Hospital Post-Construction Water Disinfection by Chlorine Dioxide vs. Known Alternatives

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Why do people go to the hospital?

Because they are sick!

- ✓ *Sick people have a compromised immune system!*
- ✓ *Sick people often spread pathogenic microorganisms and viruses!*

CONSEQUENCES

Hospitals by the nature of their business are:

- A potential source of infection for the general public.
- A potential source of infection for their patients, because many of them are ill and already have a compromised immune system, which make them sensitive to otherwise harmless organisms.

Conventional Solutions for Infection Prevention in Hospitals

1. *Hand washing.*
2. *Floor and surface cleaning and disinfection.*
3. *Thorough cleaning of reused components: laundry and dishes.*
4. *Disinfection of washrooms and showers.*
5. *Medical equipment sterilization.*
6. *Use of disposable consumables.*

More than 50% of the conventional solutions for the prevention of spreading infections use water as an ingredient.

BUT! What if the water itself is contaminated?

Specifics of Hospital Water Distribution Systems

- *A hospital's water distribution system is always under danger of contamination.*
- *When contaminated, the hospital water distribution becomes a potential source of infection for its users.*
- *Due to the specifics of hospital water distribution systems, it is very difficult to keep them completely pathogen free.*

Specifics of Hospital Water Distribution Systems

Waterborne pathogens can infect patients through:

- *direct contact (e.g. hydrotherapy, bathing);*
- *drinking, or inhalation (e.g. when pathogens become airborne after opening a faucet, flushing a toilet, or taking a shower);*
- *cleaning supplies can be infected with pathogens (through dilution with contaminated tap water).*

In fact, the most common source of extrinsic contamination of germicides, is from the water used to make working dilutions.

*This is why **reliable disinfection of hospital distribution systems serve as the first line of defence** for the prevention of hospital infection.*

Specifics of Post-Construction Hospital Distribution Systems

*Newly constructed or re-constructed hospital water distribution systems are **always contaminated**!*

CONTAMINANTS OF CONSTRUCTION MATERIALS

Biological (bacteria, fungus, etc.)	***Chemical (solvents, glues, etc.)***	***Mechanical (dirt, grease, etc.)***

Sanitation of Post-Construction Hospital Distribution Systems

- *It is important to flush the lines to clear mechanical and chemical contaminants.*
- *Line flushing should be followed by line disinfection to clear biological contamination.*
- *Disinfection should be done for all lines, including all fixtures (taps, showers, toilets, etc.)*

*Disinfection with **non-moving** disinfection solutions in the distribution is less efficient than with **moving (circulating)** disinfection solutions.*

Specifics of Modern Hospital Water Distribution Systems

1. At least three, sometimes four, different water distributions.

2. At least one re-circulation line.

3. Large number of non-touch (electronic) taps.

4. Special supply lines for dialysis units.

5. Separate supply lines for ultrasonic sterilizers.

Specifics of Hospital Water Distribution Systems that Undergo Renovation

1. All components for new hospitals that are listed in the previous slide.

2. In addition, old distribution lines constructed from different materials (cast iron, copper, stainless steel), which increase corrosion problems.

Standard Methods of Post-Construction Disinfection of Distribution Lines

Shock or Hyper-Chlorination

- *At least 50 ppm chlorine concentration for 24 to 48 hrs*
- *Usually followed by de-chlorination or neutralisation*

Super Heat-and-Flush

- *Water must be heated to 70°C*
- *Not for cold water distributions*

Shock or Hyper-Chlorination

Advantages

- *Effective against some bacteria*
- *The process is well known*

Weaknesses

- *Ineffective for biofilms*
- *Ineffective for Legionella elimination and mycobacteria*
- *Decomposes at higher temperatures*
- *Efficiency is pH dependent*
- *Corrosive for Pipes*
- *Forms high levels of THM and HAA and chlorate*
- *Requires dechlorination*

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Super Heat-and-Flush

Advantages

- Inexpensive
- Does not require special equipment
- Can be initiated quickly
- No disinfection by-products are produced
- Does not effect taste or odour of the water

Weaknesses

- Ineffective for biofilms
- Certain groups of L. *Pneumophila* exhibiting thermotolerance
- Not effective beyond thermostatic mixing valves
- Corrosive for pipes
- Does not prevent recolonization
- Risk of scaling

Chlorine Dioxide is Alternative Disinfectant for Post-Construction Distribution Lines

Advantages

- Superior activity against spores, bacteria, viruses, protozoan cysts and biofilm
- Requires relatively low concentrations
- Longer residual activity than chlorine
- Does not form THM and HAA
- Does not require neutralisation

Weaknesses

- Chlorite and chlorate are formed as a result of chlorine dioxide decomposition

Additional Advantages of Post-Construction Disinfection with Chlorine Dioxide

- All fixtures in the hospital, including sinks, shower cabins, and toilet bowls are disinfected when water with chlorine dioxide is running.
- Air is also disinfected in the washrooms, showers, surgical rooms, and all areas were fixtures are installed and functional.

WHY?

BECAUSE

- Chlorine dioxide gas does not react with water. It is soluble in water but remains in water as a dissolved gas, which can be removed from dilute aqueous solutions by aeration.
- Disinfection of distribution systems with chlorine dioxide is always done with constantly moving water that contains disinfectant. When a tap is open or a toilet is flushed, residual chlorine dioxide airs out of the water and disinfects the surrounding air and surfaces.

OSHA Permissible 8 hours Exposure Limit (PEL) is 0.3 mg/m^3.
NIOSH Recommended Exposure Limit (REL) is also 0.3 mg/m^3 TWA.

Studies show that chlorine dioxide at concentrations of 0.3 mg/m^3 are efficient against airborne pathogens (viruses and bacteria).

Chlorine Dioxide vs. Chlorine in Post-Construction Disinfection of Distribution Lines

- Special equipment such as RO systems, dialysis units, UV systems, sterilizers are often constructed from stainless steel.
- Hot water tanks, boilers, heat exchanges are all built from different metals and metal alloys.
- ✓ *Any metal, including stainless steel are susceptible to corrosion.*
- ✓ *There are many factors that will initiate, support and catalyze corrosion in pipes and equipment built of metals.*

Factors Affecting Metal Pipes Corrosion

Water Composition

- pH
- Buffer capacity
- DO
- NOM
- Disinfectant
- Chloride concentration

Biological Activity

- Biofilm
- Tubercles

Flow Conditions

- High flows
- Stagnation

Metal Composition

- Pipes age
- Presence of different alloys

Chlorine Dioxide vs. Chlorine in Post-Construction Disinfection of Distribution Lines

Usually for hyper-chlorination is used alkaline solution of sodium hypochlorite.

When hypochlorite is added to the water to generate 50 ppm chlorine concentration, pH of the water increases.

1. *Increase of pH changes chemical balance in the water and minerals that where in solution, precipitate on the inner surface of pipes or equipment, forming mineral film that effectively* ***protects microbiology on the walls from disinfectant****.*
2. *Concentration of chloride in the water significantly increases with hyper-chlorination. Chlorides are known to attack any metal surface, in stagnant water (especially stainless steel), causing pitting and crevice corrosion (localized corrosion).* ***Ones, protective layer on metal surface is damaged, corrosion process is initiated and will continue.***

Chlorine Dioxide vs. Chlorine in Post-Construction Disinfection of Distribution Lines

Chlorine dioxide solution is acidic, and in high concentrations (above 2 ppm), it will cause decrease of pH.

Addition of chlorine dioxide to the water will increase chloride concentration. If 1 ppm of ClO_2 is added, increase of chloride is negligible.

1. *Concentration of chlorine dioxide used in post-construction disinfection usually* ***does not exceed 1 ppm***.
2. *At this concentration and in circulating water, potential of* ***metal corrosion is extremely low*** (much lower than with use of hyper-chlorination).
3. *Chlorine dioxide is a gas dissolved in water, this is why it efficiently* ***eliminates microorganisms in biofilms***.

Chlorine Dioxide vs. Chlorine in Post-Construction Disinfection of Distribution Lines

Chlorine dioxide (ClO_2) post-construction disinfection of hospital distribution system has following advantages over hyper-chlorination:

1. *ClO_2 is active against much wider range of microorganisms than chlorine.*
2. *ClO_2 disinfects both water and surrounding air.*
3. *ClO_2 is effective in wide range of pH and temperatures*
4. *ClO_2 is efficiently eliminates microorganisms in biofilms.*
5. *ClO_2 disinfection is done at concentration of 1 ppm vs. 50 ppm of chlorine, this is why: a) it is less damaging for any metal pipe surface and equipment, and b) can be done when hospital is in operation.*

Disinfection with Chlorine Dioxide

- Osorno has long term experience in chlorine dioxide applications
- Osorno pioneered chlorine dioxide disinfection technology in Canada.
- The first chlorine dioxide generator for the disinfection of drinking water was installed by Osorno in 2004.
- Since then chlorine dioxide generators have been installed by Osorno in small and remote communities in Manitoba and Ontario.

Disinfection with Chlorine Dioxide

The first chlorine dioxide, post-construction disinfection of a hospital's distribution system was performed in 2006. The efficiency of this application was confirmed by bacterial analyses.

Since its first application, the efficiency of post-construction disinfection with chlorine dioxide has been confirmed after each job performed by Osorno.

Osorno always guarantees chlorine dioxide disinfection results.

Disinfection with Chlorine Dioxide

- In 2012, Osorno started a long-term R&D project that was focused around the concept of using smart remote communication in water and wastewater treatment systems.
- This project was supported by a NRC-IRAP Grant.
- One of the developed systems was a chlorine dioxide generator with capabilities of smart remote communication over the Internet.

Disinfection with Chlorine Dioxide

As part of the smart remote communication concept, a device called the SecureWall™ was developed to guard and defend communication channels used for remote communication.

The first Osorno chlorine dioxide generator was installed near the beginning of 2015.

Since then, the system's performance has been monitored remotely by Osorno.

The further jobs for disinfection of distributions can be done more efficiently, due to the availability of remote monitoring 24/7 over Internet.

QUESTIONS?