Desalination and Water Treatment
www.deswater.com
6 (2009) 119–124

Performance of ultrafiltration plants in France

Leroux Antoine*, Banham John John

401 Jones Road, Oceanside, CA 92054, United States
Tel. +33 (0) 9 77 83 48 59; Fax +33 (0) 1 39 93 02 01; emails: aleroux@hydranautics.nl, jbanham@hydranautics.nl

Received 15 September 2008; accepted 5 February 2009

ABSTRACT

The demand for high quality municipal potable water is booming all over the world, especially in France where there is an additional requirement for virus reduction that can be satisfied with the use of ultrafiltration (UF) membranes. Many of these advanced treatment plants have been awarded, and are using capillary UF membrane technology, such as the HYDRAcap UF membrane as part of the treatment process. Plant output from these installations ranges from 1000 m^3/d to 150,000 m^3/d and they treat different types of feed waters (mainly surface water and ground water), typically high turbidity values.

Capillary UF is usually used as a final treatment step to successfully remove viruses, bacteria and the finest particles. The removal rating depends upon the pore size of the active layer of the membrane; for example HYDRAcap UF, has approximately 0.02 μm pore size.

This paper will present the current and future trends regarding the use of UF in treatment plants in France. In particular, detailed design and commissioning data for two different plants will be presented. One site is a medium-scale operating plant for potable water use. The high quality of feed water enables the system to run at high fluxes, as we have also demonstrated at many other sites. Secondly, a small scale plant will be described; this plant can also run at high fluxes, but is subject to high concentrations of iron in feed water, which requires frequent cleanings at low pH.

In both cases, UF performance data, including flux, transmembrane pressure, backflush trends and fiber integrity will be presented in order to have a clear picture of the potential of the plant.

Keywords: Ultrafiltration; Performances; Surface water; High permeability; High integrity

1. Experience of a medium-scale plant: Nerac, France

1.1. General information on the plant

Nerac is located in south west of France near Toulouse. The potable water treatment plant has been upgraded in 2008 in order to meet high water quality criteria. The plant has been designed and commissioned by OTV (Veolia group) and can provide 10,000 m^3/day (2.64 MGD) of ultrafiltered water with a 4 log removal of cryptosporidium, giardia and viruses. It has been accepted by the enduser and approved by Competent Sanitary Agency early June 2008.

The treatment upstream of the ultrafiltration (UF) line is composed of a coagulation-flocculation-clarification step, followed by filtration on granular activated carbon bed.

These treatment steps will mean that the UF membranes actually receive feed water which has undergone a significant reduction in solids loading along with removal of other pollution parameters. This allows the membranes plant to run at high flux and relatively long filtration cycles, thereby allowing a

*Corresponding author

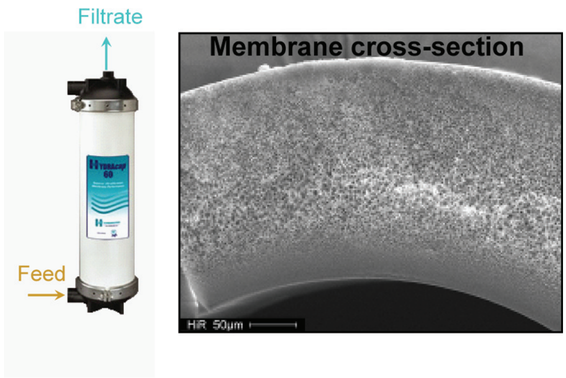

Fig. 1. Hydracap 60 ACS – 46 m^2 UF module.

reduced number of membranes and an optimized water recovery for the UF plant.

The UF facility is equipped with 100 Hydracap 60 ACS membranes arranged as 2 racks of 50 modules. The Hydracap module is a self-contained module which has 46 m^2 of surface area and approximately 13,000 polyethersulfone fibers. These fibers have an active membrane layer on the inside and more porous supporting structure on the outside (Fig. 1). Water passes from inside to outside of the fiber, in 'dead-end' mode operation as shown in Fig. 1 diagram, although the module configuration does allow for a 'cross-flow' option in which some of the feed flow can displace accumulated solids to waste, if required for short periods of time.

The modules operate at a nominal flux of 110 Lmh, and the filtration timer is set at 45 min. This timer can be increased when the flux per skid is lower any fouling layer will build less quickly. Every rack must be backflushed frequently in order to remove solid loading accumulated at the membrane surface. In addition to normal backflushes, the membranes are frequently cleaned by dosing chemicals into the backflush flow. These 'chemically enhanced backflushes' (CEBs) are fully automatic in operation to administer effective cleanings for disinfection of the membranes (2–3 chlorine clean (CEB1) per day ay 10 ppm free chlorine concentration), for organic fouling removal (1 caustic clean (CEB2) every 3 days at pH 12) and for mineral foulant removal (1 sulfuric acid clean (CEB3) every 12 days). The flux used for these CEBs is the same as for the normal backflushes at 250 Lmh (approximately two times design filtration flux).

The efficiency of these chemical backflushes is further improved by combining with an 'air enhanced backflush' (AEB), which is incorporated during soaking of the chemical. In this step, the inside of the fiber is pressurized up to 1 bar, while the outside of the fiber is soaked in chemical solution (chlorine, caustic or acid).

The relatively high fluxes using ultrafiltered water in reverse flow provide a sufficient driving force to remove particulates accumulated at the membranes surface. As such, all of these cleanings are carried out over a relatively short cycle time.

1.2. Performance of the UF workshop

As shown in Fig. 2, the UF inlet turbidity (blue trend) has been successfully kept at a low level (ranging from 0.05 to 0.2 NTU average). Although the temperature (yellow trend) currently remains at high values, it is likely to go down to 5°C in winter periods. Thus, it is important to maintain high membrane permeabilities to be able to operate well with the higher viscosity of feed water at these low temperatures, which reduces the ease of water passage through the membrane. In order to follow the membrane performance, it is necessary to refer to temperature corrected specific flux (TCSF) which adjusts the actual flux to a 20° reference temperature.

Fig. 3 shows the evolution of performance of rack no. 1. The TCSF is ranging from 500 Lmh/bar to 600 Lmh/bar average. This is ideal for handling any increase in transmembrane pressure (TMP) during periods of low temperature. Note that the flux (pink trend) is normally set at 110 Lmh or 55 Lmh, depending on water demand.

The first months of operations show very stable hydraulic performances. The membranes have coped with particulate loadings and operated under controlled conditions. All fouling events have been handled successfully using relatively low chemical backflushes frequencies.

Fig. 4 shows the evolution of permeability (light blue) and TCSF (dark blue) over a filtration timer for skid no. 1. TCSF is dropping gradually from 490 to 450 Lmh/bar until release of a regular backflush (yellow spike). This backflush enables to recover initial TCSF threshold. This curve evolution is repeated every time a backflush is carried out.

2. Experience of a small scale plant: Maumont, France

Many small capacity plants have been commissioned or will be commissioned by the end of 2009. One of them is Maumont plant located in Limousin, France which has started its operation in April 2007.

The plant has been designed and commissioned by OTV (Veolia group), its capacity is 2800 m^3/d (513 gpm) and it is equipped with two racks of 16 Hydracap ACS 60 membranes. It is treating surface water that has high concentrations of iron, especially in summer.

Water is first of all treated by aeration then by ACTIFLO (OTV's high speed lamellar settler aided

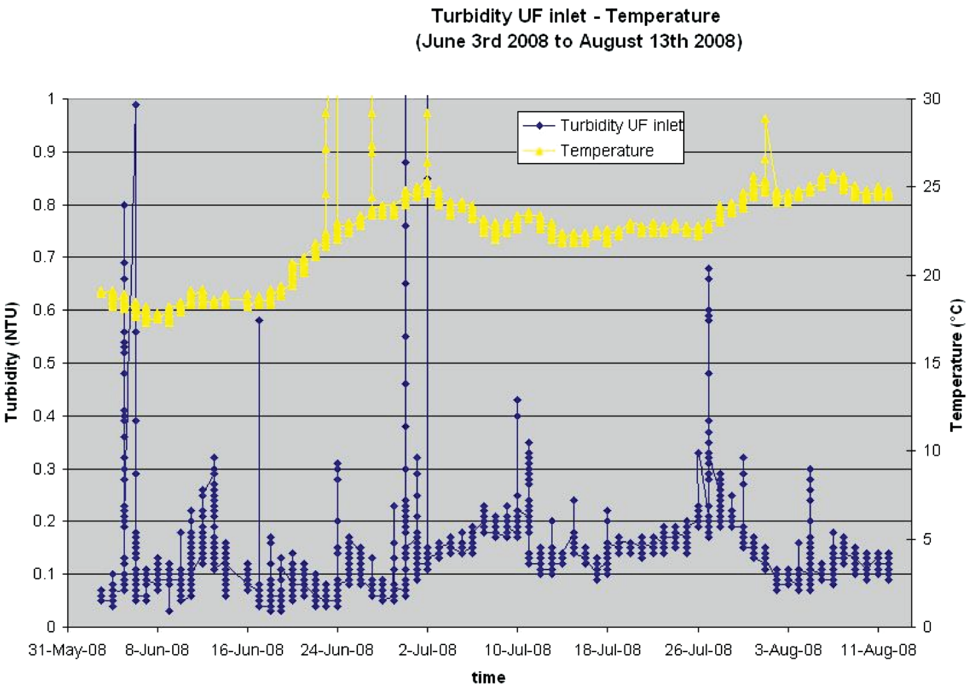

Fig. 2. Evolution of UF feed water parameters: turbidity and temperature – from June 3rd 2008 to August 13th 2008.

by micro sand) which includes coagulation (ferric chloride) – flocculation (anionic polymer) steps, followed by filters (three layers manganese dioxide, sand and granulated activated carbon). The UF step is the final polishing step (Fig. 5).

As presented in the chart above, UF inlet turbidity is below 0.5 NTU enabling UF membranes to perform under stable feed conditions in terms of solids loading.

The water temperature is quite variable over the year and can reach values around 7°C in winter period.

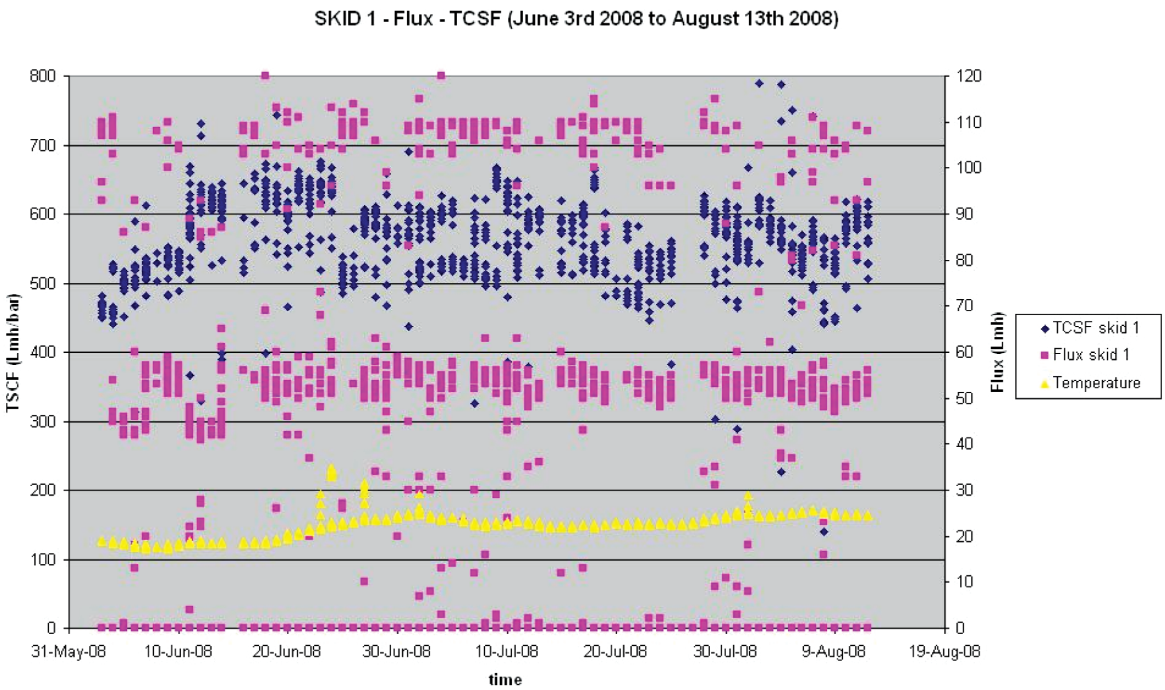

Fig. 3. Evolution of TCSF and flux for skid no. 1 – from June 3rd 2008 to August 13th 2008.

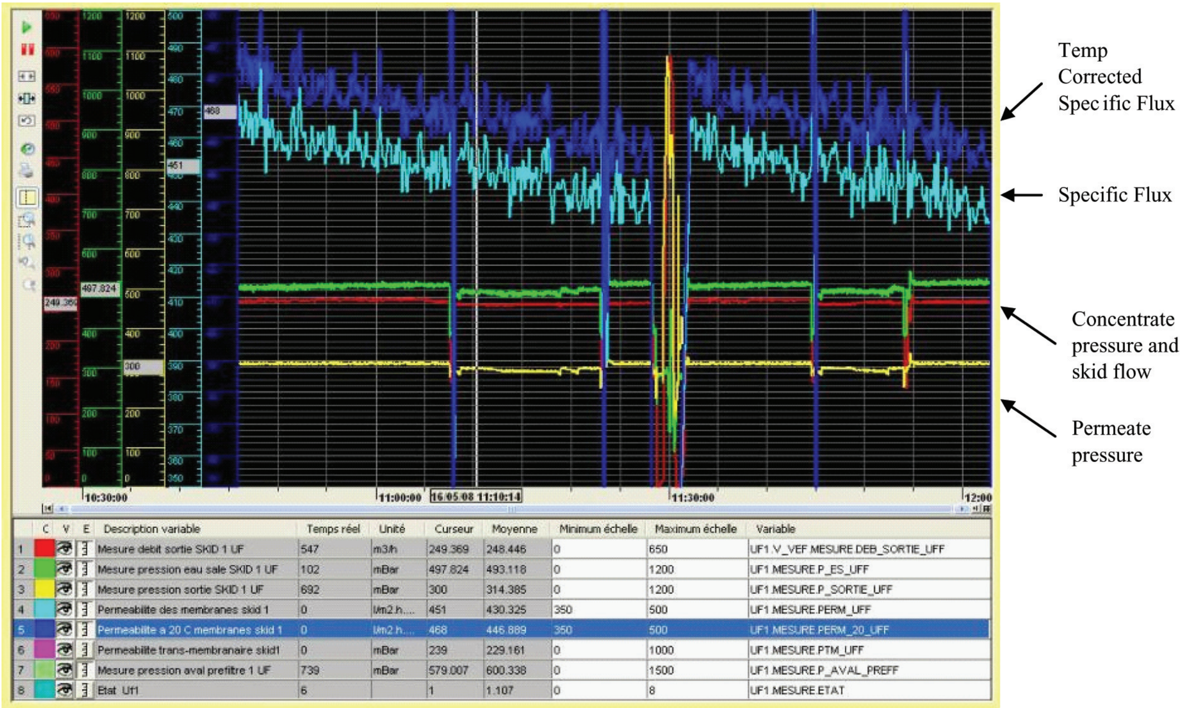

Fig. 4. Evolution of TCSF for skid no. 1.

Nominal flux is set at 105 Lmh with a 40 min filtration timer (this timer can be changed for a lower demand). CEBs using chlorine are performed 2–3 times a day, with caustic and acid backflushes every 3 days. The chemical backflushes are actually more frequent for this plant as the UF feed water is likely to contain some iron derivatives (in Fe^{2+} and Fe^{3+} forms).

Permeability drop over the August to December 2007 was due to iron fouling on the membrane surface. This has an effect on the TMP since the fouling layer will disturb water passage through the membrane and higher feed pressure is required to achieve the output flow. Initial acid chemical backflushes had been set at 12 days interval but were readjusted early 2008 taking

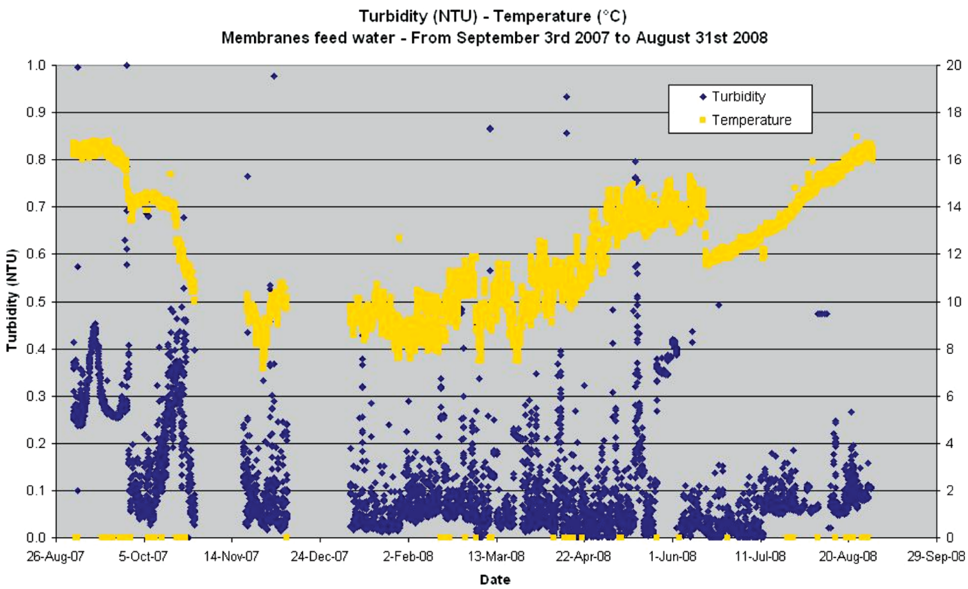

Fig. 5. Evolution of UF feed water parameters: turbidity and temperature – from September 3rd 2007 to August 31st 2008.

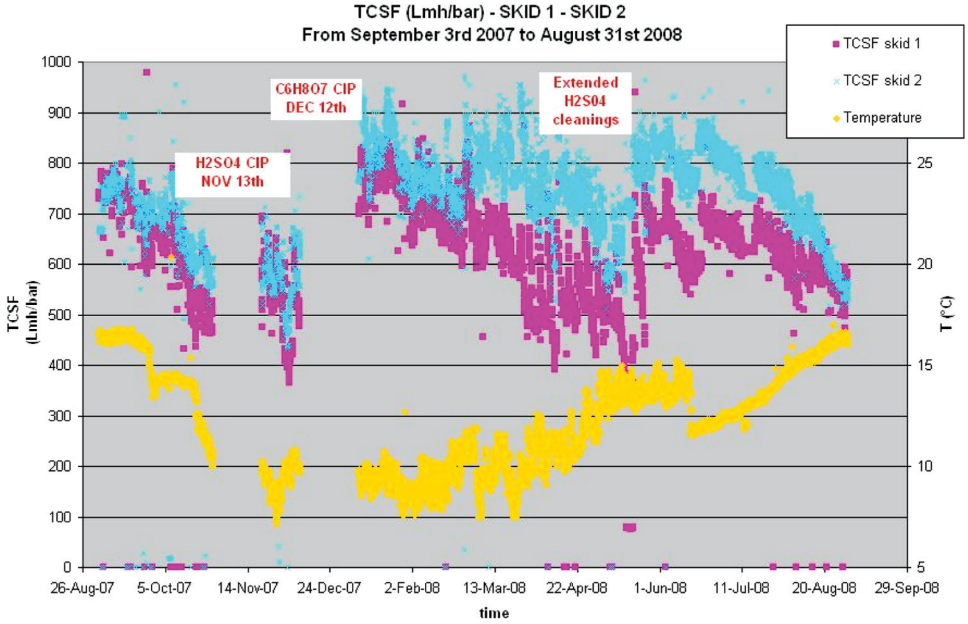

Fig. 6. Evolution of UF performance: TCSF (Lmh/bar) skid 1 and skid 2 – from September 3rd 2007 to August 31st 2008.

into account the levels of iron in the water. These chemical backflushes enable to prevent this kind of fouling from building up on the membrane over time.

As presented on Fig. 6, following the TCSF decrease in October 2007, a first clean in place was carried out on November 13th using sulfuric acid heated at 29°C. However, this CIP did not enable a good recovery of permeability which remained at the same level (TCSF around 450 Lmh/bar).

A 2% citric acid solution (heated at 35°C) was used for a clean in place procedure in December 2007. The solution has been recirculated through fibers for quite a long time (3 h).

This CIP was very successful for removing the iron fouling.

TCSF values after that cleaning were even higher than the initial threshold. The modification in chemical enhanced backflush frequency enabled the plant to

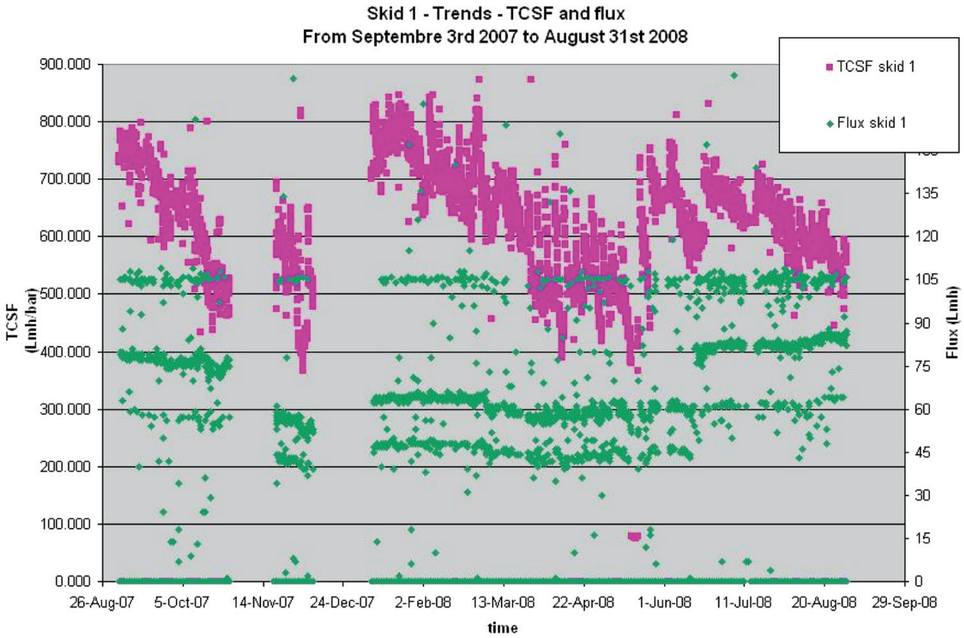

Fig. 7. Evolution of UF performance: TCSF (Lmh/bar) and flux (Lmh) skid 1 – from September 3rd 2007 to August 31st 2008.

operate for the next six months with permeabilities higher than 400 Lmh/bar. Another CIP was performed in May 2008 with sulfuric acid and was efficient to recover permeability (Fig. 7).

3. Conclusion

Hydranautics has a long experience in UF potable water application.

We have seen that UF capillary membranes can be effectively employed as a final treatment for low solids loaded water applications. They offer protection against parasitic protozoa, bacteria and viruses as well as guaranteeing very low turbidity 'particulate-free' treated water. As Maumont demonstrates, they can successfully handle different types of water, including those with iron fouling potential. The relatively high operating fluxes offer an economical solution to the provision of treated water of the highest microbiological quality.

For both of these plants, high integrity of the modules was maintained since commissioning of the plant. In addition to having a robust and strong fiber within the modules, the systems are designed with optimized hydraulic conditions and electromechanical operation.

For now, four fiber breaks have been counted in Nerac and Maumont since the beginning of operations.