Zenon Zeeweed 500c Submersible, Vacuum-Driven Low Pressure Membrane for the City of American Canyon Commission in October 2004
Membrane Filtration – is defined as pressure or vacuum driven separation process in which particulate matter larger than 1 um is rejected by a nonfibrous, engineered barrier, primarily through a size exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test.
Membrane Classification

- Microfiltration
- Ultrafiltration
  - Aquasource Ultrafiltration
  - Hydranautics Hydracap
  - Zenon Zeeweed (500 series and 1000)
- Nanofiltration
  - DESAL DK-5 Thin Film Nanofiltration Membrane
- Reverse Osmosis (RO)

No DOC Removal

DOC Removal
### Target Contaminants for Membrane Processes

<table>
<thead>
<tr>
<th>Target Contaminant</th>
<th>Membrane Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles, bacteria, protozoa</td>
<td>Microfiltration (MF)</td>
</tr>
<tr>
<td>Particles, bacteria, protozoa, viruses</td>
<td>Ultrafiltration (UF)</td>
</tr>
<tr>
<td>NOM, selected SOCs and IOCs, hardness, salts</td>
<td>Nanofiltration (NF) and Reverse Osmosis (RO)</td>
</tr>
</tbody>
</table>
**System Configuration for the City of American Canyon**

- Installed 3.0 MGD plant (Zenon Zeeweed 500c)
- Has 4 trains
- 2 of 4 trains have membranes
- Expandable to 6.0 MGD
- Operations began in October 2004
- Pre-treatment for NOM removal
Process Configuration

Needed for NOM Reduction

1 mm Strainer

Acid
Alum

Rapid
Mixer

Flocculation

Air

Vacuum
Air Pump

Air separator

NaOH

NaOCl

Vacuum Permeate Pump
Process Configuration

1 mm Strainer

Acid Alum

Rapid Mixer

Flocculation

NaOH

Air

NaOCl

Vacuum Permeate Pump

Vacuum Driven

Vacuum Air Pump

Air separator

Vacuum Valve

Reject
1 mm Strainer (Self Cleaning)

- Raw water is strained to remove particles that can damage membrane fibers.
Flash Mixer

Max Hydraulic Gradient, 700/sec
Flocculation Process

Max Hydraulic Gradient, 114/sec
Membranes

- Two trains
- 1.5 MGD per train
- 7 cassettes per train
- 26 modules per cassette
- 25,000 fibers per module (250 ft²)
Membrane - Connections

- Two permeate connections per cassette
- Middle connection provide cyclic aeration
- Connected by cam locks
Zenon Zeeweed 500c

- Hollow fibers
- 0.04 microns (nominal)
- 0.1 microns (absolute)
- Poly vinylidene fluoride (PVDF)
- Flow from outside to inside center of lumen (vacuum driven)
Submersible, Vacuum-Driven (Zenon UF)
Hollow Fiber Ultrafiltration Membrane
Cyclic Aeration

- Promotes liquid circulation past and around the fibers
- Provides mechanical movements of the fibers
- Reduces localized solids accumulation.
- Ensures complete mixing of process tank.
Air Separation Vessel

Vacuum Pumps
Permeate Variable Speed Vacuum Pumps

- Creates vacuum inside lumen of membrane pulling water from outside to inside.
Membrane Tank Deconcentration

- Drain tank once every day (purge solids buildup)
Summary:
- Leak in permeate hose connections (detected via MIT)
- Permeate hose came off (detected via turbidity)
- O-Ring leakage (detected via MIT)
- Permeate pump cavitations problems after MIT
- Running out of water for chlorine analyzer
- Chemistry problems – problems with DOC removal
- Particle counters didn’t work (replace with new brand)
- Not able to retrieve process data from Zenon (City didn’t have fast connection)
Startup Problems

- Small leakages at hose connections (detected via MIT)
- Cause – tension on hose and barb connection
- Replace w/ thicker hose seal.
- Christmas Eve – hose comes off, suck in coagulated water.
Start up Problems

- Cavitation of permeate pumps after MIT.

- Solution
  - Increase size of vacuum line from air separation vessels to vacuum pumps.
**Treatment Problem (Color)**

- High color (20s – to 30s units) in permeate water
- No removal in DOC
- Water quality complaints (First quarter of 2005)
- Exceeded TTHM MCL in second Quarter of 2005
- Interim action by operator in first quarter of 2005:
  - Start conventional plant and blend water
Treatment Problem (Color)

Solution
- Lower pH, increase absorption of NOM
- Change coagulant from Alum to 10% Acid Alum
- No increase in sludge production
- Increase in NaOH for corrosion control

Results
- Reduced color to zero
- DOC removal
- Reduced TTHM
- No water quality complaints
Treatment Alternatives for NOM Removal

- Add stand alone acid addition (currently added to Aluminum Sulfate)
- Ozone
- Granular Activated Carbon
- Powdered Activated Carbon
- MIEX (charged resin)