Seedy Mill, South Staffs WTW
recovery of filter backwash water using novel UF technology

by Dr Graeme K Pearce, Ms Julie Allam, Javier Suarez & David James

The conventional treatment of surface water for potable application usually includes sedimentation followed by coagulation and media filtration. Operation of such systems generates a discharge stream, mainly comprising backwash water from the media filters. The discharged volume represents about 2% – 5% of the treated flow. The backwash stream contains suspended materials that were removed from the treated water and flocculant chemicals. It also may contain a high concentration of pathogens that were originally present in the surface water. Use of conventional-technology to process backwash water may represent a problem in systems processing surface water for potable applications. The backwash water may contain high concentration of bacteria, giardia cysts and cryptosporidium oocysts. Conventional water treatment technology does not provide a consistent removal level of pathogens.

(courtesy *Hydranautics UK)*

Novel, backwashable, membrane capillary ultra filtration technology from Hydranautics is now being applied specifically for backwash treatment of conventional filtration discharge streams. The HYDRAcap capillary technology has a very high rate of pathogen rejection, and at the same time, has the capability to reclaim some of the backwash water and reduce the discharge volume down to 10 to 15% of the initial backwash stream.

This paper will describe the design and operational results of the UF capillary system treating a settled filter backwash effluent from the Seedy Mill treatment works operated by South Staffs Water.

Seedy Mill WTW

Seedy Mill is a large potable water treatment works, which is fed with raw water from Blithfield Reservoir. The existing 100Ml/d works consists of flocculation, accelerator clarifiers and dissolved air flotation, rapid gravity filtration, chemical dosing, contact tanks and sludge treatment plant. *Purac* are just completing additional works at Seedy Mill to increase the throughput capacity of the works by 48.4Mld with the provision of eight-off new Rapid Gravity Filters (RGF), a new supply from Trent Valley Pumping Station, recovery of washwater supernatant, and incorporation of the on-site borehole. The RGFs are using a granular activated carbon medium.

Also included is the addition of a membrane treatment plant for the removal of cryptosporidium oocysts from settled dirty backwash water produced by the water treatment process. Main driver for using the membrane process has been to recover 2.4Mld of the limited water resource.

The membrane pilot programme was undertaken during May/June 2001, installation of the membrane system for the main plant was completed December 2002, with commissioning and acceptance testing January/February 2003. Operation of the fully upgraded plant is scheduled for September 2003.

The technology

HYDRAcap capillary ultrafiltration membrane technology, is manufactured by *Hydranautics* in both 0.8mm and 1.2mm O.D. Molecular weight cut-off of the capillary membrane is 100,000 - 150,000 Daltons. The fibre polymer is polyethersulfone, modified to maintain a hydrophilic property. The flow pattern is inside out (feed water enters bore of the capillary.).

The operation sequence consists of a forward filtration step of approximately 20-30min, followed by a filtrate backwash (20-30 sec). During the backwash step the foulant layer is lifted from the capillary membrane surface and flushed out from the capillaries. The frequent cleaning results in stable permeate flux rates. During the forward filtration step feed pressure is in the range of 0.3 to 1.0 bar (4–15 psi).

The *Hydracap* modules are connected together in a parallel array of *HYDRABLOC*™ skids. Each *HYDRABLOC* will process water, backwash and undergo an integrity test as a single entity.

Operating parameters

Field experience indicates that, for backwash water recovery applications, larger ID capillary fibres are required, as compared to the conventional 0.8mm, to prevent plugging of the fibre bore. A 50% larger ID of 1.2mm is sufficient to prevent fibre blockage by suspended matter encountered in filter backwash effluent. The LD module contains approximately 2/3rds of the area of the standard fibre module.

A pilot unit, equipped with the HYDRAcap LD module, was operated for the treatment of filter backwash effluent at **Seedy Mil**l. Objective of the study was to optimise process parameters for design of a full scale commercial system at this location. The unit was treating supernatant from a continuous thickener. The thickener was receiving backwash water from a commercial filtration system processing surface water for potable use. The module operated at a filtrate flux rate range of 80–100 l/m²hr (44–55 gfd). The time between backwash cycles was 20 minutes.

The backwash operation was initiated with a 5 sec forward flush at a flow rate of 7.5 m³/hr (33 gpm) (though in the main plant design, this has been replaced by an air enhanced backwash step). This was followed by a backwash, 10 seconds from the top end of the module, and then 10 seconds from the bottom, at a flux rate of 395 l/m² hr (219 gfd). The effect of backwash sequence on the capillary membrane permeability is shown in fig 2. Four times a day the backwash was followed by a five minute soak time with permeate containing 10 ppm of NaOCI. A caustic cleaning with 0.03 M NaOH was conducted 1–2 times a week. Backwash volume was 7–8% of feed flow and recovery rate was close to 90%. including forward flush step.

Results & discussion

Fig 2 illustrates the Flux and TMP profile of a module with 1.2mm ID fibres operating for five weeks (16th May to 21st June). System operational data was taken approximately every four hours. These values correspond to the instant just after backwash. Performance was very stable over this period, with permeability around 240 l/m2hr.bar (141 gfd-psi) after backwash

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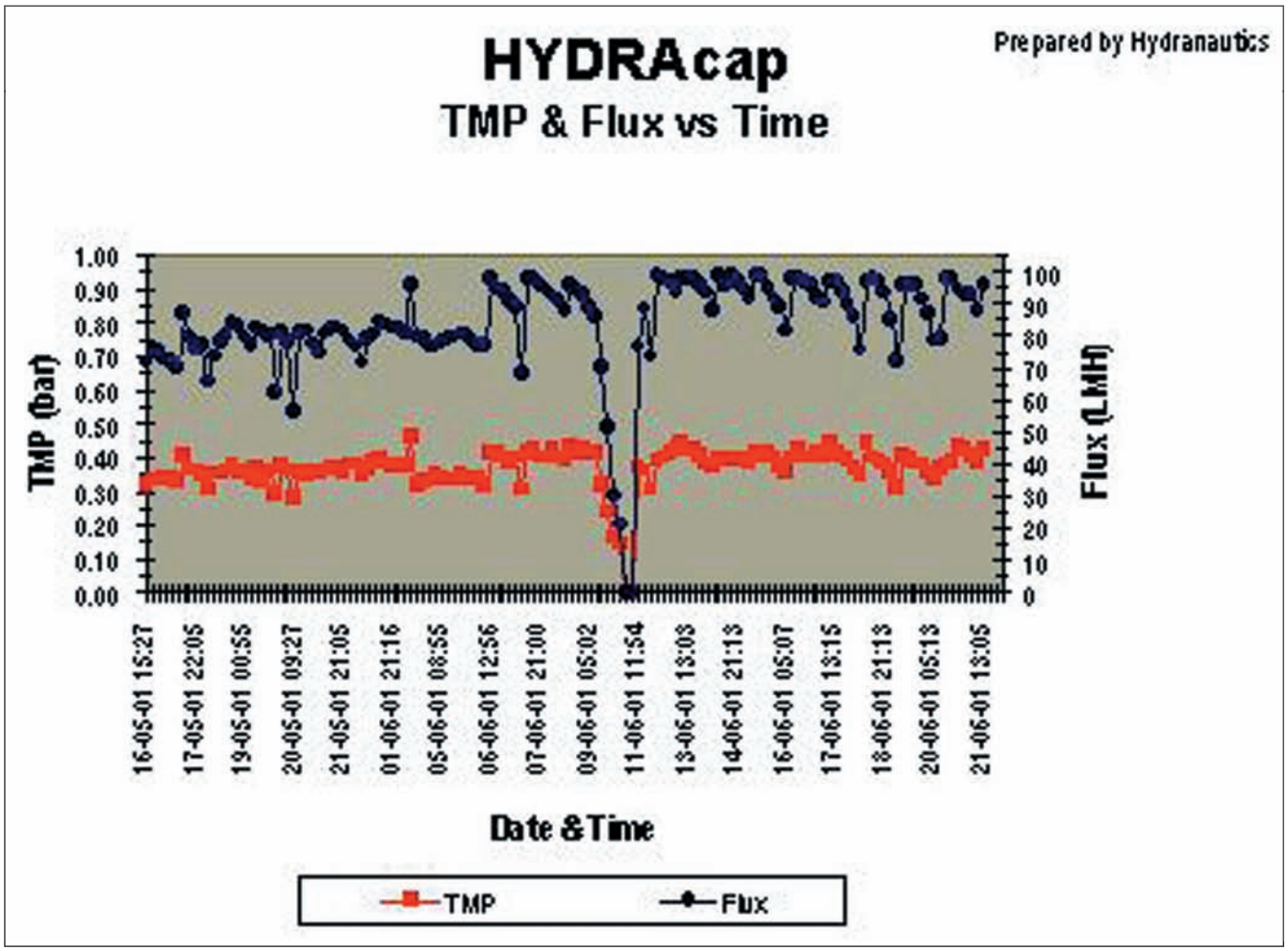
dropping to approximately 140 l/m2hr.bar (82 gfd-psi) just before backwash.

An initial trial period with a module containing 0.8mm fibres showed that it was not possible to maintain permeability without using a full chemical cleaning procedure every few cycles. It appeared that the backwash process was not capable of removing accumulated solids effectively from the inside of fibres, resulting in a progressive loss of permeability in successive cycles.

Table 1 shows a summary of feed and filtrate quality for the trial with 1.2mm fibre module. Results indicate very good reduction of turbidity and coliform bacteria. As can be expected, no significant reduction of colour was achieved. As the graph shows, occasionally permeability declined especially during the night and weekends due to fouling of the strainer which occurred on 10th-11th June. However, after manual cleaning of the strainer, the flux returned to its original value.

of 80 l/m²hr (47gfd) with a 20 minute operation sequence between backwashing. The forward flush cycle used in the pilot has been replaced by an Air Enhanced Backwash step in the main plant design. In this step, feed is displaced by air and pressurised at 1 bar prior to backwash (b/w), thereby significantly enhancing the b/w efficiency in high feeds solids applications. This has been found to be at least as effective as the forward flush, and improves recovery by approximately 1.2%. The Air Enhanced Backwash is carried out four times per day immediately after the chlorinated CEBs to minimise the chemical waste volume.

In January 2003, the membrane system was commissioned. Performance tests were satisfactorily completed in February, with confirmation of the pilot plant operating and performance data. One polymer fouling incident occurred during commissioning when an excess of untreated polymer passed through to the membrane, but a caustic clean effectively restored performance.



(courtesy *Hydranautics UK)*

Table 1. Summary of feed and filtrate quality results

	Average	Minimum	Maximum
Feed turbidity	2.08	0.97	4.50
Filtrate turbidity	0.12	0.05	0.26
Feed fecal coli	1.48	0.00	10,20
Filtrate fecal coli	0.00	0.00	0.00
Feed colour (Hazen)	8.12	6.25	10.50
Filtr.colour (Hazen)	7.36	4.20	10.00

UF system design

The commercial system design, based on the results of the pilot unit operation, utilises *48 HYDRAcap-LD membrane modules* mounted vertically in a parallel array in four racks of 12 modules. The plant has been designed to operate at a flux rate

Conclusions

* performance of the HYDRAcap LD module (1.2mm ID fibres) on the settled filter backwash effluent gave stable performance, with a TMP of 0.35 – 0.40 bar (5-6psi) at a flux of 80-100 l/m².hr (47 – 59 gfd) and 20 mins run time;
* backwash volumes were 7.8% of forward flow and recovery of the plant was close to 90%, including forward flush;
* filtrate quality was excellent
* disinfection with 10 ppm NaOCI is required 4 times a day;
* chemical cleaning with 0.03M NaOH is required 1–2 times a week.■

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