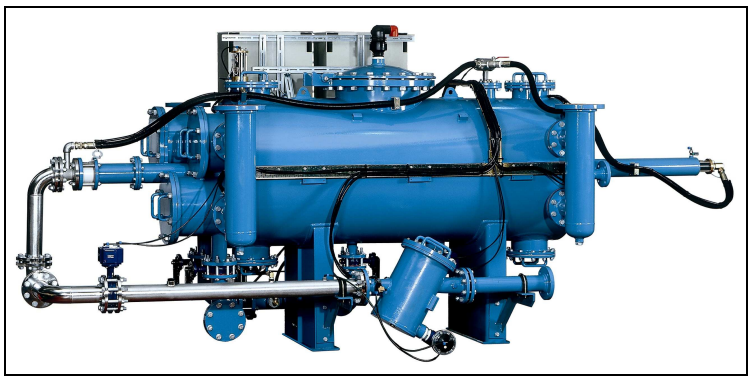
Amiad have undertaken extensive trial work comparing solids removal between AMF² units and sand filters. The results of one study are shown in Table 1.

Table1 – Surface water study data (average values during May to July 2004 – data courtesy of Amiad)

Sample Point	**Turbidity**		**Suspended Solids**					
			Total		*Inorganic*		*Organic*	
	NTU	% removal	mg/l	% removal	mg/l	% removal	mg/l	% removal
Raw Water	3.39		4.8		1.2		3.6	
After Filtomat Microfibre Unit	0.60	82	1.7	65	0.3	94	1.4	71
After Sand Filter	0.74	78	3.2	33	1.3	73	1.4	71

Whilst turbidity reduction was similar at this particular site for the two solids removal methods, the trial results show that the AMF² removed 65% of the TSS as opposed to only 33% removal by the sand filter. The trial also concluded that the AMF² provides for a similar level of organic suspended solids removal in comparison to sand filtration (71%). Also, a higher efficiency removal rate in the inorganic particles is clearly established (94%) compared to the sand filter (73%).

Figure 1 – Typical AMF² automated filtration system installation



If we compare options for NF pre-treatment using an AMF² system as opposed to a sand-cartridge filter system, this would have been more favourable due to lower

capital cost and lower operating cost. The replacement cost of cartridge filters required downstream of sand filtration would be high due to the residual solids loading passing through the sand filter.

The use of self cleaning conventional strainers in membrane pre-filtration has two problems. Firstly, strainers generally filter to a level of 15 µm so additional cartridge filters would be required to meet the 5 µm membrane specification. Secondly, as with sand filters, a substantial loading would pass through to the cartridges, increasing their associated operating cost. This is compounded by the low filtration area of strainers which means they are particularly vulnerable where there is the possibility of higher solids loadings.

The AMF² is a viable option to overcome these problems. Because the filtration medium is constructed of fine threads wound in layers, the Amiad technology combines the advantages of surface and depth filtration in a compact design.

Filtration levels can be selected as low as 3 µm but the main advantage of the system in membrane pre-filtration applications is the large filtration area. The largest unit (model AMF²93K – 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 40 m^2 compared to 1m^2 for conventional strainers. The high filtration area results in reduced backwash frequency but a further advantage of the AMF² is low wastewater production, which is less than 3 m^3 per backwash cycle.

The lower level of filtration achievable by AMF² units has been found by Scottish Water to reduce the chemical cleaning requirement on membranes by a factor of four compared to conventional strainers. Reduction in cleaning frequency has the obvious benefit of reduced chemical costs but also can lead to extended membrane life as each time an NF membrane is cleaned, membrane integrity is slightly reduced.

Reduced membrane system operation costs combined with the ability to remain reliable under varying solids loading conditions means that the additional capital costs of AMF² units compared to strainers are soon recovered.

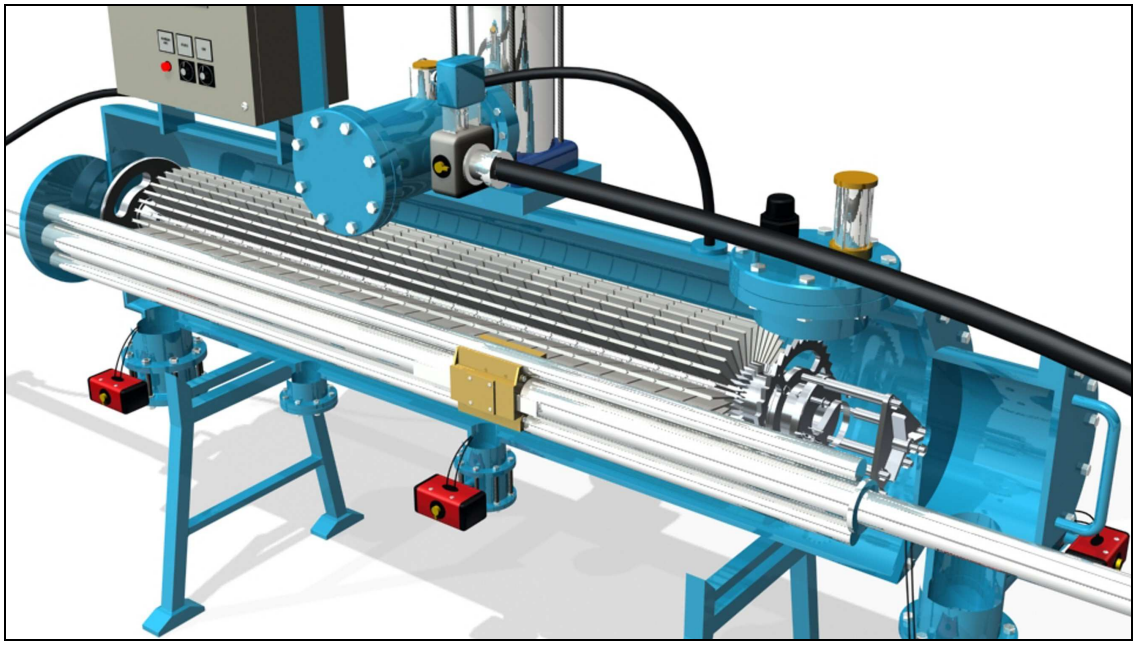
AMF² Operation

Figure 2 shows a schematic of an AMF²93K unit. The automatic self-cleaning filter uses a unique filtration medium constructed of fine threads wound in layers around a grooved plastic spool cassette. Raw water enters and is filtered through the cassettes before passing to the collecting pipe and to the outlet.

When particles accumulate on and inside the thread layers, differential pressure increases. At a preset level or time interval, an automatic controller activates the backwash control sequence. Firstly, inlet and outlet valves close, and the drain and backwash valves open. The backwash pump then 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 the particles out of the cassette, into the filter housing, and through the drain valve to waste.

Figure 2 – AMF²93K construction



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 goes back into service.

Scottish Water Mallaig Project

To illustrate the effectiveness of AMF² units in membrane pre-filtration we now describe one of Scottish Water's NF systems installed at Mallaig WTW. The plant was designed, fabricated and installed in 2001 by water and wastewater process engineering contractor ACWa Services Limited (www.acwa.co.uk), in a building constructed by Tulloch Civil Engineering Limited (*www.tullochlimited.com*).

ACWa's process design comprised Amiad AMF² pre-filtration (supplied by Atkins Fulford), chemical dosing, a single-pass NF membrane system (see Figure 3), post treatment and remineralisation.

The process treats up to 1,764 m^3/day of raw water originating from a Highland loch. The feed supply contains variable, but generally high, levels of suspended solids and colouration. Permeate produced from the NF system is used to provide a potable water supply for local residents. Waste from the system is restricted to 15% of the raw water feed flow supplied.

The pre-filtration system comprises two AMF² units (see Figure 4) that can operate in either parallel or duty-standby mode.

The Amiad equipment was chosen by Scottish Water and ACWa because of the high and variable level of suspended solids contained in the raw loch water. The pre-filters protect the membranes from damage by large particles in the feed-water, minimise operator intervention, reduce running costs, and minimise fouling of the membranes in the NF system.

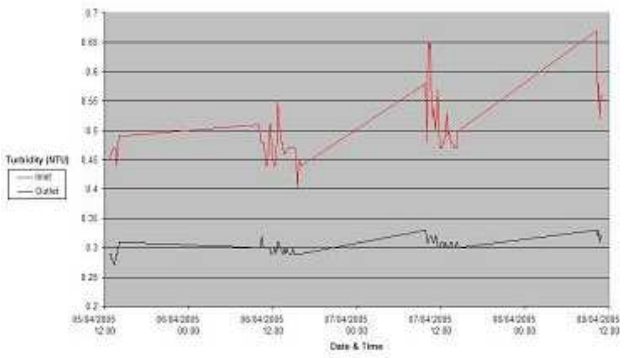
Figure 3 – Nanofiltration membrane array installed at Mallaig WTW (courtesy of ACWa)

Utilisation of the AMF² units also simplified commissioning of the membrane system; Mr Peter Brewer, Senior Process Engineer in ACWa's Membrane Systems Division said: *"During the commissioning of the plant the AMF² system consistently filtered the water as required without interrupting the forward feed flow to the membrane system."*

Regular servicing of the pre-filtration equipment is being carried out every six months by Atkins Fulford. The inlet and outlet turbidity from the AMF² units at Mallaig was evaluated at a recent service visit. Details are shown in Figure 5. The solids' loading is consistently reduced to less than 0.35 NTU from the highly variable loch water supply.

Figure 4 – AMF² pre-filtration system installed at Mallaig WTW (courtesy of ACWa)

Figure 5 – Pre-filtration performance at Mallaig WTW



The ACWa membrane process utilises Koch Fluid Systems 8131 spiral wound NF elements, specially developed to treat water with high levels of organics and colouration. The membrane system treats pre-filtered water, dosed with CO_2, at a rate of 77 m^3/h and comprises four arrays of eight 10 bar rated pressure tubes, each containing four 1.5 m long NF elements.

The plant features fully automatic PLC control with extensive instrumentation used to monitor pressure in the feed, concentrate and permeate sides of the system in addition to chlorine, flow, turbidity and pH in the potable water supply. The system incorporates on-line integrity monitoring using particle counters. The control system allows for remedial action to be taken in the event of a membrane failure without compromising treated water quality.

In addition to effective pre-treatment, it was essential for ACWa to minimise membrane fouling by maintaining a high hydraulic cross-flow velocity across the NF membranes. This was achieved by recirculating pre-filtered water around the membrane system using inverter driven re-circulation pumps installed within the loop containing the membranes. The PLC controls the inverters to maintain a constant low operating pressure and the required permeate flow whilst minimising fouling tendencies. Research had shown that low NF operating pressure was beneficial, as foulants are not compressed at the membrane surface as in higher pressure systems.

Permeate leaving the NF membrane array is sterile but slightly acidic and requires remineralisation. To correct this, the permeate is passed through a granular alkaline media which slowly dissolves to neutralise the acidity and add a small amount of mineral content and alkalinity into the treated water making it suitable for potable use. Residual chlorination is undertaken before the potable water enters Scottish Water's distribution network.

We asked Scottish Water's Mr Robert White for his views on the AMF² system. He told us that the pre-filtration system at Mallaig was selected following a trial on the River Glass in Easter Ross, and successful operation at Bonar Bridge WTW.

He said, *"The AMF² was chosen based on a presentation by Atkins Fulford" but, following 4 years of successful operation, he added that the pre-filtration system has been "…giving first class service at Mallaig and is highly rated by the operations team in the area. The additional bonus is the AMF²'s Cryptosporidium barrier status which gives us further protection."*

Mr White told us that an additional Amiad filtration unit has also been installed at Scottish Water's Bonar Bridge site and they are currently commissioning a unit at Inverasdale WTW.

Regarding operating costs for the membrane system, we asked Mr White whether the use of the pre-filters had reduced the frequency of membrane cleaning or extended membrane life. He said, "*At Mallaig, the frequency of chemical cleaning is significantly less than at our other spiral membrane plants. We await with interest the commissioning of the* AMF² *at Inverasdale where we intend to trial less frequent cleans on the back of our Mallaig experience.*"

Conclusions

The AMF² self-cleaning filter provides a highly effective pre-filtration solution for NF membrane systems. In our particular Scottish Water case study the technology was chosen because of the high and variable level of suspended solids contained in the raw Highland loch water, to prevent damage from large particles in the feed-water, to minimise operator intervention, reduce running costs, minimise fouling of the membranes in the NF system, and simplify commissioning of the overall process.

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