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## Mixed Oxidant Solution in Hospital and Other Premise Plumbing Water Systems

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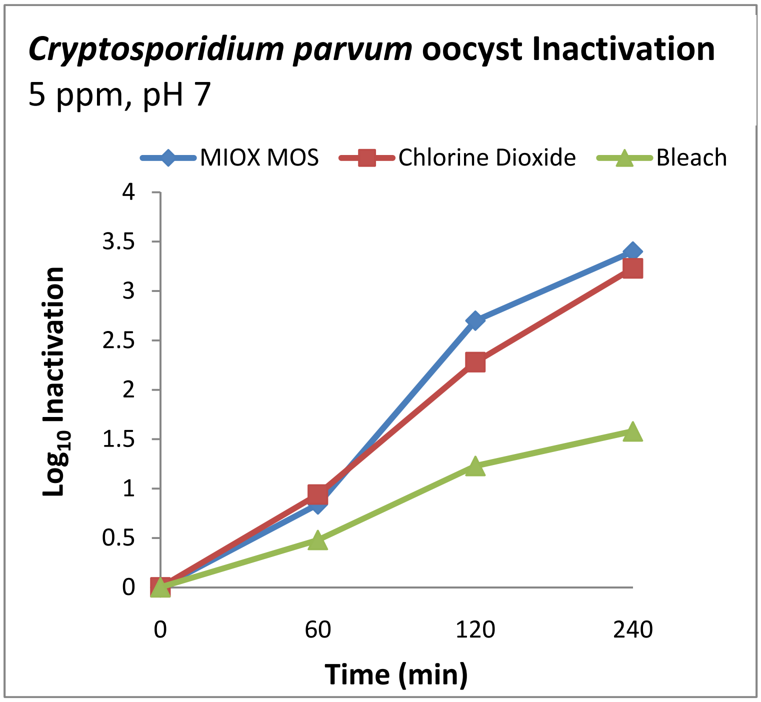
### Introduction

Waterborne pathogens in building's potable water systems (premise plumbing) can cause significant risk to both patients and hospital administrators. These pathogens include *Legionella pneumophilia*, *Psedomonas aeruginosa*, *Actinetobacter baumannii*, *Stenotrophomonas maltophilis*, Mycobacterium Avium Complex (MAC), *Aspergillus and* protozoan oocysts. Microorgansims are often introduced via municipal water supplies, making an active monitoring and maintenance program important. Many of these pathogens are known to form inter-dependent biofilm communities and biofilm-embedded (sessile) microbes are far more resistant to disinfectants than free-floating (planktonic) organisms. If planktonic pathogens release from a biofilm, it is critical to have a residual in the system to kill the microbe(s). MIOX's on-site generated mixed oxidant solution (MOS) uses only salt and power to provide a chlorine-based disinfectant with biofilm removal properties. After installing MIOX MOS generators, several hospitals managers interested in preventing or removing Legionella from their water systems report that no hits have occurred. Both MOS and chlorine dioxide disinfect hard-to-inactivate microorganisms, such as *Cryprosporidium parvum*. But only salt and power are required to run the MOS generator whereas chlorine dioxide uses hazardous starting materials and the gas itself can be dangerous to handle.

The disinfection and regulatory considerations for premise plumbing applications are complex. Selecting the best technology and management practices are critical to reducing the risk associated with water systems. This short white paper covers the required monitoring, generation, and disinfection efficacy for two technologies, chlorine dioxide ($ClO_2$) and on-site generated Mixed Oxidant Solution (MOS). In short, MOS and $ClO_2$ are both generated on-site and will perform similarly in this application. However, the operational challenges and dangers coupled with the monitoring requirements for $ClO_2$ are much more onerous than those for a chlorine-based disinfectant.

### Disinfection Efficacy of Chlorine Dioxide and MOS

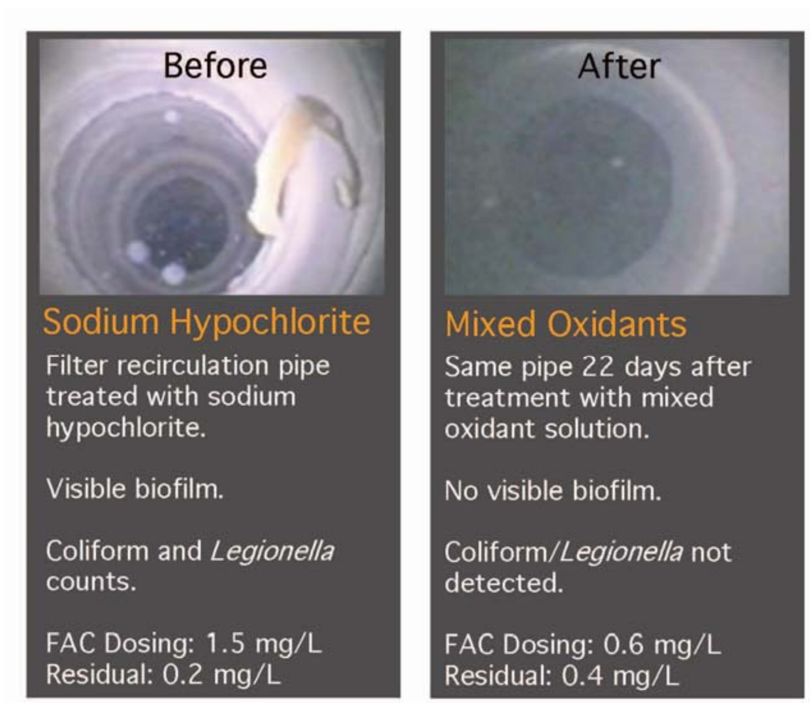
Both $ClO_2$ and MOS are effective at inactivating microorganisms. The first figure shows that in comparative laboratory inactivation studies using *Cryptosporidium parvum* oocysts as the challenge organism, MOS and ClO2 perform similarly, giving at least 1 log greater inactivation than bleach at the same concentration and pH.




It is well know that chlorine dioxide can remove biofilms at high enough concentrations. Sub-lethal doses are not as effective and can sometimes cause microorganisms to form a biofilm as a protective measure to avoid being killed by the oxidant.

MOS can also remove biofilms at reasonable concentrations (0.5-4 ppm) that will not cause significant building pipe corrosion. To provide continuous disinfection and reduce risk, MOS should be fed continuously. If desired, the system can be sized to provide "shock chlorination."

Experience with distribution systems indicates that once a biofilm is removed, maintaining a constant residual of at least 0.2 mg/L will minimize biofilm regrowth. The second figure shows a typical before and after biofilm removal and residual stabilization scenario. When sodium hypochlorite was dosed at 1.5 mg/L, Legionella hits were detected, despite a measureable residual of 0.2 mg/L. After replacement of bleach with MOS, the biofilms were no longer visible using a boroscope camera. More importantly, after system stabilization, the does was maintained at 0.6, more than ½ that with bleach and the residual was higher.





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**Operational Considerations**

Both $ClO_2$ and MOS are generated on-site. However MOS only requires salt as a feedstock, whereas $ClO_2$ requires chlorite, an explosive chemical and at least one other chemical, usually chlorine. Chlorine dioxide in gas form is hazardous and extremely difficult to handle safely. Because of its instability in gaseous or liquefied gaseous form, it is almost never shipped and therefore must be generated on-site. Short term exposure to chlorine dioxide and its by-product, chlorite ion, in amounts which exceed allowable concentration pose certain health risks such as mucosal irritation and damage to red blood cells. Vulnerable populations such as infants and immune compromised are especially at risk.

**Regulatory Considerations**

The US Environmental Protection Agency (EPA) regulates Public Water Systems (PWS) under 40 CFR 141 of the Safe Drinking Water Act (SDWA). Most hospitals fall under the definition of a PWS and are therefore subject to regulation.

The Disinfectant and Disinfection Byproduct Limits for $ClO_2$ and chlorine ($Cl_2$) are shown in Table 1. The maximum amount of residual disinfectant is only 0.8 mg/L for $ClO_2$, whereas it is 4 mg/L for chorine. Because elevated levels of $ClO_2$ and its main byproduct, chlorite are a public health concern, the best available technology proposed by US EPA for chlorite control is limitation of $ClO_2$ dosage at the point of entry.

| TABLE 1 | $ClO_2$ | Chlorine |
|---|---|---|
| Maximum Residual Disinfectant Level (MRDL) | 0.8 mg/L | 4 mg/L |
| Maximum Contaminant Level (MCL) for Disinfection By-products (DBPs) | | |
| Chlorite | 1.0 mg/L | NA |
| TTHM | NA | 80 µg/L |
| $HAA_5$ | NA | 60 µg/L |
| Monitoring Requirements | | |
| Disinfectant | daily | 1-2 times per month |
| Chlorite | daily | NA |
| TTHM and $HAA_5$ | NA | monthly |

Monitoring is required for both disinfectants and their respective byproducts. However, the EPA requires daily monitoring of both $ClO_2$ and chlorite, whereas chlorine and its byproducts are typically monitored only 1-2 times per month, depending upon the number of people served by the water system. Further, the EPA approved methods for measuring chlorine are simple compared to those for measuring $ClO_2$. The EPA lists the Penalties for non-compliance include fines for each violation of up to $27,500 per day and may be applied retroactively for 5 years.

**MOS Advantage**

The advantage of MOS is that the solution is generated on-site, on-demand with only sodium chloride and power as the starting materials. At normal doses of 1-4 ppm, MOS is not corrosive to building distribution piping. The measurable component of MOS is FAC, which makes monitoring and reporting the same as what one would do with a chlorine or sodium hypochlorite system. Laboratory and field studies show that MOS is no more corrosive that bleach, so concerns about building piping are not t warranted unless very high concentration of MOS are used.

**Conclusions**

The primary advantage of MIOX Mixed Oxidant solution is related to **Operational Considerations.** Both $ClO_2$ and MOS are generated on-site. However MOS only requires salt as a feedstock, whereas $ClO_2$ requires chlorite, an explosive chemical and at least one other chemical, usually chlorine. Chlorine dioxide in gas form is hazardous and extremely difficult to handle safely. Because of its instability in gaseous or liquefied gaseous form, it is almost never shipped and therefore must be generated on-site. Short term exposure to chlorine dioxide and its by-product, chlorite ion, in amounts which exceed allowable concentration pose certain health risks such as mucosal irritation and damage to red blood cells. Vulnerable populations such as infants and immune compromised are especially at risk.

MOS not the same as chlorine dioxide. It provides similar disinfection benefits to chlorine dioxide, but it safer to maintain and service. Further, monitoring of chlorine, the measurable component of MOS is easier than chlorine dioxide.