FAILURE OF UF MEMBRANES AT COWES CLASS A TREATMENT PLANT

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ABSTRACT

The Cowes Recycled Water Treatment Plant (CRWTP) was commissioned early in 2012 utilising ultrafiltration (UF) membranes. Almost 3 years later the membranes were suffering an increased rate of failure during daily integrity tests. Initial investigations pointed to either an over exposure to chlorine during periods of preservation or prolonged periods of drying out of the membranes due to a leaking non return valve, again during periods of preservation.

This paper summarises the investigation and serves as a warning to other facilities to ensure that instrumentation, SCADA and procedures are in place to better protect this expensive infrastructure.

1.0 INTRODUCTION

In 2011, Westernport Water commenced construction of the Cowes Recycled Water Treatment Plant (RWTP) at the Cowes Waste Water Treatment Plant on Phillip Island. This RWTP comprises pre filtering, Ultra Filtration (UF) membranes, Ultraviolet (UV) disinfection and chlorination.

In early 2012, the plant was commissioned and successfully produced Class A standard water. This water was delivered into a new pipe network to the Cowes Golf Club and various new residential subdivisions fitted out with 3rd pipe infrastructure.

In 2014, after a 6 month period of preservation, the membranes were brought back into service and immdiately began failing daily integrity testing. An investigation revealed several issues with the RWTP and its operating procedures.

2.0 DISCUSSION

When the Cowes RWTP is operating, a daily integrity test is performed on the UF membranes, which entails pressurising the membrane modules with compressed air, monitoring pressure loss and visually inspecting the transparent tops of the membranes for evidence of air bubbles as depicted in Photograph 1. UF membranes have properties that allow water but not air to pass through the pores in the membrane wall. Evidence of air bubbles, therefore indicates that there is a hole in the membrane wall larger than the pore size of the membrane. Each pore is smaller than the smallest expected virus, therefore evidence of air bubbles is a warning that viruses may be able to pass through the filtration process.

If air is observed during an integrity test, the top of the membrane module is removed and the suspect membrane fibre is located visually and pinned, which entails pressing a small nail into the fibre, as shown in Photograph 2. This fibre is then permanently isolated from the filtration process. There are approximately 6000 fibres per module and the Cowes RWTP has 24 modules.

During the first 3 years of operation approximately 10 pins were required which equated to an average of one pin per 20 days of operation.

In 2014 however, 10-30 pins were required each day. Aside from the labour involved in finding and pinning 30 failed fibres across 24 modules, this rate of failure indicated that there was a serious problem with the membranes with respect to water quality and public health.

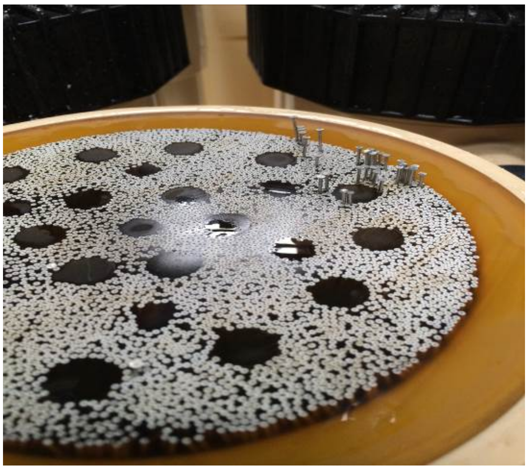

Figure 1: ***Integrity Testing*** **Figure 2:** ***Membrane Pinning***

3.0 INVESTIGATION

The Cowes RWTP was taken offline and a systematic investigation was undertaken, revealing two plausible causes for the increase in membrane defects.

Cause No. 1

In preservation mode, an EFM (Enhanced Flux Maintenance) is undertaken which involves the preparation of a hypochlorite (300ppm) and caustic soda solution, which is recirculated through the membranes for a few minutes, then left to sit for 24 hours. The following day, the chlorine concentration is checked, adjusted if required, then recirculated through the membranes once again for a few minutes. This process is repeated every day during the preservation period.

An ambiguity between the SOP and site training meant that that when the EFM preparation was checked each day, it was re chlorinated back to 300ppm before it was recirculated. This style of membrane has a limit with respect to exposure to chlorine, expressed in terms of ppm of chlorine over a time period. In this way the allowable time period of exposure reduces as the concentration of chlorine increases. Membranes will become brittle as their exposure to chlorine increases.

Our investigation confirmed that only the initial EFM, at the start of the preservation period, requires an elevated chlorine concentration. The subsequent daily recirculation must have a much lower chlorine concentration of 1-2ppm.

Cause No. 2

After recirculation through the membranes, the pump was turned OFF and it was discovered that the membranes did not remain flooded. Over an hour or so, the water level in the membranes fell, leaving the upper portion of the membranes dry. The reason for this was either a leaking check valve or a leaking drain valve. Closer inspection revealed that the O Ring seal on the check valve after the recirculation pump was missing, suspected to have been torn away by the pumped flow.

Figure 3 shows an elevation of the UF membrane modules with respect to the UF feed water tank. Due to the leaking check valve, the water in the vertical modules (in the left of the photo) drained down to the level of the water in the feed tank (in the right of the photo). This backflow continued for an hour or so, leaving the upper 1/3 of the membrane modules without water for the following 23 hours. Membranes can be damaged if they are allowed to dry out, and there is still some debate whether 23 hours is long enough for the membrane fibres to dry out fully enough to cause damage.

Figure 3: ***Side View of Membrane Modules and Feed Water Tank***

4.0 SOLUTIONS

At this point it cannot be confirmed which of the two suspected causes is the reason for the membrane failures. While an autopsy of the individual membrane fibres should determine the actual mechanism of failure, it is acknowledged that both situations are undesirable and in need of rectification, consequently the following actions are to be put in place.

4.1 Modify Preservation Procedures

The SOP for the preservation of the membranes has been modified to reflect that only the first recirculation is exposed to a highly chlorinated solution. The new SOP also states that after 24 hours, the water in the feed tank is to be replaced with potable water and recycled daily with the chlorine residual manually maintained at 1ppm. Every 14 days, the feed water is to be replaced with fresh potable water.

4.2 Minimise Risk of Backflow

A HAZOP was undertaken at the design stage of this project and the consequences of reverse flow were mainly directed at the risk to public health rather than the protection of the membranes.

The consequences of drying out of membrane fibres was not a consideration, therefore a basic check valve arrangement was deemed to be adequate. A testable check valve arrangement will soon be installed between the pump and the membrane modules enabling a routine confirmation that the check valve is sealing fully.

4.3 Add a Point Level Switch

A point level switch is to be installed on the upper mainifold of the membrane pipework as shown in Figure 4. This will alert if water is not detected above the membrane modules.

<u>Figure 4:</u> ***Upper Membrane Manifold where Level Switch will be Located***

4.4 Modify SCADA

The SCADA system is to be programmed with the following modifications in order to warn of possible backflow:

Alert if the water level in the feed water tank rises after the recirculation pump is turned OFF each day during preservation mode.

Alert if the new point level switch goes into alarm during preservation mode.

5.0 CONCLUSION

There are various lessons from this experience at the Cowes RWTP. This has been an harsh introduction to membrane technology, and we a trust that this paper highlights a few issues and emphasises that adequate instrumentation, SCADA and procedures must be in place to better protect this expensive infrastructure.