Ozone for Water Treatment Gains Acceptance

by Carl Schleicher

Dealers of water enhancement products are increasing ozone sales rapidly, while finding sales of chemical-oriented products are less attractive to their clients. The advantages of ozonated water are becoming better understood and easier to sell. As consumers demand a better water supply, the use of chemicals will continue to diminish while the use of ozone increases.

Dependant on the application and the contaminants present, ozonation can either eliminate or substantially reduce the chemicals required for water treatment, and provide a better quality water than conventional water treatment.

It is possible for dealers of water enhancement products to increase sales and profits by providing accurate information that differentiates between the myths and the truths concerning water supply contamination and viable solutions. Ozonation can play a major role in many of these solutions.

Ozone vs. Chlorine

Ozone is recognized among the strongest, fastest, commercially-available disinfectants and oxidants for water treatment. In addition, chlorine can not treat all water-borne pathogens, while ozone can. *Cryptosporidium* is only one of the many known but unregulated pathogens that chlorine alone cannot treat (assuming practical, safe doses are used, and remembering that chlorine is a poison at high doses). Further, chlorine generates trihalomethanes (THMs), which are disinfection by-products known to be carcinogenic, according to the American Journal of Public Health. THMs, including chloroform, occur due to a reaction with organics in the water, and are regulated by the USEPA.

It was planned that THMs were to be more stringently regulated; however, budget limitations have prevented the needed efforts to effect a limit lower than the 100 ppb (parts per billion) USEPA Interim (I) standard now in effect.

An approach for municipal water treatment, used in many large cities, and public water supplies, is to use ozonation for pretreatment and a reduced amount of chlorine for post treatment. This method takes advantage of the best of chlorine and ozone characteristics as reported by the Electric Power Research Institute in 1993. If there is any unused ozone, it reverts back pure to oxygen. The decreased amount of chlorine used for post treatment provides protection for miles of distribution. Chlorine residual lasts for a longer time than ozone, and provides a measure of protection for the water.

This method of using ozone for pretreatment in a public water supply decreases the amount of chlorine used in comparison to traditional chlorination, all while providing a quality product water. The decreased amount of chlorine used results in reduced THMs and other disinfection byproducts that are caused by chlorination.

The reduction in chlorine also has the benefit of reducing or eliminating the taste and odor complaints municipalities receive. Conventional

Table 1: The Troublesome Trio Strikes Again!

Contaminant	Secondary Maximum Contaminant Level •	Theoretical Ozone Dose for 1 ppm of Contaminant •	Practical Ozone Dose for 1 ppm of Contaminant •
Ferrous Iron (Fe^{+2})	0.3	0.43	0.14–0.5
Manganese (Mn^{+4})	0.05	0.88	0.5–1.0
Hydrogen Sulfide (H_2S)	*	6.00	0.6–1.5

• in parts per million

* The Safe Drinking Water Act has established Secondary Maximum Contaminant Levels for contaminants like hydrogen sulfide which may affect the odor of drinking water. Hydrogen sulfide must be tested properly at the source, or the H_2S gas escapes rapidly and will introduce errors.

Table 2: Ozone Injection Options (for pressurized water systems)

Method	Efficiency	Remarks
Venturi	Excellent	1. Requires suction to top of cycle for maximum efficiency. 2. Limits water flow. 3. Requires sufficient pump to provide flow and pressure. 4. Suitable for 1 horsepower pump and 6.5 gpm injector or other compatible pump and injector combinations.
In Line Booster Pump & Venturi	Excellent	1. Ensures suction to top of cycle to achieve maximum efficiency.
Sidestream Pump & Venturi	Excellent	1. Maintains flow and pressure available from pump. 2. Ensures suction to top of cycle to achieve maximum efficiency.
Compressor-Assisted Venturi	Good	1. Ensures good efficiency by helping force ozone into water through the venturi. 2. Used in applications where well pump cannot drive venturi to ensure suction to the top of the pump pressur cycle.
Compressor-Fed Stone Diffuser	Moderate	1. Maintains flow and pressure available from pump. 2. Requires pressurized ozonator or uses compressor after the pump.
Compressor-Fed Tee In Line	Moderate	1. Does not generate small bubbles required for efficient contact.

For longevity, the compressor should not be connected in line after the ozonator. Ozone will decrease the life of the compressor pump. To connect the compressor before the ozonator, you may require an ozone generator capable of handling pressure.

full strength chlorination in municipalities is well-known for chlorine taste and odor problems. When dealing with public water supply water, disinfectants should be used at the POU to further protect the consumer against possible contamination that could be introduced in distribution pipes, filters and other sources such as an unintentional cross coupling or backflow. There are small undersink ozonators, for example, that do a quality job of protecting the water at the POU.

Ozone and POE Well Water Applications

The use of ozone has continued to expand rapidly in POE well water applications for whole-house residential use. Ozone treatment is directed toward specific aesthetic- and health-related contaminants. The sidebar shows an abbreviated list of problems ozone is used to treat.

Many associations and publications list ozone as a disinfectant, but do not include it as an oxidant. This is probably due to its popularity for bottled water disinfection. The FDA recognizes ozone as GRAS (generally recognized as safe). Most bottled water is ozonated. The International Bottled Water Association (IBWA) recommends that an ozone dose be applied to all bottled water. The ozone residual disinfects the water, the bottle and the bottle cap.

Ozonation treats the "troublesome trio"—iron, manganese and hydrogen sulfide (Table 1). Many ground water supplies contain sufficient amounts of at least one component of this trio to cause objectionable taste, odor, slime, stain or color problems. Each can also be associated with bacteriological problems such as iron bacteria or sulphur bacteria. These bacteria do not generally present a health concern, but they are objectionable to live with.

Ozone and POU Water Applications

There is a large market for ozone water treatment of public-supplied water. The primary requirement is for POU drinking water. Consumers are concerned that the public water supply,

What Ozone Will and Will Not Do

It is important that dealers recognize where ozonation helps water treatment and where ozone doesn't contribute.

Some common uses for ozone in water treatment are
Disinfection: Bacterial disinfection, viral inactivation, biofouling control

Oxidation of inorganics: Iron; manganese; organically-bound heavy metals; cyanides; sulfides; nitrites; arsenic

Oxidation of organics: Color; tastes and odors; detergents (some); phenols and some other organics; algae control; turbidity control; microflocculation (of soluble organics); pretreatment of organics for biological oxidation; and THM precursor control

Reduce or eliminate aesthetic problems: Rust or black colored water; stained cloths or fixtures; discolored, unpalatable food and beverages; slime in toilet tanks and sinks; fuzzy particles in water; odorous or cloudy water

Some common ozonation benefits:
- Reduces or eliminates major chemical use
- Improves turbidity
- Excellent flocculent and coagulant
- Provides good tasting water
- Virtually maintenance free

The contaminants and/or water problems that ozone will not treat include hardness; nitrates; chlorides; low pH; high TDS; sodium; corrosive water and others.

although fine for drinking, is not of the quality they desire. This is best demonstrated by observing the growing water bottling and vending sales. The concern is directed toward aesthetic- and health-related contaminants. It is becoming more commonly accepted that water-borne pathogens can exist in chlorinated water. It is also known that many water-borne pathogens are not regulated. *Cryptosporidium*, *Cyclospora* and *Microsporidia*, three examples of nonregulated pathogens, can exist in chlorinated water, and have been known for years to cause human disease.

There are ozonation devices that, when coupled with filtration devices, provide a major reduction in aesthetic and health-related contaminants. Benefits of these undersink type ozonation/filter devices include

- Providing water on tap that meets or exceeds the Safe Drinking Water Act specifications;
- Safely reducing bacteria, viruses, cysts (*Cryptosporidium*, *Giardia*), metals (lead, mercury), THMs, benzene, chlorine taste and odor;
- No handling or storing of chemicals. No storage tanks;
- Virtually maintenance free;
- No harmful residuals;
- No wasted water. All the ozonated water is delivered to the consumer at the equipped faucet;
- Requires minimum under-the-sink space; no heavy bottles to lift, carry or store; and
- Low power requirements (40 watt) when in operation. Operation (power) is required only when water demand through the special faucet is present.

COMPONENTS OF A STATE OF THE ART OZONE SYSTEM

Quality parts for ozone generator longevity

To date, ozone generators are not regulated. It is important for dealers to select a manufacturer that provides sales and service support. Ozone generators that provide outputs large enough to deal with problem water are usually of a corona discharge design. Corona discharge (CD) ozonation requires the use of rugged parts that will stand up to the high concentration ozone required for success. Parts should be constructed of a high grade of teflon, glass, stainless steel and other ozone-tolerant materials including certain proprietary materials such as KYNAR and special proprietary, high technology glass to provide long life under field conditions.

Air dryers for steady, greater ozone output

The use of an air dryer provides more ozone output than a system using ambient air. In addition, ozone output won't vary with different humidity conditions. Without a dryer, the ozone generator output decreases when humidity increases and vice versa.

The lower the dew point, the less the water content in the feed gas for the ozone generator. Ozone generators must be operated at an extremely low dew point. Their longevity depends on dry air because moisture creates nitric acid, thus decreasing output and corroding equipment.

Compared to a system using ambient air, an ozone system using an air dryer operating at –76 F dew point achieves more than three times the ozone output; feed gas moisture of less than one ten thousandth that of ambient air; negligible nitric acid production; a substantial increase in longevity; and a decrease in required maintenance.

Manufacturers have now developed a number of effective air dryer configurations which are available for different applications.

Efficient injection system minimizes system cost

There are many ozone injection options to maximize performance and minimize system cost with a given size ozonator and specific contaminant levels (see table 2). The efficiency achieved is a direct function of the size of the bubbles formed. Because ozone is only partially soluble in water, ozone bubbles must be as small as possible to increase bubble surface area and achieve maximum contact.

High efficiency venturi injectors form millimeter size bubbles. These injectors also cause vigorous mixing action which greatly increases the efficiency of mass transfer of the ozone gas into the water. High efficiency injectors provide up to 99 percent mass transfer.

Stone diffuser injection also creates small bubbles, but the limited life and the cost of the compressors handling high concentration ozone could be a disadvantage.

When required, inline and sidestream booster water pumps provide a low cost, effective, and longer life approach than compressors. Sidestream injection maintains all the flow and pressure available from the well pump.

Allow sufficient contact time

Most contactors used for residential applications are pressurized tanks using an appropriate in–out closure and vent valve arrangement. This allows the contactor tank to function as an off–gas tank and a contactor.

Contactor tanks provide the residence time for the ozone to do its work. Ozone contactor tanks are much smaller than chlorine tanks because ozone reacts 3,125 times faster than chlorine. Tank size should provide sufficient time to decomplex contaminants tied up with organics and to ensure disinfection. Tank size can require four to eight minutes of contact to disinfect microbials.

Ensure adequate filtration

Multimedia depth filters with automatic backwash are an important part of an ozone system. The wrong filters can plug, channel, increase pressure drops and become a maintenance nightmare. Longterm operation of an ozone system, particularly one handling higher levels of contaminants, requires skills in the design and maintenance of depth filters, which require backwashing every 24 hours. Depth filters are typically rated to provide a flow rate equal to one-half the backwash flow rate. For example, the flow capability for a typical 10-in. x 54 -in. depth filter is five gallons per minute (gpm) backwash and 2.7 gpm filter flow rate.

The performance possible with a well designed multi–media 10-in. x 54 -in. depth filter is 5.5 gpm backwash and 10 gpm filter flow. These flow rates are greater than the typical flow rates and are essential to maximize ozone performance.

The 10-in. x 54 -in. tank size described will suffice for most residential, single family applications, but longterm operation depends completely on the selection of multi-media filtration. Selection of the multi-media must take into account pH, flow rates, contaminants and other factors.

For better water quality, follow the multi–media depth filter with an automatic backwash granular activated carbon filter. ■

Ozone Water Treatment Applications

Ozone is being applied in a wide range of applications. Basically the reason ozone use is wide spread and growing rapidly is the need and desire to reduce or eliminate chemicals that would otherwise contaminate our water supplies and cause aesthetic, pollution and health problems. The many applications include swimming pools, spas, lakes, industrial, wastewater, process water, bottling, vending and cooling towers. There has been a 200 percent increase in U.S. drinking water plants since 1990.

Improve System Design with Tests

Before designing a system, define the problem. A comprehensive water test kit is essential. In home tests for iron, hydrogen sulphide, manganese, hardness and tannins should be included. Also look for iron bacteria or sulphur bacteria slime in the toilet. Special problems that require lab tests may be required. Emphasize your testing to the customers as part of your professional approach to gain their confidence in your water treatment abilities.

Ozonation with Other Treatment Equipment

Ozone is not a panacea; systems must provide a solution to the total water problem which may include other water treatment technologies including RO; anion exchange; cation exchange; filtration; ultraviolet; advanced oxidation and others.

Ozone Enhances Other System Components

Use ozone pretreatment to reduce or eliminate organic loading of softeners and RO to extend the life of softener resins, and RO membranes to ensure better long term RO and/or softener performance. Ozone can be combined with ultraviolet treatment to provide greater disinfection capabilities where ultraviolet alone does not treat Crypto and certain viruses.

The Future for Ozone

The future for ozonated water treatment is bright. There are many consumer-driven aesthetic and health pressures to improve water quality. Ozone is a viable technology that can replace or reduce the wide spread use of chemical water treatment and provide improved water quality. ■

About the Author:
Carl L. Schleicher is president of Applied Ozone Technologies, Inc., Sarasota, Florida. He has been in the manufacturing industry for over 35 years and holds advanced technical degrees.

For more information on this subject, write in 1018 on the reader service card.