Recovery of Filter Backwash Effluent using HYDRAcap UF at Seedy Mill, South Staffs Water

By

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Introduction

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.

Novel, backwashable, membrane capillary ultrafiltration 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 10-15% 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 Water Treatment Works

Seedy Mill is a large potable water treatment works, which is fed with raw water from Blithfield Reservoir. The existing 100 Mld works consists of Flocculation,

Accelator Clarifiers and Dissolved Air Flotation, Rapid Gravity Filtration, Chemical dosing, Contact Tanks and Sludge Treatment Plant. Purac are just completing addition works at Seedy Mill to increase the throughput capacity of the works by 48.4 Mld with the provision of 8-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 media.

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. The main driver for using the membrane process has been to recover 2.4 Mld 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

HYDRAcap Membrane Technology

Hydranautics manufactures the HYDRAcap capillary ultrafiltration membrane technology in both 0.8 mm and 1.2 mm O.D. Molecular weight cut-off of the HYDRAcap 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 20-30 min, 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 the 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^{TM} skids. Each HYDRABLOC will process water, backwash, and undergo an integrity test as a single entity. Figure 1 shows the 4 HYDRAbloc installation at Seedy Mill.

Figure 1: HYDRAcap Installation at Seedy Mill WTW

Operating parameters

Field experience indicates that, for backwash water recovery applications, larger ID capillary fibres are required, as compared to the conventional 0.8 mm, to prevent plugging of the fibre bore. A 50% larger ID of 1.2 mm 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 Mill. The objective of the study was to optimize process parameters for a 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 $l/m^2.hr$ (44-55 gfd). The time between backwash cycles was 20 min.

The backwash operation was initiated with a 5 sec forward flush at a flow rate of 7.5 m^3/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 the flux rate of 395 l/m^2.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 5-minute soak time with permeate containing 10 ppm of NaOCl. A caustic cleaning with 0.03 M NaOH was conducted 1 – 2 times a week. Backwash volume was 7 – 8% of feed flow and the recovery rate was close to 90%, including forward flush step.

Results and Discussion

Figure 2 illustrates the Flux and TMP profile of a module with 1.2 mm 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 a permeability around 240 l/m^2.hr.bar (141 gfd-psi) after backwash dropping to approximately 140 l/m^2.hr.bar (82 gfd-psi) just before backwash.

An initial trial period with a module containing 0.8 mm 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 the fibres, resulting in a progressive loss of permeability in successive cycles.

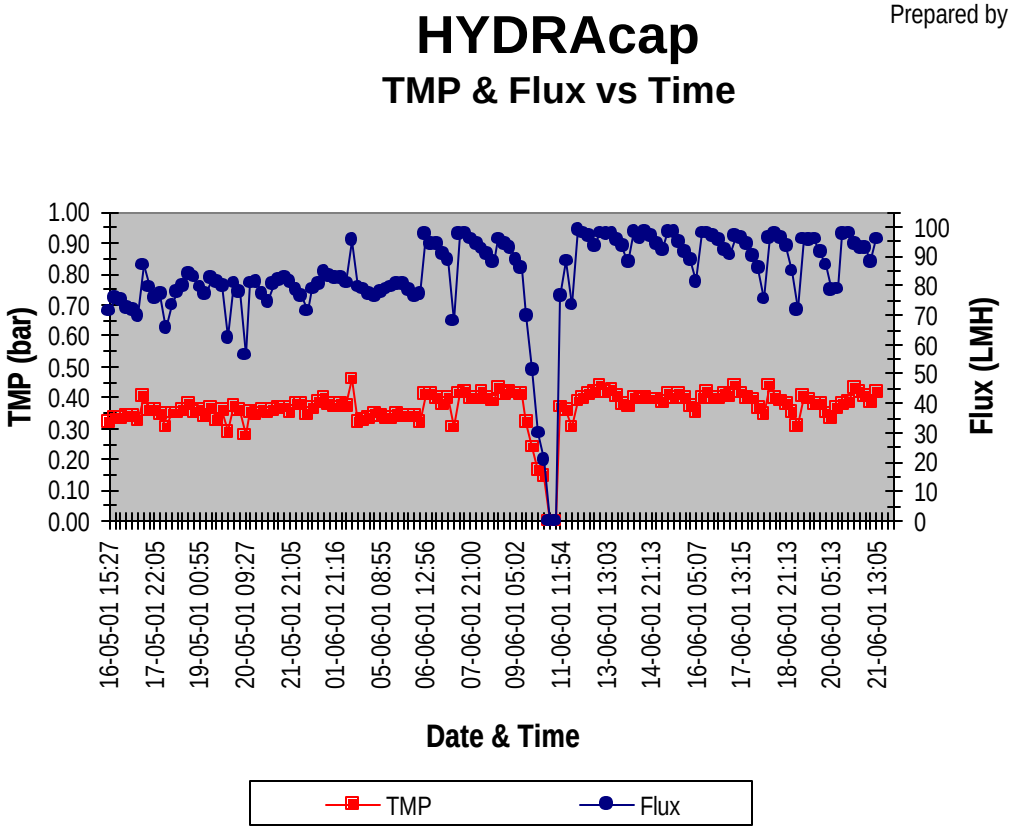

Figure 2: HYDRAcap TMP & Flux vs. Time

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

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 color (Hazen)	8.12	6.25	10.50
Filtr. color (Hazen)	7.36	4.20	10.00

UF system design

The commercial system design, based on the results of the pilot unit operation, utilizes 48 HYDRAcap-LD membrane modules mounted vertically in a parallel array in 4 racks of 12 modules. The plant has been designed to operate at a flux rate of 80 l/m^2.hr (47 gfd) with a 20 min 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 pressurized 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 4 times per day immediately after the chlorinated CEB's, to minimize the chemical waste volume.

In January 2003, the membrane system was commissioned. The 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 unreacted polymer passed through to the membrane, but a caustic clean effectively restored performance.

Conclusions

- Performance of the HYDRAcap LD module (1.2 mm ID fibers) on the settled filter backwash effluent gave stable performance, with a TMP of 0.35 - 0.40 bar (5-6 psi) at a flux of 80-100 l/m^2.hr (47 – 59 gfd), and 20 minute run times.
- Backwash volumes were 7-8% of forward flow, and the recovery of the plant was close to 90%, including forward flush.
- Filtrate quality was excellent.
- Disinfection with 10 ppm NaOCl is required 4 times a day.
- Chemical cleaning with 0.03M NaOH is required 1-2 times a week.