Tools and Methods for Filter Run Optimization

Presented by:
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Helix Water District
Helix Water District

- Established 1913
- 50 square miles
- 268,000 population
- 106 MGD Levy WTP
- Plant built in 1965
- Major Upgrade and expansion 2002
Water Quality

- Levy Plant treats a blend of CRW & SPW both are low NTU water supplies
- In wet years we augment with local water stored in nearby reservoirs
- Local waters typically require a flocculant aid for best filter performance.
- 50 years of service and 675 Billion gallons with no violations.
Chemical feed

- Caustic Soda
- Chlorine & Ammonia
- Alum & Cat poly
- Anionic poly
- Floc
- Sedim
- Filters
- Ozorne
Filter Optimization Beginning to End

- It’s the chemicals
- Jar testing
- Shear testing
- Zeta testing influent and jars
- Filter production with Water Quality
- Backwash monitoring
- Savings water and power
Plant Optimization Tools

Jar Testing has been the standard for determining chemical doses

- Previously HWD tried to mimic plant conditions.
- Now we standardize mixing times (we do not vary for flows). Why?
  - Data from jar tests can be reliably compared without as many variables.

Zeta meter tests run on jars and actual plant flash-mixed influent and settled water
Zeta Meter

Measures the charge on particles in a sample, slightly negative is better than positive.
Plan and Objectives

- Plan and objectives for test will need to be entered at the top of jar test sheet.
- Enter your water sources and blends
- Account for your raw water quality
- Account for your various chemicals
Plan and Objectives

<table>
<thead>
<tr>
<th>Raw Water Source</th>
<th>MGD</th>
<th>%</th>
<th>Date</th>
<th>7/5/12</th>
<th>El Cap. Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Aqueduct Conn.</td>
<td>15</td>
<td>26%</td>
<td>Test Time</td>
<td>1:00 PM</td>
<td>El Cap. pH</td>
</tr>
<tr>
<td>#6 Aqueduct Conn.</td>
<td>10</td>
<td>17%</td>
<td>Temp C</td>
<td>22.00</td>
<td>EC.Hardness</td>
</tr>
<tr>
<td>#7 Aqueduct Conn.</td>
<td>8</td>
<td>14%</td>
<td>Raw Turbidity</td>
<td>0.40</td>
<td>El Cap. Alk.</td>
</tr>
<tr>
<td>#8 Aqueduct Conn.</td>
<td>11</td>
<td>19%</td>
<td>Raw P. Count</td>
<td>1477</td>
<td>CWA Color</td>
</tr>
<tr>
<td>El Capitan</td>
<td>14</td>
<td>24%</td>
<td>Raw pH</td>
<td>7.80</td>
<td>CWA Hardness</td>
</tr>
<tr>
<td>Lake Jennings</td>
<td>0%</td>
<td></td>
<td>Raw Alkalinity</td>
<td>109.00</td>
<td>CWA pH</td>
</tr>
<tr>
<td>San Vicente</td>
<td>0%</td>
<td></td>
<td>Raw Hardness</td>
<td>191.00</td>
<td>CWA Alk</td>
</tr>
<tr>
<td>Future</td>
<td>0%</td>
<td></td>
<td>Raw Zeta Pot.</td>
<td>-12.80</td>
<td></td>
</tr>
<tr>
<td>Total Flow MGD</td>
<td>58</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mixing</th>
<th>Time (min.)</th>
<th>RPM</th>
<th>Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Mix (seconds)</td>
<td>5.0</td>
<td>200</td>
<td>All mixing and settling parameters do not change.</td>
</tr>
<tr>
<td>1 Stage</td>
<td>6</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>2 Stage</td>
<td>6</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>3 Stage</td>
<td>6</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>4 stage</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Settling Time (min)</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Important Chemicals</th>
<th>Active Weight</th>
<th>Cost / Lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum</td>
<td>5.27</td>
<td>$0.12</td>
</tr>
<tr>
<td>CationicPolymer</td>
<td>8.60</td>
<td>$0.34</td>
</tr>
<tr>
<td>Chlorine</td>
<td>8.34</td>
<td>$0.25</td>
</tr>
<tr>
<td>Ammonia</td>
<td>1.47</td>
<td>$0.58</td>
</tr>
<tr>
<td>Caustic</td>
<td>2.66</td>
<td>$0.49</td>
</tr>
<tr>
<td>Anionic Polymer</td>
<td>8.34</td>
<td>$1.40</td>
</tr>
</tbody>
</table>
Historical Water Quality

- Jar tests and Zeta testing has historically worked very well.

- 2011 was totally different water quality all previous dosing schemes did not work.

- On some source waters, standard interpretation of jar test data was inadequate, and did not work at plant scale.
Indicators of an Issue

- After the usual selection of a normal dosage scheme we developed from our Jar and Zeta testing we saw:
  - Increased particle counts at filter effluents
  - Particle rise in filters with increase filter velocities due to backwash or plant flows
  - Sharp rise in particles resulting in reduced filter production
  - Low NTU with higher than normal alum (20 mg/L)
Filter Particle Trend

[Graph showing particle counts over time on June 8, 2011]
Back to the Drawing Board

- We determined that we did not have a good way to predict floc strength in a jar
- Web search......and search...
- Found “Effect of organic polyelectrolyte characteristics on floc strength S.R. Gray, C.B. Ritchie” Critical Mixing Speed (CMS)
Basic Principle of Shear Test

- Using our standard jar test as a start
- We apply increasing levels of energy (mixing speed) for a determined time
- At some point, a substantial increase in turbidity occurs at a given mixing speed
- This is the “Critical Mixing Speed” (CMS)
Principles Continued

- Critical Mixing Speed is an indicator of the strength of the floc and its ability to resist shearing forces in the filter media.

- Standard filterability tests using filter paper on low turbidity water have been inconclusive.
Shear Test Procedure

1. Perform standard jar test
2. After taking settled water NTU return sample to each jar
3. Set RPM and timer (2 min.), press start on both
4. End of time stop mixer and start settling for 5 minutes
5. Take NTU sample from each jar
6. Repeat steps 2-5 for each RPM run
How We Developed the Procedure

- Designed a series of tests to determine what speeds and durations would be used.
- Based on results we decided to use 2 minutes of mixing and 5 minutes of settling time for each RPM tested.
- We then worked on developing a standard RPM regime.
- We found out that it is better to do a quick test with 25 and 50 RPM and then refine it.
## Test Example

<table>
<thead>
<tr>
<th>DATE</th>
<th>6/17/2011</th>
<th>5 Min. Settling</th>
<th>5 Min. Settling</th>
<th>5 Min. Settling</th>
<th>5 Min. Settling</th>
<th>5 Min. Settling</th>
<th>5 Min. Settling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mixing RPM</strong></td>
<td><strong>Starting Jar test NTU</strong></td>
<td>Jar 1</td>
<td>Jar 2</td>
<td>Jar 3</td>
<td>Jar 4</td>
<td>Jar 5</td>
<td>Jar 6</td>
</tr>
<tr>
<td>20</td>
<td>0.44</td>
<td>0.82</td>
<td>0.23</td>
<td>0.21</td>
<td>0.24</td>
<td>0.24</td>
<td>0.33</td>
</tr>
<tr>
<td>30</td>
<td>0.82</td>
<td>0.57</td>
<td>0.31</td>
<td>0.44</td>
<td>0.47</td>
<td>0.47</td>
<td>0.38</td>
</tr>
<tr>
<td>40</td>
<td>1.15</td>
<td>0.76</td>
<td>0.30</td>
<td>0.46</td>
<td>0.39</td>
<td>0.39</td>
<td>0.34</td>
</tr>
<tr>
<td>50</td>
<td>1.11</td>
<td>0.79</td>
<td>0.41</td>
<td>0.71</td>
<td>0.47</td>
<td>0.47</td>
<td>0.37</td>
</tr>
<tr>
<td>60</td>
<td>1.04</td>
<td>1.01</td>
<td>0.54</td>
<td>0.38</td>
<td>0.36</td>
<td>0.36</td>
<td>0.45</td>
</tr>
<tr>
<td>70</td>
<td>1.10</td>
<td>1.10</td>
<td>0.74</td>
<td>0.49</td>
<td>0.45</td>
<td>0.45</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**Cat Poly** | **Anionic** | **Alum** | **Comments:** Ran Jars with varying Anionic 0-1.0 mg/L in 0.2 steps. Critical Mixing Speed was > 50 RPM for any dose above 0.4 mg/L. Change plant to 0.4 mg/L dose   NOTE: Floc Aid, not Filter Aid
Filter Production Goals

- Output is 97-99% of filter production
- Wash water is 1-3% of production
- Unit filter run volume (UFRV)
  - Gallons produced per run / filter area
    - Should be $>7000 \text{ Gals/Ft}^2$
    - 15 MG production goal/$1934 \text{ ft}^2 = 7755 \text{ Gals/Ft}^2$
- Water Quality rules, NTU and PC
  - Average for HWD last year $0.03 \text{ ntu} / <17 \text{ pc}$
200 gal/ft² is Typical backwash volume

\[ \frac{R_e}{R_d} = \frac{UFRV - UBWV}{UFRV} \]
Filter breakthrough after BW is more important if you don’t have FTW, but if you do you can still save $$

Susumu Kawamura recommends in *Integrated Design and Operation of Water Treatment Facilities 2nd Edition* "Initial turbidity breakthrough may be minimized or even eliminated by terminating filter washing when turbidity of the wash waste ranges form 10 to 15 ntu."
Reduction in Backwash Times

- An example of shortening the wash time from previous by 2 minutes saved 80,000 gals.

10:09:45 NTU is 10

10:13:35 Is end of Backwash 4 mins later. Saving 80,000 gals
Monitoring Backwash NTU
Primary Benefits

- Improve Filter Cleaning
- Extend Filter Run Time
- Reduce Media Loss
- Reduce Backwash Water and Power Usage
- Save Money
Declining Trend is Good

Backwash Efficiency

- Average Daily Production (MGD)
- % Filtered Water used to Backwash
- Linear (% Filtered Water used to Backwash)
Filter Monitoring for Each Filter

- Turbidimeter (HF)
- Loss of Head (Foxboro)
- Particle Counter (Met One)
Cost Savings by Reducing Backwash Quantities

- Helix has to pump filter wash water 3X, based on saving 80,000 gals per wash and 1344 washes per year, the savings:
  - Pumping power costs = $16,800
  - Retreatment costs at $162/MG = $17,500
  - Total savings = $34,300

- If unable to reclaim 330 AF @ $885/AF = $292,126 additional costs
Key Points

- Getting your chemicals right is first
- Shear Testing by CMS and Zeta testing are tools, not a “Silver Bullet”
- Monitoring backwash turbidity and filter profiles verify (report card)
- Filter production while maintaining WQ goals is ultimate, CFE is 0.03 NTU
- Reduced backwashing, water, power = $326K
Questions?
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