Operational Experiences of the Clay Lane Ultrafiltration Plant

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Veolia Water Partnership
Three Valleys Water

- Supply area is the Home Counties, north and west of London
- 5 major treatment plants including the largest ultrafiltration plant in Europe
- 60% groundwater from over 100 boreholes
- 40% surface water
Clay Lane UF Building
Brief History of Clay Lane

- Originally a service reservoir site
- First reservoir built in c.1875
- Reservoir capacity was extended in 1920’s and 1950’s
- Treatment plant was originally constructed in 1953
  - Lime- Soda Softening, Filtration and Disinfection
- First major refurbishment took place in 1995
  - Ozone and GAC installed
- Ultrafiltration installed in 2001
The Process

- Source Works
- Ozone contact tanks
- GAC filters x12
- Contact tanks x2
- hypochlorite
- bisulphite
- Reservoirs
- Ultra-filtration
- Relift pumps
- Phosphoric acid
Ultrafiltration - the absolute barrier

- At a pore size of 0.02 to 0.03 microns it will remove Cryptosporidium and Giardia

  The removal efficiency depends on maintaining membrane integrity

  It will also remove bacteria and most viruses and is considered to be a disinfection process

  Operated to achieve 5 log 99.999% removal of Cryptosporidium
Cross-section of Membrane
Operating an Ultrafiltration Plant
Clay Lane Statistics

- 32 primary units treating a maximum of 165 Mld gross 160 Mld net. Arranged in 4 streams of 8

- Each unit has 48 X-Flow membrane modules in 2 stacks of 6 pressure vessels.

- Gross flux 130 l/mh, nett approx. 125 l/mh.

- 4 secondary units each with 24 membrane modules
Challenges in operating a membrane system

Maintain System
(Cleaning Efficiency)

Maintain Output
(Permeability)

Maintain Quality

Membrane Integrity
System Maintenance

Challenges are

- Constant and frequent washing cycle
- Many valve operations
- Highly corrosive chemicals
- Scaling
- Extracting data
System Problems at Clay Lane

- Initial operation air ingress causing membrane failures
- Hydrochloric Acid mist damage to equipment
- Design issues with thin wall stainless steel pipework
- Protection strainers failing
- Lack of capacity in secondary treatment
Challenges in Maintaining Output

- Need to keep permeability (Flux Rate/ headloss) as high as possible at all times.
- Can decline rapidly when dirty water or a fouling event occurs.
- Need to monitor performance over a long term to determine trends.
- Ability to clean is limited by need to maintain production and the capacity of the secondary system and waste discharge.
- Need to have available techniques to deal with different types of fouling and to determine which is affecting the plant.
- Developed a circulating CIP which was much more effective.
Permeability Problems at Clay Lane

Initially plant seemed to have no problems but:

- System problems meant that cleans were being missed
- Slow downward trend in permeability not noticed by membrane supplier in monitoring contract.
- Deterioration in water quality led to rapid loss of output
- Cleaning sufficiently effective and limited by secondary system capacity and waste discharge.
- Once restored extra vigilance has maintained capacity.
Operating an Ultrafiltration Plant

An example of cartridge requiring cleaning
Operating an Ultrafiltration Plant

- Process Monitoring
  - Regular checks of the effectiveness of cleaning chemicals.
  - Reviewing fibre breakage data.
  - Monitoring trends e.g. permeability after a backwash

- Clean in Place
  - Dynamic CIPs
  - Selection of Chemicals

- Autopsy
  - Destructive testing of modules
Challenges in Maintaining Integrity

- Finding a suitable test that does not take productive capacity
- Automation and setting failure limits
- Location of faulty membrane elements
- Removal and handling of membrane elements
- Testing to identify failed elements
- Repair of failures and retest
- Membrane tracking
- Trending and analysis
Automated Integrity Test

- Tested once per day
- Tested by measuring air flow passing through the membranes as displaced water flow.
- 24 membranes tested at one time
- Pass / Warning / Fail test and flow recorded for statistical purposes
- Failure automatically removes unit from service
- Once affected housing is detected and isolated unit can return to service awaiting repair
Operating an Ultrafiltration Plant

Vacuum testing provides rapid screening of suspect membranes
Reduces workload for bath testing
Bath Testing
Operating an Ultrafiltration Plant

Membrane Handling Machine
Operating an Ultrafiltration Plant

Modules Tested & Fibre Repairs done

CLWTW UF Membrane Module Repairs 2002

<table>
<thead>
<tr>
<th></th>
<th>ESS June 02</th>
<th>ESS July 02</th>
<th>ESS Aug 02</th>
<th>ESS Sept 02</th>
<th>ESS Oct 02</th>
<th>ESS Nov 02</th>
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<tbody>
<tr>
<td>Modules Tested</td>
<td>261</td>
<td>472</td>
<td>416</td>
<td>493</td>
<td>508</td>
<td>629</td>
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<tr>
<td>Fibre Repairs</td>
<td>199</td>
<td>322</td>
<td>363</td>
<td>255</td>
<td>705</td>
<td>399</td>
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<td>Housings on line</td>
<td>25</td>
<td>50</td>
<td>48</td>
<td>52</td>
<td>64</td>
<td>85</td>
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Membrane Water Testing

Water Bath Test - what has been learnt

• Make fittings robust but light.
• Heat water
• Purge Cartridges prior to adding pressure
• Understand the theory - increasing pressure will not find leaks
• Recently - can take up to 90 minutes to detect fault
Membrane Repair Problems

- Repair Technique: Polyethersulphone pin fixed with glue provided by supplier
  - Glue damages Polyethersulphone
  - Surface must be dry.
  - Repairs on repairs
  - Wouldn’t an interference fit stainless steel pin be better?
<table>
<thead>
<tr>
<th></th>
<th>Rapid Gravity Filters</th>
<th>Ultrafiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve Actuations</td>
<td>For a bank of 12 approximately 240 per month</td>
<td>10000 per day</td>
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<tr>
<td>Blocking of the filters</td>
<td>Loss of Head</td>
<td>Transmembrane Pressure</td>
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<tr>
<td>Quality parameters</td>
<td>Turbidity</td>
<td>Permeability</td>
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<tr>
<td>Trending</td>
<td>Days/weeks</td>
<td>Months/years and by the second</td>
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<tr>
<td>Cleaning</td>
<td>Daily Backwash</td>
<td>Hourly Backwash plus chemical cleaning</td>
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<tr>
<td>Personnel</td>
<td>Plant Attendants</td>
<td>Process Engineers</td>
</tr>
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What would we do Differently?

- Larger and more resilient secondary membrane system, or one not dependent on membranes.
- Ensure that protection strainers are there solely for that purpose and have sufficient strength.
- Locate chemical storage and dosing in a separate room to the membrane system.
- Ensure that membrane handling design is enforced as part of the construction contract.
Summary of Operating Experience

- We have operated for nearly 6 years and whilst at times it has been a challenge we have remained in control.
- Membranes at 6 years life are near to original levels of permeability.
- Breakage has been a large issue particularly connected to fouling. Repairs on repairs are another.
- We have had to develop new techniques for identification and repair of leaking membranes.
- A higher level of technical input is required compared to traditional systems but automation helps to make this efficient.