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ANALYSIS OF OZONE WATER

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Abstract

Ozone treatment is the most frequently used disinfection process in water today. With the application of a single ozone treatment step, the water can disinfect the water, the bottling equipment, the bottle, the air above the water and the sealed cap of the bottle; thereby provide a most effective barrier to microbiological contamination for the protection and benefit of the consumer. These are the reasons why most water bottlers rely on ozone treatment to provide a safe, good tasting, aesthetically pleasing and storage stable product. As the ozone treatment became a well-accepted, routine part of the water bottling process, many of its other benefits beyond the disinfection have become taken for granted and nearly forgotten. Some water bottlers may not even realize today that the use of ozone also provides benefits, such as, improved taste, elimination of odour, and long 2 years storage stability. These benefits have improved their product substantially making it a good tasting and safe. These are the product quality features that the costumers have grown to expect and enjoy. Since ozone treatment has become such a key process for the water bottlers, they need to stay current with the advances in the technology, and the improvements in the ozone treatment process..

Index Terms: *Ozone treatment 1, disinfection process 2, microbiological contamination 3, etc.*

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1.INTRODUCTION

Ozone is formed naturally in the atmosphere as a colorless gas having a very pungent odor. Chemically, ozone is the triatomic, allotropic form of oxygen having the chemical symbol O3 and a molecular weight of 38. Under standard atmospheric temperature and pressure, it is an unstable gas that decomposes into molecular oxygen. This very powerful oxidant, with a redox potential of 2.07, has many commercial and industrial applications. It is used commonly in potable and non-potable water treatment, and as an industrial oxidant. The considerable oxidizing power of ozone and its molecular oxygen by-products make it a first choice for oxidation or disinfection since then, ozone rapidly has gained public acceptance in the United States, with the introduction of the modern ozone generation equipment. This new technology makes it feasible to generate substantial concentrations of ozone for a multitude of applications. Recently, ozone has been granted G.R.A.S. status (generally recognized as safe) by the U.S. Food and Drug Administration (FDA). When ozone is applied as a gas for drinking water treatment, it is done primarily because of its oxidative strength. This powerful oxidation potential allows ozone to be effective in the reduction or elimination of color, aftertaste and odor. More importantly, ozone will effectively destroy bacteria and inactive viruses more rapidly than any other disinfectant chemical. Ozone also will oxidize heavy metals. Iron and manganese can be reduced to very low, safe levels in water supplies through ozone oxidation. This same process is used to liberate organically bound heavy metals, which otherwise are not easily removed. When properly applied at the start of a water treatment process, ozone will not lead to the formation of halogenated compounds such as Trihalomethanes (THMs), which are formed when chlorine is added to the raw water containing humic materials. Once a THM is formed, it is quite difficult, if not impossible, to oxidize — even with ozone. Thus, ozone can be used as an oxidant, where it is applied at the latter stages of water treatment.

1.1 History Of Ozone

A Dutch chemist called Van Marum was probably the first person to detect ozone gas sensorial. In the description of his experiments, he mentioned the notion of a characteristic smell around his electrifier However, the discovery of ozone was only just mentioned by name decennia later, in a writing of Schönbein that dates back to 1840. This discovery was presented to the University of München. Schönbein had noticed the same characteristic smell during his experiments, that Van Marum had tried to identify earlier. He called this gas 'ozone', which is distracted from ozone the Greek word for scent. Generally, the discovery of ozone is ascribed to Schönbein. Moreover, Schönbein is mentioned as the first person to research the reaction mechanisms of ozone and organic matter.

1.2 Maintenance

Ozone generation uses a significant amount of electrical power. Thus, constant attention must be given to the system tonsure that power is optimize for controlled disinfection performance. There must be no leaking connections in or surrounding the ozone generator. Therefore, leaks should be checked for routinely, since a very small leak can cause unacceptable ambient ozone concentrations. The ozone monitoring equipment must be tested and calibrated as recommended by the equipment Manufacturer. The operator must on a regular basis monitor the appropriate subunits to ensure that they are not overheated. Like oxygen, ozone has limited solubility and decomposes more rapidly in water than in air. This factor, along with ozone's reactivity, requires that the ozone contactor be well covered and that the ozone diffuses into the wastewater as effectively aspossible. Ozone in gaseous form is explosive once it reaches a concentration of 240 g/m Since most ozonation systems never exceed a gaseous ozone concentration of 50 to 200 g/m this is generally not a problem. However, ozone in gaseous form will remain hazardous for a significant amount of time; thus, extreme caution is needed when operating the ozone gas systems. It is important that the ozone generator, distribution, contacting, off-gas, and ozone destructor inlet piping be purged before opening the various systems or subsystems. When entering the ozone contactor, personnel must recognize the potential for oxygen deficiencies or trapped ozone gas in spite of best efforts to purge the system. The operator should be aware of all emergency operating procedures required if a problem occurs. All safety equipment should be available for operators to use in case of an emergency.

2. PROCESS

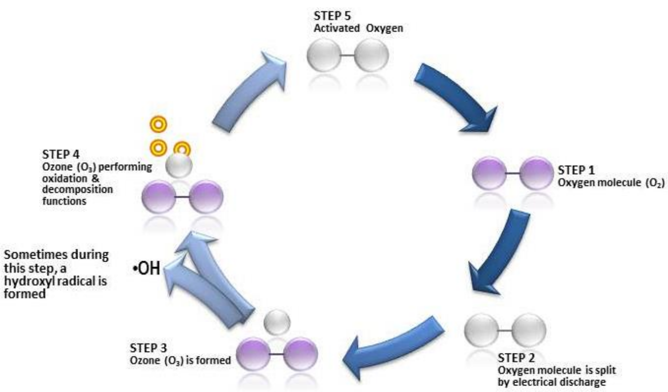
Ozone is created with what is called an Ozone Generator. It creates O3 in much the same way as the sun does. A chamber with a high intensity Ultraviolet (UV) light is filled with compressed air which then converts some of the oxygen in the air into ozone. This ozone is then sent through a line into a diffuser, which creates ozone-saturated bubbles. Water is drawn in to mix with the bubbles, and then fed into the water purification tank. The weak Oxygen molecule in the Ozone attaches to other organic molecules in the water and oxidizes them. This is the oxidation process that was discussed earlier. It is important to note that the effectiveness of the process is dependent, on good mixing of ozone with the water, and ozone does not dissolve particularly well, so a well-designed system that exposes all the water to the ozone is important. The ozone water purification system is one of the most advanced water treatment processes in the water industry. In the home, ozone is often combined with activated carbon filtration to achieve a more complete water treatment. These systems for your home can be quite expensive and are not readly available.

2.1 What Are The Safety Aspects

Ozone is a naturally occurring molecule that is with us constantly. Properly utilized and handled, it is safe, natural, and extremely useful. It can become harmful or dangerous only if used improperly or in excess. In 106 years of continuous ozone use in thousands of municipal water treatment facilities worldwide, no case of fatality has yet been attributed to ozone. Unfortunately, the safety record of chlorine is not as good. Although ozone is a naturally occurring molecule, it is abnormal and uncommon for it to exist in high concentrations near ground level. It is quite unstable and has a high activity rate at the temperatures and pressures that occur near the Earth's surface. As natural and necessary as ozone is for Earth and its inhabitants, ground level is not its Ideal environment, and this contributes to its reactivity and usefulness in water treatment. Worker exposure levels are not to exceed 0.002 g/m3 in the air for an 8 hour work day, or 0.1 ppm by volume. Fortunately, this is well above the threshold a person is able to detect by smell. The human nose is extremely sensitive to ozone, being able to detect concentrations of about 0.01 to 0.05 ppm or 0.0002 g/m3.

2.2 How Is Ozone Concentration Measured

Ozone has a very short half life in water. It is highly unstable and reacts by itself, as well as contributing very rapidly to the formation of other oxidants. In water, ozone is measured electronically, spectromically or via wet chemistry. Measuring electrically, or amperometrically, is accomplished with either bare electrodes or through a membrane, such as conductivity, DO, ORP and pH meters. As a gas, ozone can be measured in several ways: amperometricly using bare electrodes or with membranes; calorimetrically measuring the heat change; eudiometrically as a chemical method; isothermal pressure using volumes; and spectrometrically using wave length, which is usually the preferred method.



2.3 How Much Ozone Is Needed

Two steps are used to determine the amount of ozone required. First is the cumulative need, which is the number of milligrams of ozone necessary to oxidize the number of milligrams of contaminates present. This is the stoichiometry of the reaction representing the consumption of ozone, normally in mgO3/mg substance. When several contaminates or substances are present, the totals for each are added together. This includes metals, minerals, organics, pesticides and etcetera. When this need is satisfied, the reaction is done. This is the calculation for oxidization, coagulation, flocculation, precipitation, colour removal (ie. 1-3mgO3/mg Carbon) and etcetera. Second is the disinfection calculation, measured in *mg/L* of ozone over a specific period of *contact* time, usually minutes. This is a concentration & time (C t or C t) needed for inactivating living organisms, from single cell to higher life forms. It is the disinfection calculation for pathogens and pests, such as; algae, amoebae, bacteria, virus and etcetera. The cumulative demand must be satisfied before a concentration of ozone can be held stable for any period of time in solution. Both steps require adequate injection, mixing and time for the small amount of ozone to physically contact the target. One mg/L is only 1/1000 of a gram dissolved in one kilogram (1000 grams) of water, or 1:1,000,000. The time required for contact and/or reaction can be from several seconds to many minutes and is the obvious reason for the "t" in the C t. The ozone must physically contact the target to react with it. It is not just economical and beneficial, but almost essential, to remove substrates or turbidity prior to the disinfecting steps, so that the target organisms are not shielded from the disinfectant. Organisms can be attached to, as well as enclosed within, the turbidity or other particles. This principle applies to other disinfectants as well ozone. 14 If excess ozone is produced, OFF GAS can be a problem, so don't waste ozone and don't pollute with it. Attention to this will also minimize production costs. If there is any trick to using ozone, it is to make only as much as is needed and then place it correctly to do what is required. This automatically assumes the following:

1. The raw water quality is known. (= test it).
2. The desired specifications for the finished water quality are decided prior
to designing the system. (= the shotgun approach works poorly here).
3. The operation must allow sufficient time at appropriate points in the treatment
Sequence for the ozone to chemically react with the targets. (=design it)

Ozone will react when injected into water and there will be a reaction of some kind with
Everything in that water. This means everything, not just the contaminant targeted.

2.4 Is Ozone Treatment Expensive

Ozone is not cheap, but it is very effective. Ozone reacts somewhat differently than other treatments, so in cost comparisons, the apples to oranges problem frequently comes into play. While only barely competitive in some applications, ozone is very economical in others and at times it is the only treatment that will work. If other methods are not satisfactory, then efficacy becomes the major consideration in rating the cost of treatment. The designs and costs of equipment used in the production and handling of ozone vary widely at present. However, by making a few assumptions, some estimated costs can be calculated for small systems. Using air as the oxygen source, ozone can be produced at .25-1.8 g/kWhr of electricity. Using pure oxygen, about 15-25 g/kWhr can be expected. Assuming $.05 per kWhr, the production costs can range from $28- 200/kilogram with air and $2-3.3/kilogram using oxygen. Large efficient drinking water facilities are producing ozone for $1.57-3.30/kg ($.70- 1.50/lb), which includes all capital equipment, depreciation, power, operation, maintenance and the feed gas preparation or oxygen. With chlorine available at less than $400/ton in bulk, or less than $.45/kilogram, it is little wonder that eyes widen at the first mention of ozone. But, the amount of O3 required, speed of reaction, results, residuals, safety, other accomplishments and efficiencies need to be considered along with the cost per kilo. The smaller amount of ozone needed may result in the same or even less cost to achieve the desired results. AN EXAMPLE: A single family residence with a contaminated well system could expect to spend ~$1,000 to $2,000 for an ozone source, plumbing, electrical outlet and 15 automatic backwashing filter. A typical system may use 5 gO3/d and could increase the electric bill $4 to $8 per month at $.05 per Kw/hr. AN EXAMPLE: A small municipal system serving a population of 5,000 is delivering 500,000gpd from a surface water source and needs to upgrade its filtration plant facilities to inactivate Cryptosporidium and to address potential contaminate problems, such as pesticides. Attempting to inactivate the Cryptosporidium by increasing the chlorination disinfection level to a four log reduction would be futile. Although the cost increase for chlorine may only amount to less than 1¢/1000gallons, the water would be unpalatable, no cleaner or clearer and the potential for THMs significantly increased. To additionally treat their water with 1.5mgO3/L would require 6.26 pounds per day of ozone generation (~118 gram/hr). To insure adequate public health protection and allow for varying flows, three variable 4lb/day ozone package plants can be installed for about $55,000. The pumps, plumbing, electrical, misc. and monitors could cost an additional $20,000. Using a ten year life, this $75,000 capital equipment expenditure can be amortized for about $9,500 per year. Assuming $.05/Kwh, power for producing the 6¼ lb/d of ozone would cost $8.00/d, plus an estimated $3.00/d for pumping, monitoring and other. This O&M of $11.00/d plus $26.03/d for the capital, provides the additional ozone treatment of the 0.5mgd at $37.03/d, or about 7.5¢/1000 gallons. For ozonation of this system, the cost increase per person then amounts to about 0.0074¢ per day, 22.5¢/mo or $2.70/yr. Some of the O&M expenses will be reduced by longer filter life and less need for coagulant, flocculant and chlorine. Lower chemical usage will also decrease the requirement for sludge removal and disposal. The reduction in total chlorine need, as well as where and when it is applied, reduces the potential for formation of THMs. This system will now produce safer, cleaner, clearer, colorless, odorless and more palatable water for it's customers. Legal liability should also be diminished, so the system may get a break on insurance or legal fees. It is now better prepared to safely enter the next century. It is also a system that can be altered easily and economically for future contaminates problems. In addition, more efficient use of filters can allow some increase in services without major capital expenditures. The perception that ozone is a more expensive treatment is one apparent reason for it not being more commonly used in the United States. Also, widespread availability and distribution of information or publicity on ozone treatment has been very lacking in the United States. Without this ready transfer of knowledge and expertise to designers, planners and regulators, ozone has had little chance of competing with chlorine. There was no high profit major industry, like the huge petro-chemical complex, to foster, research, push, lobby and advertise for the use of ozone.

2.5 Advantage

• Possesses strong oxidizing power and requires short reaction time, which enables the germs, including viruses, to be killed within a few seconds;
• Produces no taste or odour;
• Provides oxygen to the water after disinfecting;
• Requires no chemicals;
• Oxidizes iron and manganese;
• Destroys and removes algae;
• Reacts with and removes all organic matter;

2.6 Limitations

• Toxic (toxicity is proportional to concentration and exposure time);
• Cost of ozonation is high compared with chlorination;
• Installation can be complicated;
• No residual effect is present in the distribution system, thus post chlorination is required;

Application

1) It is use in drinking water.
2) It is use in swimming pool purification.
3) It use in various industries like paper mills, etc.
4) Ozone in treatment of toxic wastes.
5) It is use to eliminate heavy metals from water.

3. CONCLUSION

The ozone treatment is essential for water bottling because it plays a multiple, beneficial role in the production of bottled water and can when, properly done, assure a good quality, storage stable product. Ozone is the most powerful, chemical disinfectant available. It disinfects them all: the water, the bottle, the bottling equipment, the sealed cap of the bottle and any air borne microorganisms in the air space above the water. Furthermore, it improves, taste, eliminates odor and oxidizes undesirable organic and inorganic materials that might be present in the source water. Then, once ozone has done its job, it decomposes to harmless oxygen. Should you wish for an ideal disinfectant for bottled water, you could not dream of a better one than ozone?

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