Gf and An Overview of Oxcide™: The Definitive Solution to Disinfection in Facility Water Distribution Systems & Equipment

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PREFACE

Water and water distribution systems in facilities (such as hospitals, hotels, dental clinics, nursing homes, prisons, industrial plants, agricultural/food processing plants, schools, restaurants, homes, etc) and equipment (such as cooling towers, evaporative coolers, misters, etc.) are all subject to microbial contamination.[1-4] Various studies and incidents of infection have revealed waterborne pathogens including *Staphylococcus, Streptococcus, E. coli, Cryptosporidium, Giardia Lamblia, Listeria and Legionella*, the bacterium that causes *Legionaires= disease*. Bacterial contamination can be found within biofilms throughout entire facility water distribution systems.[5] **Biofilm** is a layer of microorganisms contained in a matrix (slime layer) which forms on surfaces in contact with water.[6] **Scale is also a major harbinger of pathogens**. Even high levels of disinfectant cannot eliminate pathogens within even small amounts of scale.

Contamination may come from **two basic sources:** contamination in water received from the source and contamination from reverse migration.

Source Water Contamination

Municipal water treatment agencies are required to reduce, or test for, a dizzying number of microorganisms, disinfectants, disinfectant by-products, inorganic and organic chemicals, and radionuclides. **Although municipalities provide water of high standards, they are not required to, nor claim to eliminate contaminants entirely.**[7] For example, only requiring 99% elimination of *Cryptosporidium*, the EPA quantifies the expected number of illnesses from the 1% allowable at 463,000 cases annually.[7,8] In 1993, Milwaukee experienced a major outbreak of Cryptosporidium where about 400,000 people were affected, more than 4000 were hospitalized and about 100 people died.[8,9] Municipalities are not required to control or even test for Legionnaires'disease. Surveys of hospitals= water systems have shown that up to **70% are colonized with *Legionella***.[10,11] From 2% to 15% of mortalities from nosocomial cases of pneumonia in hospitals are from Legionnaires' decease. OSHA estimates that over 25,000 cases of Legionnaire's disease occur each year and cause more than 4,000 deaths. It is understood by the EPA and the municipalities, and generally misunderstood by the general public, **that even a well-operated water treatment system cannot ensure that drinking water will be completely free of parasites, bacteria, and other contaminants**.[12]

Another source of water, underground wells, is not regulated by the EPA. Well water comes in various shades of quality, none of which comes with any disinfection to treat possible contaminants.

Reverse Migration

Reverse migration of bacteria is another source of contamination within water distribution systems. American Dental Association studies show that **colony-forming units (CFU's) begin at the discharge point of water appliances and migrate back to the source of the water**.[13] One study showed that the devices dental professionals use to apply water to teeth and oral surfaces is contaminated by microbes in their patients' mouths. Microbial populations increase rapidly, **migrating up inside the water line**, even when using completely sterile water, flushing the line 20 seconds between patients and flushing the system with bleach once a week.[13] Sinks, faucets, showerheads and many other types of water using or water dispensing equipment, in any kind of facility, are constantly being exposed to various human and environmental contaminants. **These contaminants are pronounced in high use settings, like hotels, hospitals and restaurants, used by numerous people in various stages of transmitting, or having a heightened susceptibility to, infectious bacterium.**

Whether its source is from municipality or well supplied water, or from reverse migration, bacteria survive and grow within cold and hot water distribution systems partly because the **chlorine residual levels of municipal water treatment (between .5 - 1.5 ppm) are not sufficient to destroy all contaminates**.[13] In fact, one study in a relatively new hospital where the municipality added sodium hypochlorite to consistently maintain the available chlorine level at approximately 1.5 ppm, tests revealed over half of the samples taken in patient room faucets contained bacterial colony forming units too numerous to count. If the chlorine residuals were to be raised to the level required for microbial elimination (2 - 6 ppm)[5], the taste and safety of the water would be unacceptable. Even then, sodium hypochlorite would not eliminate scale and therefore the pathogens and spores harbored in the scale would remain and recontaminate the system.

The contamination dilemma is applicable to many industries. The health care industry, for example, **knows that waterborne pathogens are in their systems**, and they know attacking the problem at its root is typically the best and most cost effective approach.[14] Many hospital administrators feel that nosocomial (facility acquired) incidents of Legionnaires' disease, although causing 2-15% of the nosocomial cases of pneumonia, is less of a concern than other more prevalent bacteria, such as *staphylococcous,* which causes an estimated 500,000 nosocomial infections and 88,000 deaths annually.[14-16] Six percent (6%), (over 2 million) of all patients admitted to US hospitals contract a nosocomial infection. A significant portion of these are from water borne contaminates. Hospitals, healthcare facilities, food processing and other industrial facilities are required to adhere to guidelines (OSHA, JCAHO, CDC, FDA, etc.), some of which their own associations have created, to attack and treat the sources of contamination.[14] Individual facility engineers, tasked with solving the potentially catastrophic problem, just don't know how to proceed.[14] The experts disagree, and the literature and web sites of the various companies that offer numerous types of treatments are adept at highlighting the strengths of their particular method/chemical/system, but they downplay, or even omit, their respective significant dangers or burdens. None of these treatments reduce scale. Perhaps this inability to affect scale is a contributing factor to scale being marginalized as a significant factor.

Faced with the challenge of facility contamination, the primary question remains: "What is the definitive solution to waterborne pathogens in water distribution systems?"

ABSTRACT

A pure substance, known as hypochlorous acid (HOCl), has now become available for disinfection of water. Oxcide™ is the trademarked brand name of this pure hypochlorous acid. **Oxcide <u>is</u> the definitive solution to waterborne pathogens in water distribution systems.**

The use of chlorine (sodium hypochlorite) as a micro-biocide/water disinfectant is declining because of safety, environmental and community impact considerations. Various alternatives have been explored, including bleach, bleach with bromide, bromochlorodimethyl hydantoin (BBCDMH), non-oxidizing biocides, ozone, ultraviolet, chlorine dioxide, sodium chlorite, chloramine (chlorine & ammonia), copper-silver ionization, and thermal disinfection.[17] Each offers some unique advantages. Each has unique disadvantages.

Oxcide is found to have the advantages of other biocidal alternates without their disadvantages. Categories of objective analysis include: efficacy, safety, taste and odors, impact on equipment and systems, effect on scale, biofilm, residual effects, ease of use, maintenance and cost. This paper will describe Oxcide and compare its use with the alternatives**. Oxcide is being found to bring a significant, new standard of safety to building occupants by being able to completely eliminate pathogens from water, while also eliminating scale, from every faucet, every piece of water-using equipment and every other plumbing outlet.**

INTRODUCTION

When a search is done for "**Hypochlorous Acid"**, minimal **definitions** are found, such as, "the by-product formed when chlorine gas is added to water"[18]. A continuation of the search will bring the understated, powerful point that it is the HOCl component of the NaOCl chlorination disassociation of Cl_2 and Sodium Hypochlorite process that actually does the sanitizing.[19] Information is sketchy and even sometimes inaccurate because HOCl is currently thought of, and only minimally analyzed, as a transient byproduct in the ubiquitous chlorine chemical family. "Pure hypochlorous acid", as described in this paper, carries with it fewer negative hydroxides than HOCl formed via disassociation from sodium hypochlorite. For this and other reasons, under a light organic load (like the light organic contaminants as described above in water already treated by a municipality or from a normal water well), HOCl/Oxcide behaves uniquely and must be considered separately from chlorine. HOCl/Oxcide as a stand-alone chemical, separate from chlorine, has not been available in the market until now.

A breakthrough in chemical engineering has produced consistent high quality, pure HOCl from unassuming food grade precursors. This will result in a need for a paradigm shift in biocidal approaches. Hypochlorous acid is an "old", listed, well appreciated chemical but is now "**new**" **in availability as "Oxcide"** with possibilities/applications many, who understand the chemistry, consider revolutionary.

Production of Oxcide is similar to the process of fabricating standard sodium hypochlorite (NaOCl) with one significant difference. Sodium hypochlorite combines Cl_2 with caustic soda (lye) to stabilize chlorine. Elimination of sodium and caustic soda by the use of high rejection membrane technology produces pure hypochlorous acid.[20]

With the **sodium removed**, the benefits of pure HOCl/Oxcide become immediately evident when used as a biocide. **Elimination of lye** (also referred to as caustic soda and sodium hydroxide) makes disinfection possible without the high pH elements associated sodium hypochlorite. Even though it is considered a "weak acid", **pure Oxcide is delivered at a neutral pH (5-6.8) thereby delivering high efficacy, in short contact times, without the caustics**.[21]

Oxidation Reduction Potential (ORP)(expressed in mili-volts) describes the oxidation potential, **the level of sanitizing ability**, or the "killing potential" of treated water **irrespective of the kind of disinfectant <u>or pH</u>**.[22] Any water, for example, treated to have an ORP of greater than 500mV for more than one hour (approx.) would be assured of being free of E. coli, Listeria, Salmonella and other pathogens..[22] High ORP levels in Oxcide are possible due to the elimination of the caustics. This feature of Oxcide allows for a higher level of ORP than say, Sodium Hypochlorite (NaOCl). When caustic Sodium Hypochlorite is used, it also simultaneously raises the pH of water and thereby dramatically reduces its efficacy (ORP). When Oxcide is used, the pH of water is not raised / slightly lowered and its efficacy (ORP) remains/is enhanced.

All water disinfection will result in the formation of **disinfection by-products**.[23] Oxcide is no exception. Oxcide has the advantage that it does not contain the hydroxl ion and will oxidize organic material to form lower levels of chlorates thus reducing halogenated by-products. The inorganic by-products, (trihalomethanes (THMs), chlorite, chlorate and chloride ions) formed when Oxcide is used, are held in balance at much lower levels. Thus, lower disinfection by-products are produced in the process, **about 30% - 50%** compared with sodium hypochlorite and other oxidants.[24]

Oxcide produces a residual of CL_2 that continues to remain available based on bacterial demand.[21] ORP levels can last for long periods of time depending on organic burden.[21] Tests show that not only is Oxcide a **sanitizer** and a **disinfectant**, but it is also **sporicidal**.[25] Sporicidal tests also demonstrate that Oxcide treatment **eliminates bacterial spores and biofilm**.[25]

Oxcide, even at residual levels over 12 ppm in treated water, leaves **no** or **minimal odor or chlorine taste**.

Water treated with Oxcide will result in the **elimination of scale and calcification** of minerals on plumbing piping, plumbing fixtures, other equipment and their orifices. Oxcide in treated water prevents the formation of insoluble calcium and magnesium salts such as carbonates and chlorides (scale/calcification). This conditioning effect of water is found to be similar, and in some ways superior, to other conditioning systems like filtering or reverse osmosis, which wastes large quantities of water and still allows passage of a percentage of minerals.

FDA certified lab testing proved Oxcide to **be non-hazardous, non-toxic and non-irritating to the skin, eyes, nor the environment.** [26-28] Oxcide is rated **safe** for transportation and storage, and does not require containment or ventilation.[29]

Systems have been commercially developed that use pure Oxcide to treat water and water distribution systems. Oxcide has been **approved by NSF** for use in public drinking water for scale control. Oxcide is currently in the process of being registered for biocidal claims by the EPA and other state regulatory agencies. Succinctly described, **Oxcide Treatment Systems** consist of off the shelf components applied at the main water supply line (after the meter, but before it branches off to various parts of the building). These components inject precise amounts of Oxcide solution into the water. Because Oxcide is safe and tasteless, the water can be consumed and used without disruption, or the slightest notice, of the building patrons.

A **protocol** for the system's use would have a period of continuous "high" ORP water treatment. This treatment would not only clear the water of pathogens, but would also clear the faucets and shower heads where harmful pathogens begin their reverse migration back up into the piping. Importantly, the treatment will also eliminate the scale and biofilm in the piping systems that harbor the pathogens.

After the initial treatment, the **crucial key to maintaining a facility free of pathogens** in the water distribution system and equipment is the **on going treatment** of the building's water distribution system to achieve constant "end point disinfection", verified by targeted ORP readings at individual orifices and/or periodic biological sampling. These treatments destroy any recontamination of pathogens beginning their intrinsic regeneration of colony formation and block minerals in the water from forming scale again.

Treated water with residual ORP levels supplied from each building faucet will also **eliminate or reduce pathogens from surfaces it contacts**. **Hand washing** at sinks supplying treated water, for example, will result in **greater eradication of bacteria on the hands and, subsequently, fewer cases of cross contamination and nosocomial infection**. Similarly, **equipment** (ice machines, dental unit water systems, beverage dispensers, endoscopes, countertops, etc.) in contact with treated water **will be cleared or reduced of pathogens and be kept free of mineralization and biofilm.**

Once the system's components are installed and the controller is programmed, **the system operates itself**. The only maintenance requirement is to make the connection from the system to the prepared solution that is delivered at scheduled intervals. The solution is delivered on specification and does not depend on performance/maintenance issues of on-site equipment.

DISINFECTION METHODS:
Advantages, Disadvantages, and Comparisons to Oxcide

By way of comparison, the following presentations are offered to show the advantages and disadvantages of current approaches to water disinfection. Much of the following information has been reproduced verbatim in many cases, from two recent landmark articles: "Legionella in water distribution systems", by Yu-sen E. Lin, Radisav D. Vidic, Janet E. Stout, and Victor L. Yu, as found in Volume 90, Issue 9 of Journal AWWA; and, "Legionnaires= Disease - How Will the New JCAHO EC 1.7 Guidelines Impact Health Care?", by Tim Keane, found in the Healthcare Facilities Management Series, October 2001, published by the *American Society for Healthcare Engineering* of the American Hospital Association.

Copper-silver ionization.

Ions are electrolytically generated from electrodes made of copper and silver. The manufacturer recommends that copper and silver ion concentrations be maintained at 0.2-0.4 and 0.02-0.04 mg/L, respectively. These concentrations are well below the maximum contaminant levels specified by the US Environmental Protection Agency for drinking water. Copper and silver concentrations should be monitored. Copper concentration can be estimated weekly by use of a sampling kit and verified monthly by atomic absorption spectroscopy. Samples of hot water used for assays should be clear, not turbid.

Advantages. Copper-silver systems are easily installed and maintained. Efficacy is not affected by higher water temperature, unlike chlorine and ultra-violet light. Oral consumption is limited because ions are added only to the hot water re-circulating lines. Bacteria, like *Legionella,* are killed rather than suppressed, which can minimize the possibility of recolonization.[32] Recolonization was delayed by six to twelve weeks even after the ionization system was shut down in one hospital.[33,34] Thus, the residual effect provides an added margin of safety (unlike hyper-chlorination, in which *Legionella* can rapidly appear if the system malfunctions).

Disadvantages. Not only does Copper-silver not reduce scale, scale must be removed from the electrodes regularly to ensure best performance. Excessively high ion levels have turned water a blackish color and stained porcelain sinks lavender. Elevated pH (greater or equal to 8.0) reduces the effectiveness of copper-silver ions.[35] Long-term treatment with copper and silver ions could theoretically result in the development of resistance to these ions. Although there are EPA published maximal allowable limits of both these metals for potable water, Copper-silver is not EPA approved as a biocide for any application.

Comparison to Oxcide. As mentioned previously, Oxcide treatment systems are easily installed and maintained, efficacy is not affected by water temperature, bacteria throughout the entire system are killed as are any recolonization and scale is controlled. The components have long lives free from significant maintenance requirements. No staining of plumbing fixtures will occur. The optimal form of water disinfection is the pursuit of the reduction of any disinfectant by products (DBP=s) which Oxcide demonstrates.

Thermal eradication (superheat-and-flush procedures).

Hot water tank temperatures are elevated to 70 degrees C, and then all water outlets, faucets, and showerheads are flushed for 30 min.[36] It is critical to document that the water temperature at the distal outlet reaches 60 degrees C. If this temperature is not reached or if the duration of flushing is too brief, the procedure is likely to fail. A 5-min flush failed to eliminate *Legionella* at two hospitals; a 30-min flush was later successful.[37] *Bacteria* can re-colonize within weeks to months after superheat-and-flush procedures. Because hot water systems that are maintained above 50 degrees C are less likely to be re-colonized by *Legionella,*[38-41] several hospitals maintained hot water temperatures at 60 degrees C after using the superheat-and-flush procedure.[39,42]

Advantages. The superheat-and-flush method requires no special equipment, so it can be initiated expeditiously.

Disadvantages. The superheat-and-flush procedure is time-consuming, and a large number of personnel are needed to monitor hot water temperatures and flushing items. Mixing valves and scald guards must be bypassed. Scale is not affected. Disinfection is only temporary, and recolonization of the system will occur within months.[43] Scalding can occur.

Comparison to Oxcide. The Oxcide treatment systems are easily installed, and, as previously mentioned, once set, demands minimal attention. Disinfection is constant, safe and inconspicuous to building users. Since Oxcide in treated water is tasteless, thermal eradication becomes unnecessary, due to ongoing elimination of contamination sites.

Ultraviolet (UV) light.

UV light units are effective if installed near peripheral outlets such as showerheads and faucets. The water flows in one port of the hydraulic chamber and is sterilized by UV light generated by mercury lamps.

Advantages. UV light systems are easy to install and do not harm water or plumbing. Unlike copper-silver ionization and hyper-chlorination procedures, the UV light procedure forms no disinfection by-products.

Disadvantages. UV light does not provide residual protection because bacterium will persist in biofilms where UV light cannot penetrate.[44] Thus, UV light is unsuitable as the only control measure for an entire water system; an additional systemic disinfection method is required for building-wide disinfection.[45,46] UV does not eliminate scale hence, water must be treated or filtered to minimize the accumulation of scale on the quartz glass tubes, and the tubes must still be cleaned regularly.

Comparison to Oxcide. Not only will the Oxcide treatment systems not harm water or plumbing; pathogens, scale, as well as the biofilm, will be eliminated; and, due to the unique chemistry of Oxcide, the treated water will have many beneficial characteristics of conditioned water. Some users find they don't need reverse osmosis, or other water treatment systems, when Oxcide is used.

Hyper-chlorination.

Two approaches have been applied: shock hyper-chlorination and continuous hyper-chlorination. During shock hyper-chlorination a pulse of chlorine is injected into water to achieve a concentration of 20-50 mg/L throughout the system.[36,44] After 1-2 hours, the water is drained, and the system is mixed with incoming water so that the residual chlorine returns to 0.5-1 mg/L.

Continuous hyper-chlorination is accomplished by continuous injection of calcium hypochlorite, sodium hypochlorite; chlorine dioxide, or gas chlorination.[36,47,48] Residual chlorine concentrations will fluctuate because of changes in incoming water quality, flow rates, and scavenging by system materials or indigenous biofilms. Engineering personnel need to be trained to monitor the residual chlorine concentration.

Advantages. Residual disinfectant is provided throughout the entire water distribution system.

Disadvantages. Burdened with its stabilizing constituent elements, sodium hypochlorite systems not only do not reduce pathogen harboring scale but will contribute to scale formation. Chlorine is highly corrosive and damages pipes. Three years after chlorination at the University of Iowa hospital, the incidence of pipe leaks was 30 times the rate before chlorination.[49] Even after all hot water pipes were coated with a sodium silicate precipitate, one to three leaks per month continues to be noted.[49]

Chlorine may only suppress pathogens like *Legionella* rather than kill it, and rarely can *Legionella* be eradicated by this method. Forty minutes were required to kill 99 percent of *L.pneumophila* in vitro at 0.1 mg/L of free chlorine; <1 min was required to kill 99 percent of E. coli.[50] If a chlorinator fails or malfunctions, bacterium can reemerge within days. Most hospitals using this method will still encounter sporadic cases of Legionnaires= disease.[51] [47] In one hospital studied where the municipality dosed to maintain relatively high levels of Cl_2 via sodium hypochlorite, high levels of bacteria including *Legionella* was still found. The presence of *Legionella* within amoebae, which may be more resistant to chlorine, may theoretically allow *Legionella* to re-colonize after chlorine levels drop.[52] Similarly, bacteria is shielded within scale deposits. Sodium and calcium hypochlorite do not reduce scale and because of their stabilizers and sodium actually contribute to scale formation. Because chlorine has a limited ability to penetrate biofilms,[53] it is less effective against biofilm-associated microorganisms such as *Legionella*.

`The reaction of chlorine with organic materials produces trihalomethanes (THMs) which are known carcinogens. Several studies have documented a higher estimated risk of cancer in those who consumed chlorinated water compared with controls. A meta-analysis of 10 case-control studies[54-63] and two cohort studies concluded that this risk was clinically significant.[64] The risk of acquiring cancer is presumably even higher if hyper-chlorinated water is consumed. Finally, a higher rate of miscarriage in pregnant females has been linked to consumption of chlorinated water.[65]

Comparison to Oxcide. Although seemingly analogous to chlorine, Oxcide is unique. The Oxcide systems are clearly superior to sodium hypochlorite in the destruction of spores, bacteria, viruses and other pathogen organisms on an equal residual base. The required contact time for Oxcide is lower; Oxcide has better solubility. The bactericidal efficiency remains in pH values between 4 and 9. Oxcide solutions are minimally corrosive primarily due it's low concentrations and, also due, to the elimination of the caustic element normally found in Sodium and Calcium Hypochlorite. The reaction of Oxcide and organic materials produce about half of the trihalomethanes as does chlorine. Oxcide eliminates existing scale and pathogens harbored in scale and blocks dissolved solids in supplied water from forming new scale. Biofilm is eliminated. Sections of a building are not required to be closed to normal use during treatment. The Oxcide system does not involve hazardous chemicals or burdensome maintenance.

Chloramines.

Chloramines are formed when chlorine and ammonia-nitrogen are combined in water. This solution is added to water systems.[66]

Advantages. The benefits of chloramines are that they will not mix with organics to form THM=s or other carcinogenic byproducts, and they can penetrate biofilm. In addition, chloramines are very stable.[14] (They have very good distribution properties).

Disadvantages. Chloramines are several orders of magnitude more harmful to dialysis patients than other oxidizers and by far the most difficult to remove from water systems.[64] Chloramines are toxic to fish.[67] Chloramines do not affect scale.

Comparison to Oxcide. Oxcide treatment systems not only eliminate contamination and scale in water distribution systems and but can help provide pathogen free water within Cl_2 limits of dialysis equipment.

Chlorine Dioxide.

Chlorine Dioxide is generated in equipment on site from precursors including sodium chlorite, sodium hypochlorite and hydrochloric acid.[17] The quality of the equipment and the consistency of the chemical produced by that equipment vary significantly from one manufacturer to the other.

Advantages. Chlorine dioxide is not nearly as corrosive as chlorine and, unlike chlorine, can penetrate and destroy biofilm. Although chlorine dioxide does not form trihalomethanes, it forms another disinfection by-product, chlorite.[68] Chlorine dioxide technologies have been used for many years to affect *Legionella* in potable water systems in Europe.[14] Chlorine dioxide has been EPA-approved as a potable water disinfectant.[14]

Disadvantages. Burdened with its stabilizing constituent elements, chlorine dioxide systems not only do not reduce pathogen harboring scale but will contribute to scale formation. A great hazard associated with the use of chlorine dioxide after proper generation is that of a leak. Chlorine dioxide is a poisonous gas that is soluble in water. Spills of generator solution will release chlorine dioxide into the air. Chlorine gas, if used, is also a poisonous gas.

Sodium chlorite is a corrosive solution and a strong oxidizer when allowed to dry. Sodium chlorite solutions must never be allowed to mix with acids and organics or evaporate to dryness. Under these conditions the substance becomes explosive.

Onsite generation of chlorine dioxide brings significant maintenance issues for facility workers. In addition to issues of operating the devices and handling the hazardous precursor chemicals and output chlorine dioxide, other considerations include requirements for workers to: read and understand all MSDS for chemicals used to generate chlorine dioxide; install/have access to a wash down hose and chemical eyewash and shower; carry a yellow "Acid Gas" escape respirator when working around chlorine cylinders or a chlorine dioxide generator; wear the proper safety equipment, minimally chemical goggles, rubber gloves, and apron, when working with sodium chlorite solution; wash the area of any personal sodium chlorite contact with copious amounts of water; immediately cleanup any spill, by washing with copious amounts of water, and notify regulatory agencies as required by law.[69]

The World Health Organization has warned that chlorine dioxide has been shown to impair neurobehavioral and neurological development in rats exposed perinatally. Significant depression of thyroid hormones has also been observed in rats and monkeys exposed to chlorine dioxide in drinking-water studies.[70]

Comparison to Oxcide. As mentioned previously, Oxcide treatment systems have performance characteristics that are similar or superior to chlorine dioxide (efficacy, scale elimination, etc), but it does not have the dangerous and onerous handling issues as well as the associated costs, health, and risk management considerations.

Ozone.

This technology uses Aozone@ which is activated oxygen. Normal oxygen in the air is made of 2 atoms (O_2); ozone is made of 3 atoms (O_3), which reverts readily to O_2. As ozone gives up its extra atom, it oxidizes the contaminants in the water.[71] Many systems, including ozone on-site generators, are low maintenance and do not require chemical precursors.

Advantages. Like UV, Ozone is an extremely effective point-of-contact biocide.[14]

Disadvantages. Ozone is very unstable and does not carry well through a system. Ozone, as a point of contact biocide, has no residual disinfectant. Ozone does not inhibit nor destroy scale or biofilm.[14]

Comparison to Oxcide. Oxcide treatment is extremely effective throughout a system, has residual disinfectant, and destroys scale and biofilm.

CONCLUSIONS

A Oxcide treatment systems have significant advantages over the other known disinfectant methods. The cost of Oxcide systems is significantly less than or comparable to other methods, especially considering the risks inherent in the significant, sometimes even potentially catastrophic, disadvantages of the other methods.

The following chart shows a basic comparison between these approaches. It is based on the chart created by Gregory Bova, Johns Hopkins Hospital Facilities Engineering.[72.] It is presented here with modifications, including the addition of a Oxcide based disinfection system.

The new availability of Oxcide, combined with the solid technology of its delivery system(s), has now become nothing less than the definitive solution to a serious, expanding national and international health dilemma. The quality, safety and purity of a facility=s water and water distribution systems can now be effectively and economically assured.

COMPARISON CHART OF WATER DISINFECTION METHODS

Item	Disinfection System							
	Oxcide (HOCl)	Super Heating & Flushing	Auto-Chlorinating / Inhibitor System	Auto-Chloramine System (Mono-Chloramine	Chlorine Dioxide	Copper-Silver Ionization System	Ozonation	Ultraviolet
Used on Domestic cold Water system	Yes	No	Yes	Yes	Yes	Feasible-return loop with fixture/ equipment back flow prevention required	Yes	Yes
Used on Domestic hot Water system	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chemical Utilized	HOCl/Oxcide	None	Sodium Hypochlorite	Chloramine (Chlorine & Ammonia)	Chlorine Dioxide (Sodium chlorite, sodium hypochlorite, hydrochloric acid)	Copper & Silver (Minerals)	None	None
Hazard of chemical/ Method	Non-hazardous	Scalding hazard	Hazardous Chemicals	Hazardous Chemicals	Hazardous Chemicals	Hazardous Chemicals	Non-hazardous	Non-hazardous
By-Product	Trihalomethanes (THM=S) (Far less than chlorine)	None	Trihalomethanes (THM=S)	Trihalomethanes (THM=S) (Far less than chlorine)	chlorite and chlorate	heavy metals - copper & silver	Bromate	Ozone
Effective Max. pH	9 pH	NA	7.8 pH	9 pH	10 pH	8 pH	NA	NA
Eliminates Scale iuyiuh	Yes	No	No	No	No	No	No	No
Taste & Odors	None	None	Yes- Can cause taste & odor problems	Yes- Can cause taste & odor problems	None (below .8 ppm) - removes most taste & odors problems	None	Yes- Will add odor	None-provided high intensity ozone lamps are not used

Impact on Equipment & Systems	Minimal potential corrosion problems	Potential	Potential corrosion problems	Minimal potential corrosion problems	Minimal potential corrosion problems	Minimal potential deposition of copper on mild steel/ localized corrosion- none reported	Potential corrosion problems	Potential corrosion problems if high intensity ozone lamps are used
Impact on Dialysis Equipment	None	None	None (below 4 ppm); carbon filters and RO equipment effectively removes chlorine & by-products	Significantly difficult to remove chloramines (mono-chloramines) and by-products at 4 ppm and below; carbon filters effective, RO membrane not effective; membrane damage	None (below .8 ppm); carbon filters and RO equipment effectively removes chlorine dioxide & by-products	Information currently not available	Information currently not available	None
Environmental & Health Effects	Produces THM=S (less than chlorine)	Water is scalding temperature	Produces THM=s	Produces THM=S (less than chlorine)	Produces Chlorite. Hormonal, neurobehavioral and neurological impairments in laboratory animals	Copper is acutely toxic to many aquatic species at levels as low as 50 ppb; system operates between 200-600 ppb copper, 10-60 ppb silver	None- bromite identified as an animal carcinogen; effects on humans unknown	None
EPA Approved Primary Drinking Water Disinfectant	Pending (below 4 ppm)	No	Yes (below 4 ppm)	Yes (below 4 ppm)	Yes (below .8 ppm)	No	No	No
Breaks down Biofilm (at Nominal Operating Conditions)	Yes	Yes	No @ below 50 ppm; minimal above 50 ppm (system operates between 2-3 ppm)	No - (system operates at 2-3 ppm)	Yes	Yes/No- depending on ppm	No	No
Inhibits Biofilm (at Nominal Operating Conditions)	Yes	No	Minimal	Minimal	Yes	Yes / No (depending on ppm)	No	No

Short tem Residual Effectiveness Against Legionella (System not Operating)	Yes	Yes- (Approximately one week)	Yes	Yes- far less effective as chlorine	Yes	Yes	No	No
Labor/ Maintenance required	Minimal- Connect line to new containers of delivered solution	Significant- evacuate affected areas, open then close all fixtures.	Extraordinary- verify hazardous chemical content, supply, connections. Adjust and monitor output. Evacuate affected areas, open then close all fixtures.	Significant- verify hazardous chemical content, supply, connections. Adjust and monitor output.	. Significant- verify hazardous chemical content, supply, connections. Adjust and monitor output.	Average- verify chemical content, supply, connections. Adjust and monitor output.	Average- Adjust and monitor output.	Average- Adjust and monitor output.
Flushing Required at All Fixtures at Start Up and On Periodic Bases	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chlorine Shocking of Water System Required Prior To System Operating (Shocking Effects Bulk Water Only; No Effect on Biofilm	No	NA	Yes	Yes	Not required	Not required	Yes	Yes

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