Cooling Tower Water Treatment
MIOX Superior Disinfection
What is On-Site Chemical Generation?

SALTS + ON-SITE WATER + POWER = CUSTOM CHEMICAL

- Specialty chemistry generated on site, on demand
- Replaces multiple delivered chemicals
- Ability to create unique product characteristics
The leader in On-Demand Disinfection Chemistry

- 18 years history… continuous innovation in electrolytic cell design
- Only company able to produce multiple oxidant based products
- Technology company… 27 patents issued; 21 patents pending
- 2,000+ units installed across 30+ countries… treating 6 billion gallons/day

Municipal Water Treatment
Food & Beverage
Industrial & Commercial
Oil and Gas

[Logos of Parkson, Ecolab, Chemstar, Schlumberger, USA Global Market S.A., Quimiproductos, Sohiko, Chesapeake Energy]
Custom Chemistries from MIOX Electrolysis

1. Hypochlorite Chemistry
   • Lowest capital and operating
   • Reliable Self-cleaning cells

2. Hypobromite Chemistry
   • Optimized for replacement of pre-blended chemicals
   • Ability to change ratio of Hypo & Bromine as needed

3. Mixed Oxidant Solution
   • Optimized for biological kill and bio film removal
   • Performance is derived from 2nd oxidant - **Hydrogen Peroxide**

4. Activated Quat Hypochlorite
   • For disinfection: Maximum Biological kill with short contact time
     • Combines benefits of non-oxidizing and oxidizing biocides
   • For complete treatment: Ability to tailor the Quaternary Ammonium

5. UV-Activated Hypochlorite
   • Advanced Oxidation Process (AOP) with lower cost
   • Organic and **Hydrocarbon Removal** (OW Emulsion Breaker)
   • Ability to “mineralize” all organics to PPT levels

MIOX Proprietary & Confidential – Do Not Distribute
Disinfection is Vital in Cooling Tower Maintenance

Major Challenges in Tower Maintenance
1) Control disease outbreaks caused by aerosolization of bacteria
2) Prevent fouling in exchangers / condensers
3) Control microbiological growth
4) Control scale deposition
5) Provide corrosion protection

Aug 28, 2012 – at JW Marriott in Downtown Chicago, 3 guests died due to Legionnaires outbreak

June 6, 2012 – Diaego Distillery Cooling Tower Contamination; 80 people affected, 1 died – Class Action Lawsuit ongoing

Sep 4, 2012 - Legionnaires' disease kills 10 in Quebec, 165 total cases – suspect cooling towers

MIOX Proprietary & Confidential – Do Not Distribute
Mixed Oxidant Solution Chemistry
Vital Disinfectant for Cooling Towers and Loop (Exchanges, Chillers)

**Major Challenges in Tower Maintenance**

1) Control disease outbreaks caused by aerosolization of bacteria
2) Prevent fouling in exchangers / condensers
3) Control microbiological growth
4) Control scale deposition
5) Provide corrosion protection

**Mixed Oxidant Solution Chemistry**

- Superior disinfectant even at high pHs
- Replaces chlorine, bromine, proprietary biocides and algaecides
- Eliminates Biofilm: Control Legionella Growth & pitting corrosion
- Improves plant and community safety

...at a comparative price to Bulk Hypochlorite
Process Train for Cooling Water Treatment

Make-Up Source

Pretreatment

Clarifier

Hot Deck

Fans

Warm Water

Sump

Cooled Water

Condenser

Steam

Warm Water

Water

Boiler

Steam Turbine/Generator

MIOX Generator

MIOX for Pretreatment

Corrosion Inhibitor

Antiscalant

MIOX Proprietary & Confidential – Do Not Distribute
MIOX Mixed Oxidant Generators

- Revolutionary self-cleaning generator in the industry
- Patented self-adjusting flow control to accommodate wide pressure variations
- Direct link to DCS, ORP, SCADA
- Air-cooled power supply- Allows hotter feed water to cell
- Reduces chiller requirements and associated need for pressure boost
Superior Disinfection

- Produces more powerful disinfectant than Hypochlorite
- Easily replaces proprietary biocides (NIPSCO, IN; San Juan, PR) even at higher pH
- More power is derived from Hydrogen Peroxide in solution with Hypochlorite in 24-48 hrs

No Legionella detected at 2 mg/L Mixed Oxidant solution at 8.0 pH in 10 mins
Internal MIOX testing shows chlorine dioxide and MOS have similar efficacy against crypto.

EPA Type 2 (dirty) Test Waters, C. Parvum oocysts, Dose: FAC = 12 ppm; ClO2 = 11.4 ppm

OSHA Lethal Dose for ClO2 is 19 ppm
CASE STUDY
Spa in Japan previously using **Bulk Hypochlorite** 1.5 mg/L had Legionella cases. In 5 hours of Mixed Oxidant solution biofilm started sloughing.

- **Extensive biofilm**
- **Legionella CFU >5**
- **Dose: 1.5 mg/L Hypo**
- **Residual: 0.2 mg/L**

**Before MIOX**

22 days

**After MIOX**

- **Biofilm eliminated**
- **No bacterial hits**
- **Dose: 0.6 mg/L Hypo**
- **Residual: 0.4 mg/L**

CASE STUDY
A city in Texas was using **Gas Chlorine** where brown biofilm slime on pipes in distribution system commonly noticed.

- Distance from Treatment Plant: 200 feet
- Distance from Treatment Plant: 1/2 mile
Biofilm Harbors Legionella & Corrosion

Biofilm Harbors Coliforms

Collective neutralizing power of groups of cells leads to slow and incomplete penetration of the antimicrobial in the biofilm.*

Microbially Influenced Corrosion (MIC)

The presence of biofilm modifies deposition and dissolution rates of minerals, and by this mechanism, influences the electrochemical properties of the metals or alloys. Pitting corrosion is a great example as seen below.*

Although Hypochlorite and other proprietary biocides perfectly inactivates Legionella, it cannot inactivate Legionella in the Biofilm

* Montana State University, Center of Biofilm Engineering (MSU-CB)

MIOX Proprietary & Confidential – Do Not Distribute
Biofilm Reduces Thermal Efficiency

- **Biofilm (1mm thick) Reduces Heat Transfer by 50%**
- **In a 200 ton chiller, energy costs can increase by 35%**
Mixed Oxidant Solution Chemistry

*Less corrosive than Hypochlorite at same doses*

### 4 WEEK AVERAGE CORROSION RATES, mg/L

**Corrosion Study done by C&E Engineering Partners Inc. at Westerly, RI installation**

<table>
<thead>
<tr>
<th></th>
<th>0.2 mg/L DOSE</th>
<th></th>
<th>1.2 mg/L DOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mixed Oxidant Solution</strong></td>
<td></td>
<td><strong>Sodium Hypochlorite</strong></td>
<td></td>
</tr>
<tr>
<td>Total Pb</td>
<td>.16</td>
<td>Total Pb</td>
<td>.14</td>
</tr>
<tr>
<td>Total Cu</td>
<td>-</td>
<td>Total Cu</td>
<td>-</td>
</tr>
<tr>
<td>Pb/Cu</td>
<td>.17</td>
<td>.10</td>
<td>.14</td>
</tr>
</tbody>
</table>

|                  |               | **Mixed Oxidant Solution** |               | **Sodium Hypochlorite** |               |
| Total Pb         | .20           | Total Pb         | .31           |
| Total Cu         | -             | Total Cu         | -             |
| Pb/Cu            | .21           | .45              |

|                  |               | **Mixed Oxidant Solution** |               | **Sodium Hypochlorite** |               |
| Total Pb         | .14           | Total Pb         | .38           |
| Total Cu         | .04           | Total Cu         | .48           |

MIOX Proprietary & Confidential – Do Not Distribute
Sample ROI

Less than 2 years payback when compare to Biocide regimes

ROI~2 yrs
Sample Cost Saving With MIOX
Replace Current Disinfectants

<table>
<thead>
<tr>
<th></th>
<th>Today</th>
<th>With MIOX</th>
<th>Net Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypochlorite cost ($/year)</td>
<td>$</td>
<td>164,250</td>
<td>-</td>
</tr>
<tr>
<td>Sodium Bromide ($/year)</td>
<td>$</td>
<td>55,480</td>
<td></td>
</tr>
<tr>
<td>MIOX Salt consumption</td>
<td>-</td>
<td>$</td>
<td>32,850</td>
</tr>
<tr>
<td>MIOX Electricity consumption</td>
<td>-</td>
<td>$</td>
<td>13,688</td>
</tr>
<tr>
<td>TOTAL Operational Cost</td>
<td>$ 219,730</td>
<td>$ 46,538</td>
<td>$ 173,193</td>
</tr>
</tbody>
</table>

Return on Investment = 21 months

Assumptions
- 90,000 ton tower, 4 cycles
- 300 lbs/day 100% FAC
- Bulk Hypo 12.5% cost $0.15/lbs
- Sodium Bromide Active $3.8/lbs

MIOX Equipment
- RIO M5 – 300 lbs of 100% FAC/day
- Equipment cost $125,000
- Peripheral + Installation $175,000
- Total out of pocket $300,000
Puerto Rico PREPA Power Plant

*Biofilm Removal → Increased Thermal Efficiency → ~9% Production Capacity Increase*

**Problem**
- Proprietary biocides could not control biofilm in 40,000 ton tower. Visible biofilm/scale build up.

**Results After Using MIOX**
- Improved thermal efficiency; increased production load by 9%, equaling to $30 million+
- <2 months payback
- Reduction in 31,000 lbs delivered chemical/year
- 57% reduction in water consumption and O&M costs
- Mixed oxidant chemistry eradicated the biofilm. Replaced the biocide regime.
This graph shows results after using MIOX. The temperature drop increased by as much as 6-7°C and the power plant load increased on average by a minimum of 10 percent, or 20 megawatts. Graph courtesy of PREPA.
NIPSCO Power Plant

Cleaner Condensers, Saving ~$160,000/yr per tower, totaling ~$640,000/yr

Problem

- Proprietary biocides could not control biofilm in 90,000 ton tower. Visible biofilm build up in the condenser (seen on the left)

Results After Using MIOX

- Mixed oxidant chemistry eradicated the biofilm. Replaced the biocide regime.
- <36 months payback
- Reduced chemical cost with complete biofilm removal

“Reducing our treatment regimen … down to a single mixed oxidant product generated on site has resulted in substantial treatment chemical and labor cost savings.”

--Paul Schrock, NIPSCO Senior Chemist

MIOX Proprietary & Confidential – Do Not Distribute
Thermal Chicago Cooling Tower

Cost effective Algae and Biofilm control

Problem

- Constant biofilm and algae growth with Sodium Hypochlorite and Isothiazolin

Results After Using MIOX

- Cooling basin cleared of algae in 2 weeks
- Biofilm cleared in 4 weeks
- <18 months payback
- No degradation of scale/corrosion inhibitors (phosphonates, polymer or azole)
- Low corrosion: steel corrosion at ~1 mpy, yellow metal corrosion <0.1 mpy
- Excellent microbial control even at elevated pH
- Eliminated disposal of 51 chemical drums
Large Illinois Teaching Hospital

Effective Legionella Control at 7,000 ton cooling tower at Neurosurgery Center

Problem

- Positive *Legionella* counts in the cooling system: 7,000 ton cooling tower

Solution

- Replaced bulk bleach with on-site generated Mixed Oxidant chemistry

Results After Using MIOX

- No positive *Legionella* counts since MIOX installation July 2011
- Reduced hospital's liability from hazardous chemicals and potential *Legionella*
- Visibly cleaner - slime and live green algae is gone

Cooling tower sump looking down from the hot deck

BEFORE MIOX

AFTER MIOX