

The MIOX logo is a white, bold, sans-serif font centered within a blue teardrop-shaped graphic. The background of the slide is a complex geometric pattern of overlapping blue triangles in various shades, creating a sense of depth and movement.

**MIOX**

## Session 7A – How to Better Control Legionella

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[www.miox.com](http://www.miox.com)



Johnson Matthey



# Agenda

- Framing the key issues regarding legionella control
- Why biofilm control is important
- Options for halogen source
- On-site generation overview
- Advantages of on-site generation
  - Cost
  - Safety
  - Effectiveness
- Case studies

# Legionnaires' Risk

## Google news search

Many documented cases from systems with a free available chlorine (FAC) residual from delivered bleach.

FAC residual **and** biofilm control are required for long term risk management.

### [Legionnaire's disease lawsuit v. Castleton Comfort Inn can expand](#)

[Albany Times Union](#) - Mar 14, 2015

... for the **New York** State Energy Research and Development Authority. ...

**Legionnaires' Disease**, a severe form of bacterial pneumonia, ...



### [New York City investigates spike in Legionnaires' disease](#)

[CBS News](#) - Jan 13, 2015

**NEW YORK** -- City health officials are trying to determine if a common source is to blame for a spike in cases of **Legionnaires' disease** in the ...

Co-op City towers contaminated with **Legionnaires' Disease**

Highly Cited - [New York Daily News](#) - Jan 13, 2015

[Explore in depth](#) (60 more articles)

### [NYC officials investigating Legionnaires' Disease outbreak](#)

[New York Post](#) - Jan 7, 2015

"Providers should consider **Legionnaires' Disease** when evaluating patients presenting with signs of pneumonia," the Health Department said ...

**NYC Health Officials Investigating Spike In Legionnaires' Disease ...**

[CBS Local](#) - Jan 8, 2015

[Explore in depth](#) (5 more articles)

### [Legionnaire's Disease Cases on Rise in New York City](#)

[Newsmax.com](#) - Jan 9, 2015

An increased number of **Legionnaire's disease** cases are being reported in the Bronx, and **New York** City Health Department officials are trying ...

## Framing the Key Issues

- Effectiveness is determined by two factors
  - Remove biofilms, control Legionella
  - Maintain stable disinfection residuals
- Regulatory monitoring requirements for disinfectants
- Safety – chemical generation and storage
- Cost – capital and operational

## Bleach (Chlorine) is not sufficient alone

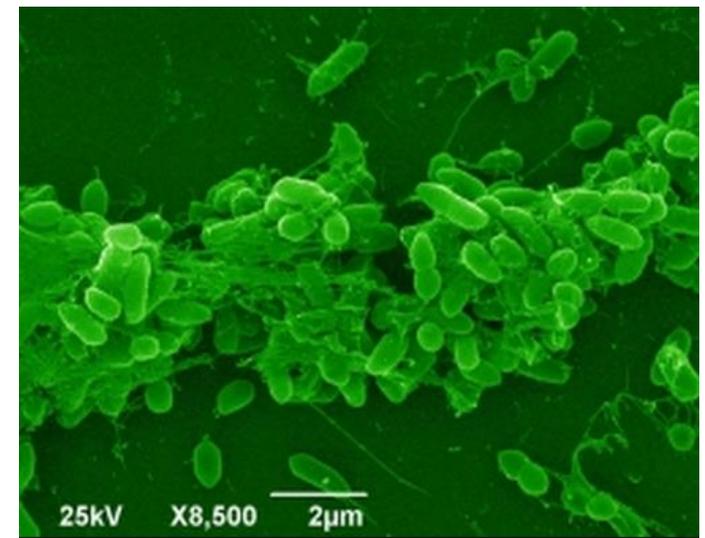
### *Biofilm Removal is needed*

Inactivating Legionella is easy with Chlorine when it does not hide behind the biofilm

Inactivating Pseudomonas aeruginosa that makes up the Biofilm is not easy

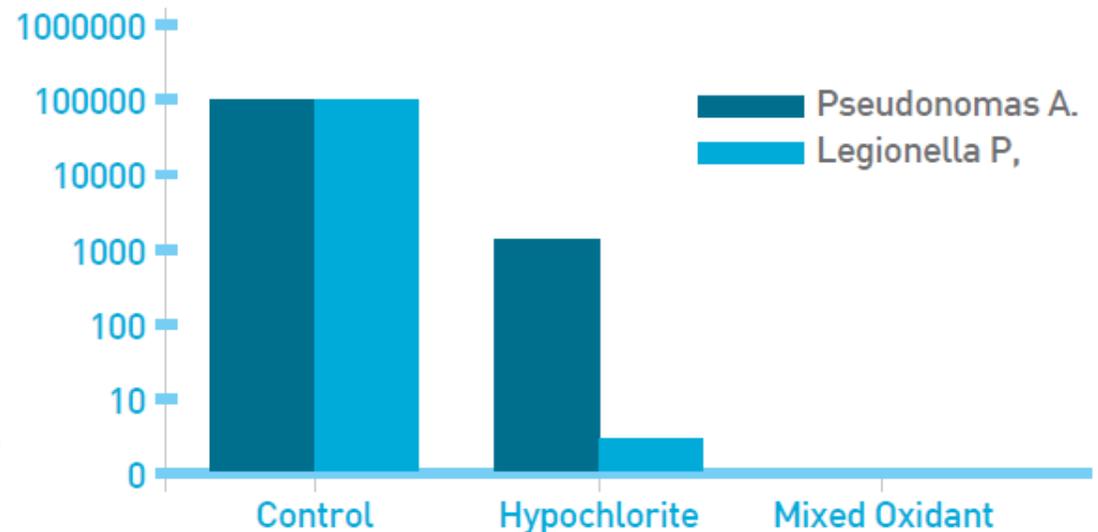
#### Options to remove the Biofilm:

- 1) Chlorine Dioxide
- 2) On site generated Chlorine
- 3) Organic Biocides



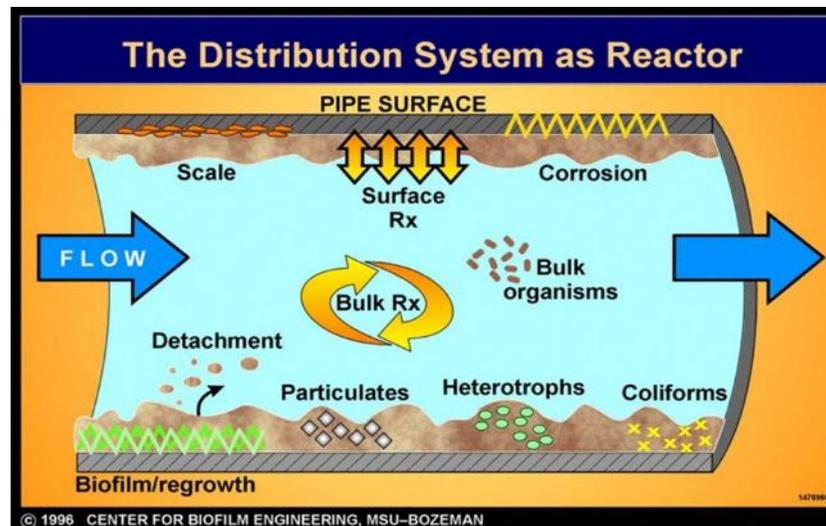
## BETTER LEGIONELLA CONTROL

No Legionella detected at 2 mg/L Mixed Oxidant Solution (MOS) in 10 minutes. Study conducted by Larry Barton PhD, University of New Mexico, "Disinfection of Simulated Cooling Tower Water". Hypochlorite is a good Legionella disinfectant when the bacteria are planktonic (free floating). However Pseudomonas, a biofilm former organism, is more difficult to kill and can also form a protective biofilm layer for Legionella bacteria to harbor. MOS removes the biofilm and kills both microorganisms more effectively than hypochlorite.

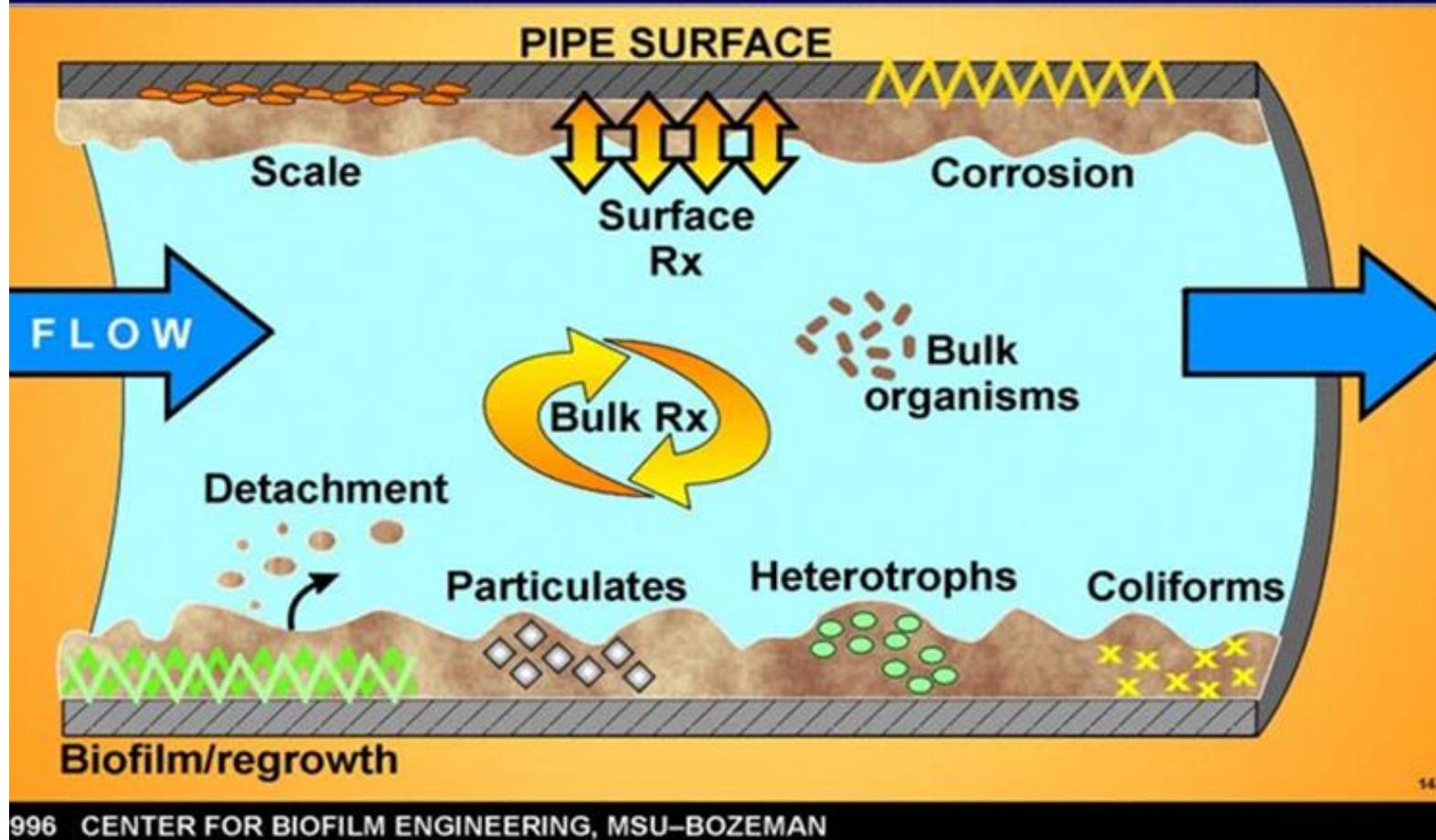


# Biofilm Harbors Legionella

- Free-floating Legionella is easy to kill
- Harbors in biofilm, which protects organisms
- MIOX removes biofilm – controls Legionella



## The Distribution System as Reactor



Concept of biofilm formation in pipes

## How Do You Control Biofilm, Then?

- ASHRAE 188 simply recommends the use of a halogen (plus a monitoring/flushing program)
  - Regular hypochlorite/bleach
  - Cannot penetrate the biofilm layer
  - Other alternatives required

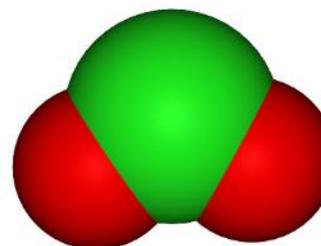
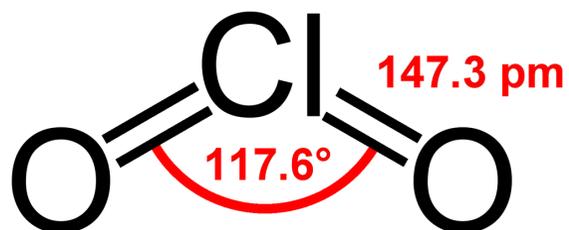
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## Most Common, Effective Methods Include:

- Chlorine Dioxide
- On-site Generated Mixed Oxidant Solution (MOS)

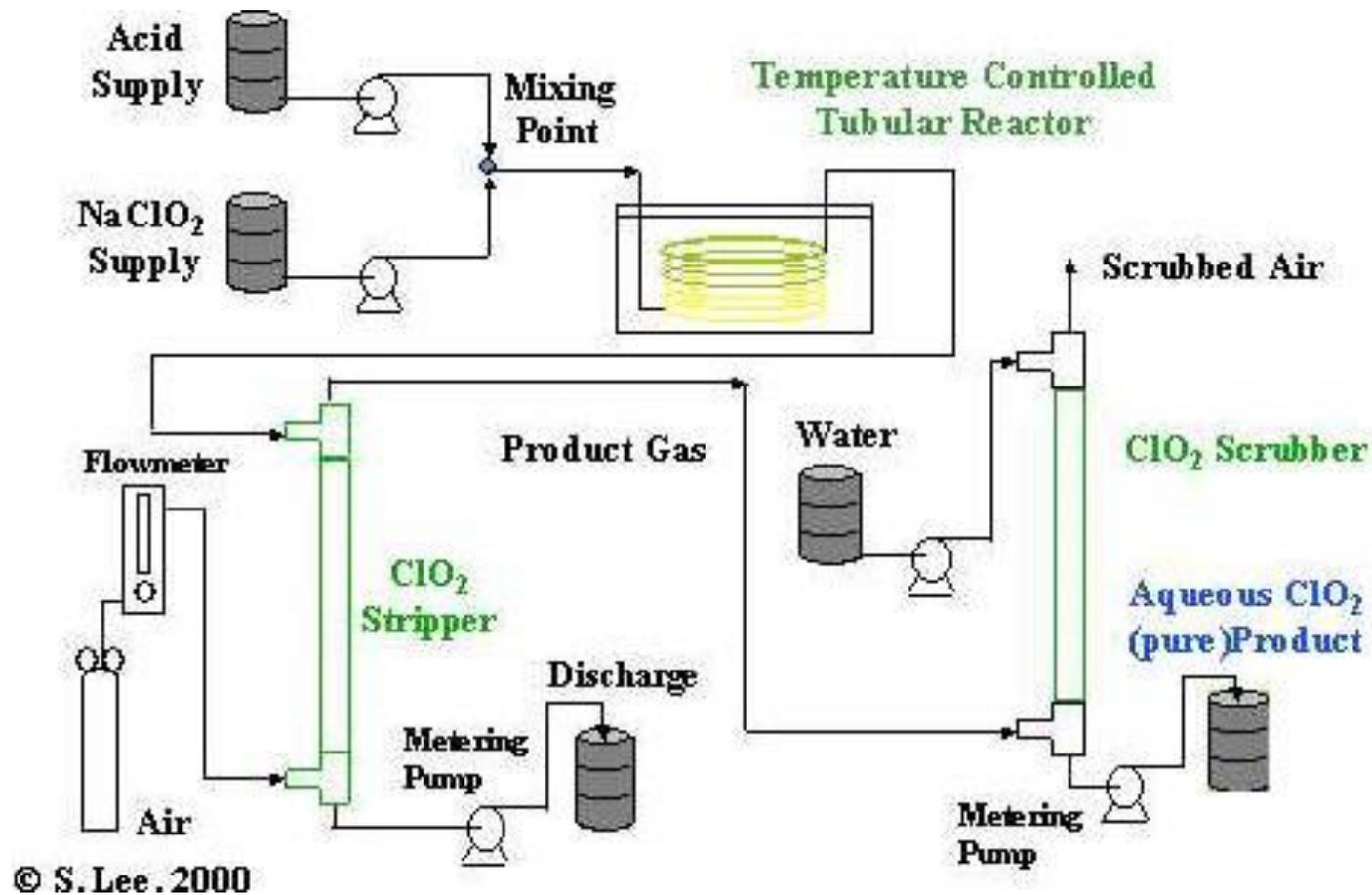
# Chlorine Dioxide

- Chemical formula: ClO<sub>2</sub>
- Is a gas, yellowish-reddish in color
- Does not hydrolyze in water, simply stays in solution as a dissolved gas



# Chlorine Dioxide

- Gas is highly toxic
- Cannot be shipped as a gas, must be generated on site or in stabilized solution
- Most common methods of generating are:
  - Precision mixing of sodium chlorate and acid
  - Electrolyze sodium chlorate



## A Safety Note on the Generation Process

- NaClO<sub>2</sub> is a strong oxidizer – pure solid, reaction product of leaked ClO<sub>2</sub> gas, or solution of NaClO<sub>2</sub> spilled continues to be a hazard.
- NaClO<sub>2</sub> solution dried in contact with combustible material can ignite spontaneously.
- Pure, dry NaClO<sub>2</sub> is shock-sensitive – even walking on it can cause detonation.
- White's Handbook (2011, pp. 752-753) is very explicit on the hazards.

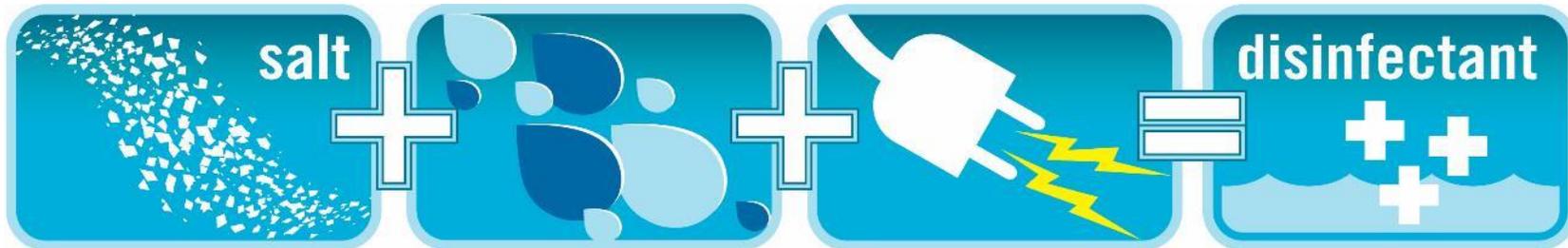
## Chlorine Dioxide Pros

- Excellent at biofilm removal and control
- Good broad-spectrum biocide
- Does not react with many other contaminants in the water
  - In certain applications can get desired kill at lower dose

## Chlorine Dioxide Cons

- Storage of base chemicals can be an issue
- Gas is very toxic, leaks must be handled very carefully
- Limited by regulation to maximum dose rate

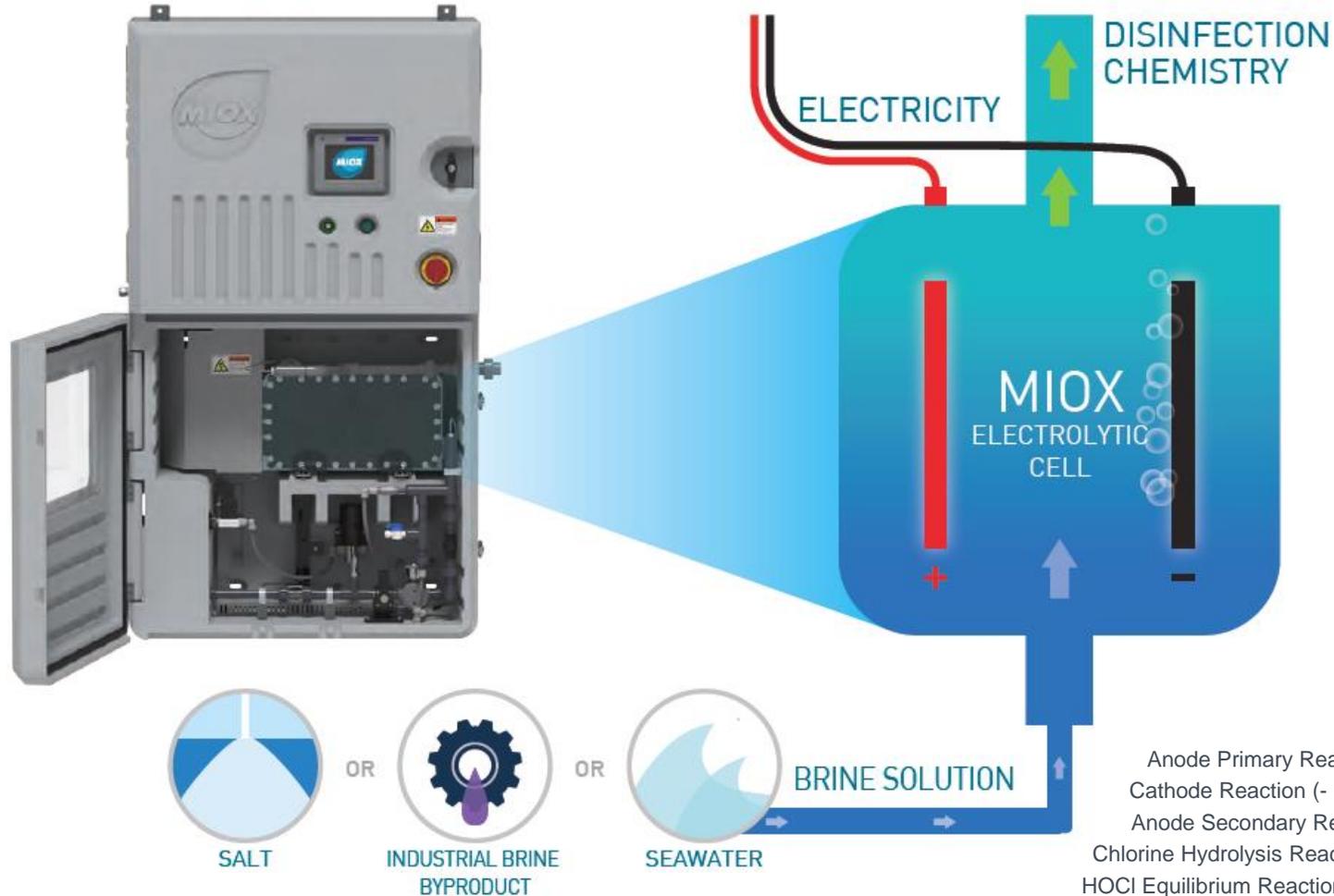
## On-Site Generation of MOS



- MIOX generates a powerful chemical using only salt, water and electricity
- In the food & beverage industry often on-site generation (OSG) is referred to as electrochemically activated water (ECA) or electrolyzed oxidizing water (EOW)

## MIOX ELECTROLYSIS PROCESS

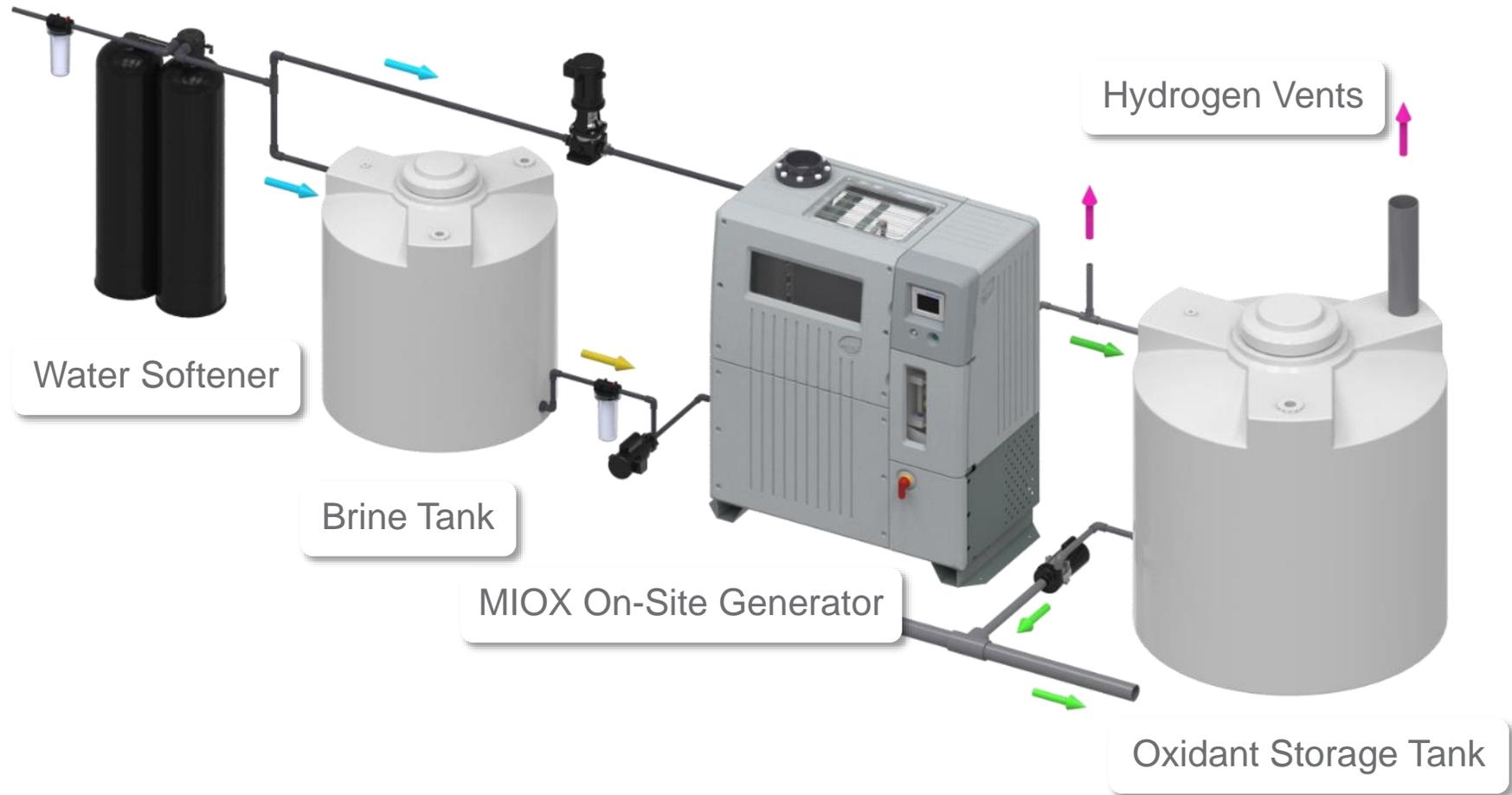
The electrolytic cell of a MIOX on-site chemical generator uses salt combined with water and electricity to generate disinfectant at the point of use.



# Cell Reactions

- Anode Primary Reaction (+ Side):  $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$
- Cathode Reaction (- Side):  $2 \text{H}_2\text{O} + 2 \text{e}^- \rightarrow \text{H}_2\uparrow + 2 \text{OH}^-$
- Anode Secondary Reaction (+ Side):  $2 \text{OH}^- \rightarrow \text{H}_2\text{O}_2 + 2 \text{e}^-$
- Chlorine Hydrolysis Reaction:  $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{Cl}^- + \text{H}^+$
- HOCl Equilibrium Reaction:  $\text{HOCl} \leftrightarrow \text{OCl}^- + \text{H}^+$  (depends on pH)

# Typical Process Flow



# Mixed Oxidant Solution Strips Biofilm

## 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

**BEFORE MIOX**



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

**22 days  
AFTER MIOX**

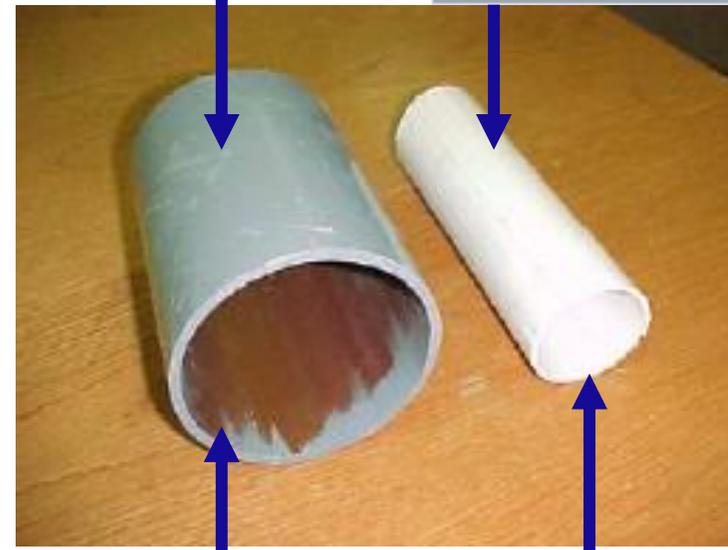


- ▶ Biofilm eliminated
- ▶ No bacterial hits
- ▶ Dose: 0.6 mg/L Hypo
- ▶ Residual: 0.4 mg/L

## CASE STUDY

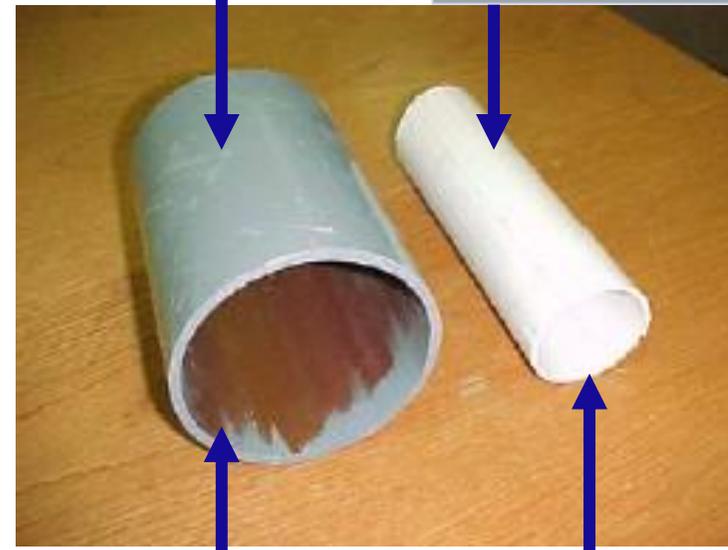
A city in Texas was using **Gas Chlorine** where brown biofilm slime on pipes in distribution system commonly noticed.

**BEFORE MIOX**



Distance from  
Treatment Plant:  
**200 feet**

**1 Year  
AFTER MIOX**



Distance from  
Treatment Plant:  
**1/2 mile**

## Spa Installation – Important Observations

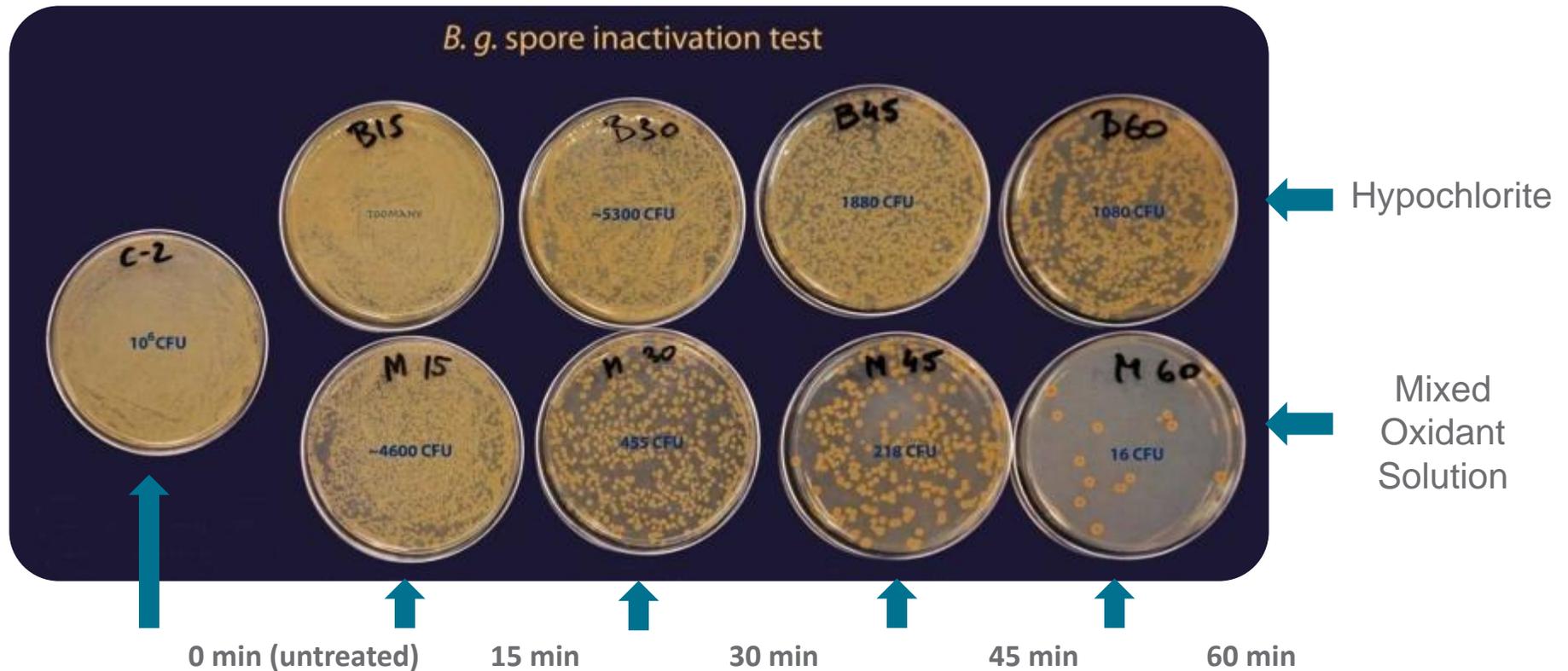
- Initial dosing was identical to original conditions
  - i.e. Dosing was begun at 1.5 mg/l as FAC
- Over time, as biofilm was removed, the resultant residual increased
  - Initially, 1.5 mg/l dose resulted in 0.2 mg/l residual as FAC
  - As residual increases, base dosing was reduced
  - After 22 days, initial dose was reduced to 0.6 mg/l
  - Biofilm was visibly lower when inspected via boroscope
- Even with lower input dose, the resultant residual was still higher
  - Evidence that biofilm was presenting a major chlorine demand
  - Visual evidence implicated that even though bleach maintained a residual, biofilm was not being effectively controlled
  - An eventual 60% reduction in dose still resulted in a 100% increase in residual due to much cleaner recirculation loop

# Mixed Oxidant Solution - *Visible Effect of Trace Hydrogen Peroxide with Hypochlorite*



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CDC Study - Inactivating *Bacillus globigii* (B.g.)

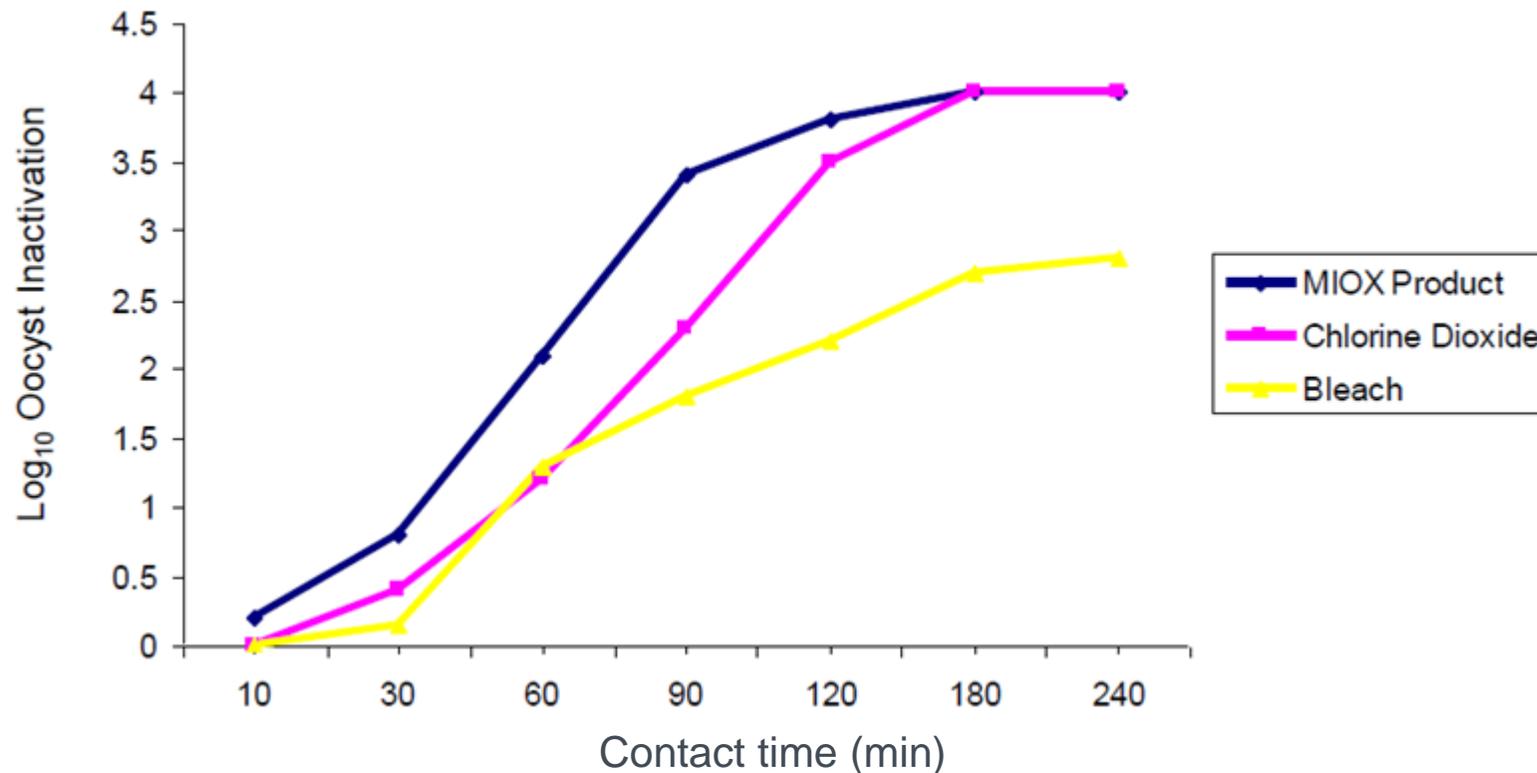


Bajszar, 2009; Validated in 3<sup>rd</sup> party studies at the Centers for Disease Control and Prevention

# How does Mixed Oxidant solution compare to Chlorine Dioxide?

- Comparing effectiveness against cryptosporidium, which is a very difficult to kill organism

EPA Type 2 (dirty) Test Water, *C. Parvum* oocyst, Dose: FAC=12 ppm; ClO<sub>2</sub>=11.4 ppm



# On-Demand Chemistry is also Safest Chemistry Option



- Regulations
  - Trend toward the safest
  - Limit on hazardous chemical storage
- Non-public incidents
  - Recent near misses of Cl<sub>2</sub> leak at two large industrial facilities South East US
- Sustainability
  - Less trucks, less chemicals
  - Lower carbon footprint

## MOS Pros

- Inherently safe base chemistry
  - Salt is only concentrated chemical
- Very effective biofilm control
- Wide range of available dosing
- Easy to control, monitor and report
- Lowest operating cost

## MOS Cons

- Capital cost can be a challenge
  - Can investigate other procurement and/or rental options
- May be space constraints at site

## Summary Table; ClO<sub>2</sub> vs. MOS

	Standard "Bleach"	ClO <sub>2</sub>	MOS
Effectiveness	Poor biofilm control but decent biocide	Excellent biofilm control	Excellent biofilm control and all purpose oxidizer Ex. When the feed water is well waters or municipal water
Regulatory Monitoring Requirements	Monthly or Quarterly Can be easily automated	Daily for ClO <sub>2</sub> and chlorite	Monthly or Quarterly Can be easily automated
Safety	Dangerous at full strength	Hazardous	Non- hazardous
Cost	~ 1.25 - \$1.50/lb FAC (average U.S.)	~ 1.80 - \$2.50/lb FAC	~ \$0.55/lb FAC



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# Case Studies

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

BEFORE MIOX



AFTER MIOX



Cooling tower sump looking down from the hot deck

## Problem

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

## Solution

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

## Results After Using MIOX

- ▶ Avoids millions in potential lawsuits for Legionnaires'
- ▶ No positive Legionella counts since MIOX installation July 2011
- ▶ Reduced hospital's liability for hazardous chemicals
- ▶ Visibly cleaner - slime and green algae is gone

# Hospital Case Study:



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## Biofilm removed, Legionella non-detectable in 8 days



- In 2006, water system non-compliance delayed hospital commissioning
- Legionella and Pseudomonas (a biofilm-former) consistently detected using chlorine dioxide (0.5 ppm dose)
- Disinfectant residual and bacterial sampling conducted at 1400 sampling points
- Within 8 days, MOS dosed at 50 ppm showed non-detectable Pseudomonas and Legionella counts

Day	<i>Pseudomonas</i> (CFU/mL)	<i>Legionella</i> (CFU/L)
Day 0	0-95	Detected
Day 5	60 (hot) 0 (cold)	ND/1 L
Day 8	0 (all points)	ND/1 L

## Secondary treatment of potable water



- Two 8 lb Systems
- One for potable water system
- One for cooling towers
- Systems purchased mainly due to concerns about Legionella control

Mixed oxidant replaces both chlorine and bromine, saving over \$150,000/year in chemical costs for one tower



(Sept, 2008) U15 Main Condenser Tube Sheet after extended run – before cleaning, after non- MIOX treatment



(June, 2010) U15 Main Condenser Tube Sheet after extended run – before cleaning, after 2.5 Months of MIOX treatment

- 300 ppd Mixed Oxidant
- Replaced both chlorine and bromine for cooling tower water disinfection
- Partial retrofit using existing tanks
- Expect 3 additional towers to switch to mixed oxidant after success at Tower #15
- Reduced price of disinfectant/oxidant by generating it on-site.
- Generating a safer chemical below the 1% threshold for consideration as a hazardous material.
- Improved chemical efficacy
- Reduced maintenance
- Early phases of operation in 2010 show promising data

Thank you for your attention!