ClearWater Tech
OZONE SYSTEMS FOR WATER & AIR PURIFICATION

EarthSafe TECHNOLOGY

THE ULTIMATE SWIMMING EXPERIENCE

A Comprehensive Guide to Swimming Pool Water Treatment

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The Ultimate Swimming Experience

A Comprehensive Guide to Swimming Pool Water Treatment

by

ClearWater Tech
Ozone Systems for Water & Air Purification

Forward

This handbook is designed to provide an understanding of water treatment and sanitation approaches used for residential and commercial swimming pool and spa waters. There are many factors that can influence the approach taken whether bather load, project goals, budgetary constraints, or even the environment.

Although the author is an ozone equipment manufacturer, this handbook will provide information regarding typical sanitation options that are available in the market today. There will be a review of each option and the pros and cons as they relate to pool water treatment. In addition, further detail will be provided in regards to ozone and its many accolades, including ozone basics, how it is generated, system design aspects, and the best combination of other sanitizers with ozone. In fact, when ozone is used properly it can have a great synergistic affect with other sanitizers, especially chlorine.

It is important to have a simple handbook that is easy to read and understand, as attempting to achieve pristine pool and spa water can be a daunting task. With a better understanding of pool chemistry and the sanitation options available, nearly any pool can achieve "The Ultimate Swimming Experience."

Why Are My Eyes Burning?

Do you wonder why pools treated with chlorine often smell bad, burn your eyes, turn your hair green, and reduce your expensive swimsuits to rags so quickly?

The answer may surprise you. Everyone seems to blame chlorine. How often have you heard someone say, "There's too much chlorine in that pool!" However, chlorine in its natural state is an odorless gas. Free chlorine, or uncombined chlorine, is also odorless. Free chlorine in your pool does not irritate your eyes or nose and will not destroy fabric. But when chlorine oxidizes microorganisms and other organic pool water contaminants (sweat, urine, suntan lotion, etc.), it combines with its targets to produce by-products called chloramines, which are responsible for the unpleasant side effects characteristic of chlorinated pools.

If chlorine is doing its job, it seems inevitable that you'll get unpleasant chloramine side effects. It's a little ironic that the most irritating swimming pools typically have too little free chlorine for proper disinfection. This is because chlorine oxidation has already taken place and is combined with heavy contaminant loads to form chloramines.

Irritation induced by exposure to chloramines can occur in any pool that uses chlorine as its only form of sanitation. Offending odors as a result of chloramines tend to be worse in indoor pools where there is little air exchange or turn over in the pool room.

Chlorine By-Product Allergies

Chlorine reacts with organic compounds in water to produce trihalomethanes (THM's). Such as carcinogenic chloroform and Larson tetrachloride. It is the combination of chlorine and organic materials already in the water that produces cancerous causing by-products. The more organic matter in the water, the greater is the accumulation of THM's.

Some people experience allergic reactions to chlorine by products with symptoms including itchy red bumps on the skin, rashes, sneezing, sinus congestion, breathlessness, and fatigue, often persisting for several days after exposure.

Can I Test for Chloramines?

Red, irritated eyes are likely a sign of chloramines. Lower concentrations still pose health risks due to further chlorine by-products called THMs, which will be discussed later. You can't directly measure chloramine concentration in your pool, but you can estimate your chloramine concentration by using a chlorine test kit to measure both free chlorine and total chlorine. According to the Model Aquatic Health Code, the maximum level of combined or total chlorine is 0.4 ppm. This means that the maximum combined level may not be any greater than 0.4 ppm over the free available chlorine level. Higher levels indicate that bather loads or pollution from bathers may be too high or treatment is inadequate. If this is the case, then there may be excessive amounts of chloramines.

Can't I Just Get Rid of the Chloramines?

The traditional treatment for chlorinated pools, that cause bather irritation, is a "shock" treatment. Shocking a pool temporarily raises the total chlorine levels and helps eliminate chloramines. The frequency of shocking needed will depend on pool volume, bather load (how many bathers per hour), and other variables including water temperature and pH.

Regular or even frequent shocking of the pool may or may not be of concern to some; however another reason why the presence of chloramines in your pool should be of concern is chlorine disinfection by-products.

Disinfection By-Products (DBPs)

Gaseous chlorine (Cl) or aqueous sodium hypochlorite (NaOCl), reacts with water to form hypochlorous acid and hypochlorite ion. Chlorine (whether hypochlorous acid or hypochlorite ion) inactivates bacteria by penetrating their cell wall to attack the nucleus, thus destroying the microbes; DBP's are caused by this reaction.

There are many DBP's that have haunted the pool industry for years. Bromoform, aldehydes, cyanogen chloride and dichlormethylamine are all nasty by-products that bathers should be aware of. One of the most frequent and most common DBP are THMs.

Unfortunately, it was discovered as far back as 1974 that hypochlorous acid and hypobromous acid react with naturally occurring organic matter to create four compounds collectively called trihalomethanes (THMs). Early research into THMs and chloroform (one of the compounds found in THMs) attracted notice because chloroform was known to cause cancer in experimental animals.[2]

Over time, chlorination of drinking water has come under intense scrutiny because of increased mutagenic activity. Modern municipal water systems have replaced chlorine with ozone as the primary oxidizer in order to eliminate this risk. (If your municipal water system treats its water with ozone, it will still introduce a small concentration of chlorine as a safeguard residual sanitizer as it distributes treated water down the delivery pipe network).
Studies have shown that chlorinated swimming pools, especially with higher temperatures, higher pH levels and higher humic acid concentration (which come from decomposing organic), are very efficient THM factories.

The four THM by-products of chlorine disinfection are notorious for producing cancers in laboratory animals when administered in corn oil.[3] The jury is still out as to the potential for increased cancer rates when administered in water; studies are ongoing on THMs both individually and in combination. However, it is worth noting that the US EPA has classified chloroform as a Group B2 probable human carcinogen.

The California Environmental Protection Agency (Cal EPA) has established a chronic exposure level of 0.3 parts per billion for chloroform. The Cal EPA states that this exposure level is a concentration at or below which adverse health effects are not likely to occur.[4] It is not a direct estimator of risk, but rather a reference point by which to gauge the potential effects. At lifetime exposures increasingly greater than the referenced exposure level, the potential for adverse health effects increases.

As you can see, if you swim regularly in a chlorinated pool you may be exposed to chloroform concentrations that greatly exceed this safe chronic exposure standard. Though the total health risk of varying exposures to THMs is still under investigation, there is good reason to think twice about creating any unnecessary exposure for yourself and those who enjoy your pool.

Chlorine Alternatives

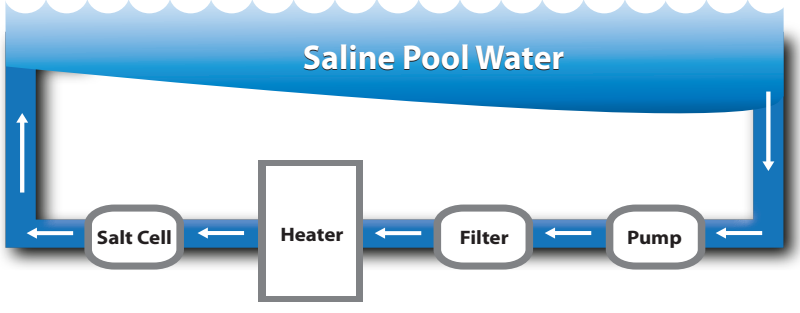
In a chlorinated pool, chlorine performs two sanitation jobs. First, it oxidizes contaminants; second, it kills microorganisms. In chlorine-only pools and spas, a residual amount of free chlorine is necessary for the pool water to remain sanitary. Oxidation consumes free chlorine and leaves chloramines as by-products. The challenge is to find an alternative that either handles both of chlorine's jobs, or takes on the oxidation task so that chlorine remains in the water as free chlorine without producing significant concentrations of irritating and harmful by-products.

Let's review the alternatives you may have heard about:

Salt Chlorine Generators

Typically known as salt generators, these systems actually produce chlorine from salt, rather than form salt. Another common misconception is that salt generators provide a chemical-free solution for your pool's sanitation needs. What some manufacturers don't tell you is that salt generators actually use large quantities of salt to generate chlorine on site. Salt is sodium chloride (NaCl); salt generators break the sodium chloride apart electrically as the "salt" water passes through the electrically charged cell to free up chloride (CI-) ions and also form hypochlorus acid.

Chlorine produced by salt generators or salt chlorinators produces the same chlorine by-products as liquid or tablet chlorine. There are many other reasons why you might prefer or reject a salt chlorination system, but if you are interested in eliminating chlorine by-products, salt generators are not an effective alternative.



Bromine

Bromine is in the same chemical family as chlorine (the Halogens) and shares many of its properties. Bromine is a weaker oxidizer than chlorine and while it does not produce chloramines, it still produces THMs as oxidation by-products.

Bromine is quickly degraded in outdoor pools by ultraviolet energy from the sun because there are no stabilizers available for it. Bromine is most often used in conjunction with other sanitizers typically with ozone in commercial pools where monitoring and maintenance requirements are satisfied by a full-time staff and water chemistry analyzers. Bromine is most often used in spas due to the more stable nature it has in warmer temperatures.

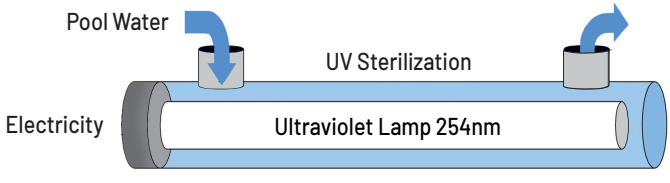
Mineral Filters and Ionizers

The operating principle of mineral filters and ionizers is to create a low concentration of metallic ions (charged particles), typically copper and silver or zinc, in the water. Silver and zinc ions have bactericidal properties, while copper ions function as an algaecide. Ionizers require electrical current, where most mineral filters do not.

Mineral filters and ionizers fulfill some of chlorine's disinfection functions, but do not perform oxidation and can be slow acting. This can lead to build up of organic matter in the water. For this reason, mineral filters and ionizers must be used together with an appropriate oxidizer. Not all oxidizers are compatible with all mineral purifiers. It's important to check the manufacturer's requirements first.

Ultraviolet Sterilization

Ultraviolet energy at a wavelength of 254 nanometers (nm) is effective in neutering bacteria and viruses. There are a number of water treatment products available that use ultraviolet energy for disinfection by passing water through a tubular sleeve containing one or more germicidal ultraviolet lamps.



A properly designed, sized, and installed UV system will inactivate most micro-organisms passing through it very quickly. Because of this, UV has been hailed as an ideal solution for pool water sanitation.

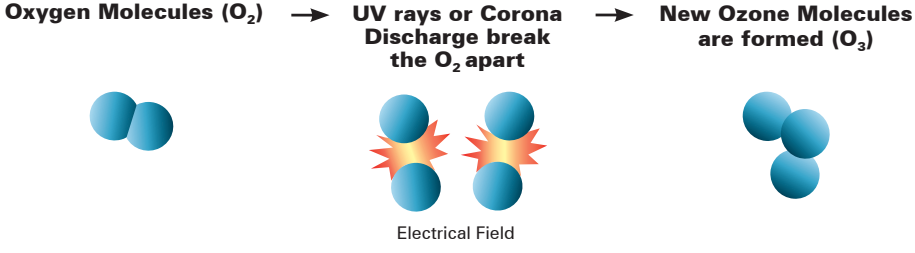
UV, operating by itself as a sanitation system, has some serious drawbacks to be considered. The most significant safety drawback is that UV provides no residual protection in the pool itself; the only biocidal area is inside the UV tube. Without any other sanitizer, UV alone will not produce pool water with any continuing disinfecting power. This means that contamination introduced into the pool may remain present for hours or even days before sufficient turnover of the pool water can expose all of the pool water to sufficient UV energy.

UV sterilization provides no oxidation, which can have an adverse effect on perceived water quality. Oxidizers can chemically "burn" contaminants so that they are easier to remove via the skimmer and filtration steps, leading to clearer water. The lack of oxidation is a double-edged problem because contamination and water clarity will reduce UV's effectiveness. Microbes and viruses can literally "hide" behind suspended particles in solution and survive, returning to the pool.

Ultraviolet sterilization has proven to be effective in neutering microorganisms, preventing reproduction. However, UV can actually break down chlorine, causing an increase of chlorine use, which will also require more stabilizing chemical. All in all, UV can be a valuable part of a water sanitation system, but should always be used in conjunction with other sanitizers.

Ozone

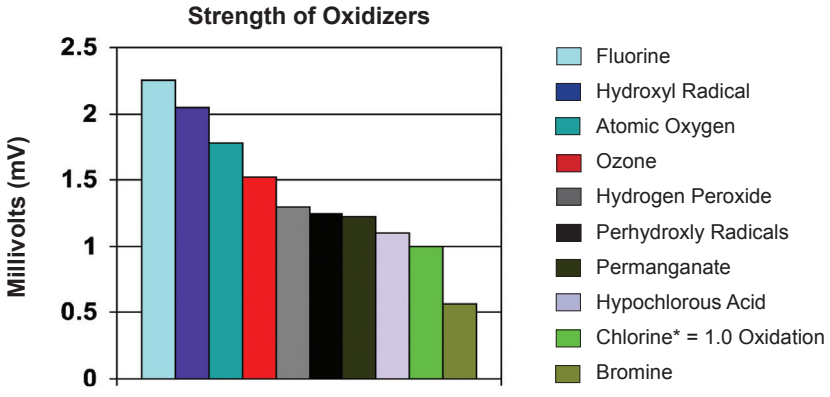
Ozone is a naturally occurring gas molecule consisting of three oxygen atoms (O_3). Sometimes called tri-atomic oxygen or "activated" oxygen, ozone is a highly reactive oxidizer. Nature produces ozone through lightning storms and chemical reactions in the upper atmosphere. Ozone has a number of beneficial properties: in the atmosphere, it helps block excessive solar UV radiation from reaching Earth (that's why there is such concern about the hole in the ozone layer); it oxidizes microorganisms in both air and water; it removes odors in air and water; and it removes off-tastes in water. Ozone reacts very quickly with other chemical compounds around it, and when it does, its by-product is oxygen (O_2).



Ozone has been used for municipal water treatment since the early 1900s and began to see use in commercial and residential swimming pools shortly thereafter. Ozone is common in European swimming pools, but is less so in the United States where chlorination has been the de facto sanitation standard.

Ozone is effective in treating pool water because it is an extremely strong oxidizer (far stronger and faster-acting than chlorine) and because it contributes oxygen to the water as its by-product. Furthermore, ozone is pH neutral therefore balancing of swimming pool water is easier compared to a chlorine pool, resulting in less adjustment of chemicals.

Ozone is the strongest oxidizer that is safe to both handle and use. In the following chart, on page 13, you can see the relative disinfecting power of ozone versus chlorine. No wonder ozone is the primary oxidizer for all modern municipal water treatment and bottled water industries. Ozone not only treats the water; it's also used to sanitize the water bottles before they are filled.



Depending on the microorganism, ozone's disinfection effectiveness will range from several times to more than 1,000 times that of chlorine.

Ozone is made on site, at your pool, using one of two primary methods: ultraviolet energy (UV) at 185nm or corona discharge (CD). The ozone generator produces ozone gas, which is then injected into a return line to your pool.

Ozone gas is produced by the ozone system and drawn into the water via a vacuum created by a venturi injector. Well-designed systems will have a vacuum switch control that automatically turns the ozone system on and off depending on the presence of vacuum from the injector. This is a safeguard ensuring that if water flow stops, the ozone system will automatically shut off as well.

Pool Sanitation - *Safety First*

How is Pool Sanitation determined?

For any pool sanitizing system you should have a means of measuring pool sanitation for safety. With a chlorinated pool, the most common method is testing for free chlorine levels. The rule of thumb for these chlorine-only pools is that 1-3 ppm of free chlorine will ensure a sanitary pool (please read the section on *Cryptosporidium* and *Giardia,* two parasites known to survive chlorination). It is very important that an adequate free chlorine level be maintained continuously.

ORP – a Better Measurement

Oxidation Reduction Potential (ORP), is an electrical measurement of the pool water, read in millivolts, that indicates potential of which a chemical substance has to oxidize (loss of electrons) or reduce (gain of electrons) other chemicals or substances.

The National Sanitation Foundation (NSF), an independent non-profit organization regarded as the authority on water sanitation, specifies that water is sanitary and potable at an ORP measurement of 650mV or higher. With ORP measurements, it doesn't matter what sanitizer or combination of sanitizers are being used. As long as the water is 650mV or higher, it's safe.

In fact, free chlorine levels as low as 0.2 to 0.4 ppm are acceptable for public pools as long as the ORP measurement is 650mV or higher. If your pool water is 650mV or higher all the time, your pool is safe and sanitary. Most commercial and some residential pools and spas in the United States use ORP as a standard method of measurement; however, it is not a requirement.

To increase ORP, oxidation must take place. Typical oxidizers used in the pool industry are chlorine, bromine, and ozone. One important note to remember is that UV sterilization simply kills germs. It has no properties of oxidation, therefore it will not increase ORP levels.

What is "The Ultimate Swimming Experience"

Now you've got enough of the basics to get to the good part. What exactly do we mean when we say "Ultimate Swimming Experience?"

"The Ultimate Swimming Experience": The cleanest, clearest pool using the power of ozone. A pool using little chlorine, containing no harmful chemical by-products such as chloramines and THMs, and is free of bacteria and virus microorganisms.

A correctly sized, installed, and maintained ozone system can provide sufficient oxidation of all contaminants, employing chlorine as required for the task it was intended to be used for: a residual sanitizer without the formation of irritating by-products. Since ozone is a naturally occurring variant of oxygen, it quickly reverts to the more common O_2 form of oxygen once it is produced, leaving behind nothing but clean, clear water.

Ozone provides "The Ultimate Swimming Experience"

How would you like to have your pool filled with bottled water? That's what "The Ultimate Swimming Experience" pool can provide. All bottled water is ozonated for sanitation and free of any off-odors or tastes. So why not do the same for your pool water. Here are the benefits:

No more eye irritation
Because irritating chloramines are eliminated in the water.

No chlorine or chloramine odors
Pool water is perfectly clear and clean.

No chlorine allergies from the pool water
There are no chloramines to be absorbed by your skin. Remember that your skin acts as an open sponge in warm water, readily absorbing chloramines.

No more green hair or self-destructing swimsuits.
This is another benefit from eliminating chloramines.

No exposure to THMs
You eliminate this health risk, as you'll be using ozone as the primary oxidizer and sanitizer, and chlorine as the residual sanitizer.

Increased water clarity
Ozonation not only oxidizes contaminants, it helps to remove them from the water and catch them in your filter through a natural process called flocculation. These very small charged particles (resulting from ozone oxidation) group together into structures called "flocs", which are easier to filter out of the water. This is another benefit from eliminating chloramines.

Increased water sanitation
Ozone, unlike other water treatment options, can fulfill both sanitation and oxidation duties without leaving behind unwanted by-products. As described in the next section on *Cryptosporidium* and *Giardia*, ozone is far more effective than chlorine at dealing with these difficult health threats.

Defense Against *Cryptosporidium* and *Giardia*

Cryptosporidium and *Giardia* are water-borne protozoan parasites that propagate via cysts (egg like structures with a very hard outer shells). These cysts may be present in high concentrations in fecal matter. Due to fecal accidents, many outbreaks of *Cryptosporidiosis* and *Giardiasis* are attributed to public and private swimming pools each year.

Both *Cryptosporidium* and *Giardia* can cause intestinal distress ranging from mild to severe. *Cryptosporidium* can pose severe health risks.[5] Infection can persist for up to two weeks and can prove fatal to people with immune system disorders. Current prevention relies primarily with filtration that can achieve 5-microns. Unfortunately, *Cryptosporidium* has been observed to pass through even a 1-micron filter. The U.S. Centers for Disease Control caution that *Cryptosporidium* is very resistant to chlorine, with the ability to remain viable in a chlorinated pool for days.[6]

The National Institutes of Health printed a University of Arizona study on the effectiveness of ozone, chlorine dioxide, chlorine, and monochloramine in inactivating *Cryptosporidium* oocysts. Ozone and chlorine dioxide more effectively inactivated the oocysts than chlorine and monochloramine did. Greater than 90% inactivation as measured by infectivity in lab mice was achieved by treating oocysts with 1ppm of ozone (1mg/liter) for 5 minutes. Exposure to 1.3 ppm of chlorine dioxide yielded 90% inactivation after 60 minutes, while 80 ppm of chlorine and 80 ppm of monochloramine required approximately 90 minutes for 90% inactivation.[7] This clearly shows how much more effective ozone is for treating *Cryptosporidium* than chlorine.

The Ct value (ppm concentration multiplied by contact time) for ozone was only five (5), whereas chlorine has a Ct of seven thousand two hundred (7,200). Needless to say, no one will be in a pool with 80 ppm of free chlorine.

How Can I Achieve "The Ultimate Swimming Experience"

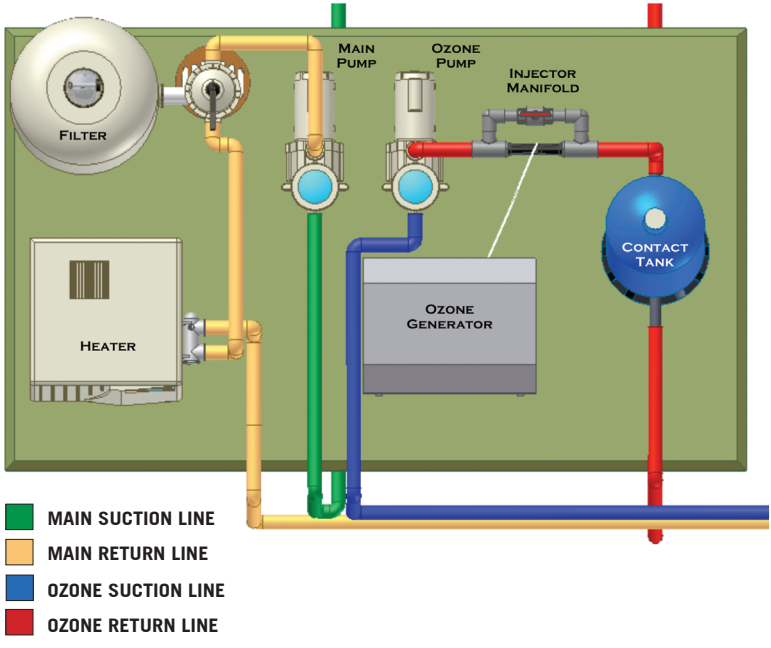
Ozone generation systems suitable for meeting the requirements of an "Ultimate Swimming Experience" pool should be high quality, precision engineered equipment, installed and serviced by qualified professionals. It's important to work with a reputable, experienced installer. The best ozone equipment in the world will fail to meet your goals if it is improperly installed. Ozone system manufacturers with experience in low chlorine pools can recommend professionals you can trust for both residential and commercial applications.

Considerations to keep in mind when using reduced chlorine levels:

• Size the ozone system appropriately to meet your sanitation requirements and bather load.

If your plan is to use a low or ultra-low residual amount of chlorine, you'll want to test the free available chlorine (FAC) to keep it within the range of 0.2 ppm to 0.5 ppm in residential pools. Most commercial pools require 1.0 ppm FAC, (check with your health department for local regulations). With a properly sized ozone system, at these levels there should be no measurable level of combined chlorine and no sign of chloramines or other harmful chlorine by-products. If there is, you may have an under-sized ozone system.

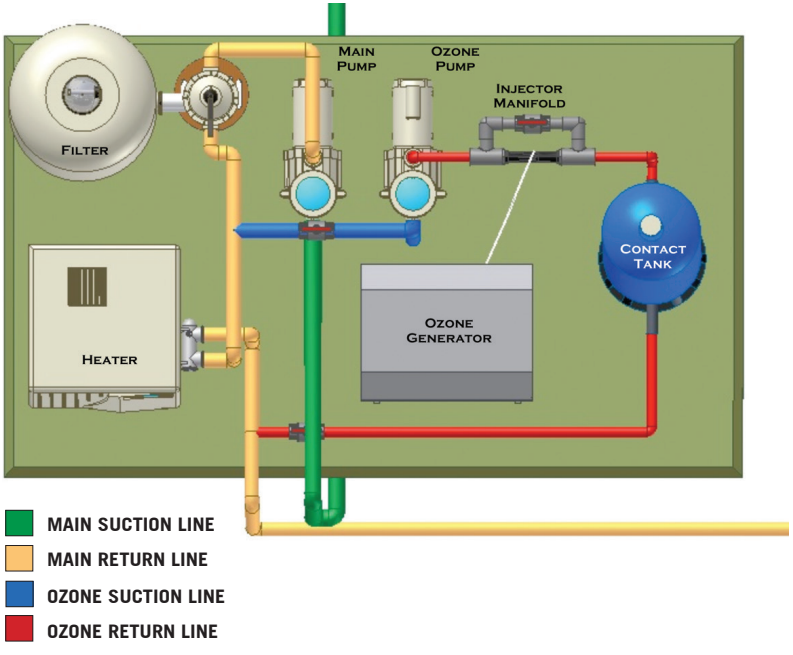
Typical Independent Loop plumbing schematic



• **New construction vs. retrofit installations.**
An ozone system can be installed whether the pool has been installed for years or is still in design stages. In recent years ozone manufacturers have suggested an independent loop be designed for the ozone systems plumbing. This will allow for the ozone loop to circulate even when the main pool pump, filter, and heater is not, providing more circulation and contacting of the ozone with the pool water. The independent loop typically is designed with its own dedicated return to the pool, and the return ports are typically located in the deep end of the pool floor, 4-5 feet away from the main drain.

In a retrofit ozone installation, the best configuration is plumbing a sidestream loop. The sidestream loop diverts water from the full flow of the main pool pump downstream of the pool's filter. The diverted water is sent through the ozone loop for injection and contacting of ozone. It then returns to the full-flow downstream of the pool's heater before any chemical injection point (if so equipped).

Typical Sidestream Loop plumbing schematic



• Ask for correct placement of the ozone return in the pool.
The best place for the ozone return is in the deep end of the pool, using a floor return between four and five feet away from the main drain. If the ozone return is too close to the main drain it may cause poor circulation of ozonated water. If the ozone returns are near the surface, there will be an increased likelihood of ozone that will be noticed by swimmers as they hang on the pool's edge.

• Determine if you need a contacting system.
A contacting system may use a booster pump and incorporates a contact vessel (either a tank or a special contact column) to increase the time that ozone is in solution before returning to the pool. By increasing the contact time, you will receive two benefits: 1) your system's Ct value (oxidation power) will increase, improving its sanitizing performance; and 2) a contacting system will purge off any excess ozone from the water, called off-gas, before returning to the pool.

Your underground pool plumbing may have areas in the piping where bubbles can be trapped. If a large ozone-containing bubble forms in the plumbing and is released, there may be a sudden release of ozone into the pool that will bubble out into the air around the pool. Often times longer runs of plumbing back to your pool can provide adequate contact time. Your qualified installer should evaluate the possible need for a contacting system.

• How heavy will your bather load (number of swimmers at a time for an average time in the water) be?
Higher bather loads will require more ozone, as you have a higher concentration load. Your pool designer or installer should work with the system manufacturer to take this into account. Note: See the ozone sizing guide at the end of this handbook.

• Does it matter if the pool is located indoors or outdoors?
Yes. Pools located outdoors can add significant load or ozone demand to the pool water due to dirt, leaves, and other organics. Therefore, if a pool is located outdoors more ozone will be required to oxidize and sanitize the pool water.

• How warm will you keep the water?
Higher temperatures require more ozone than lower temperatures. Your designer or installer should work with your ozone system manufacturer to take this into account.

• Where will the ozone equipment be installed – indoors, outdoors?
If outdoors, we advise weatherproofing to help keep dirt, debris, and precipitation away from the ozone generation equipment. These efforts will help to increase the life of the system and reduce service intervals.

• Do you have an in-ground spa with your pool?
Your installer should take into account how your spa is plumbed when designing your ozonation system. Spas require careful consideration because the amount of water is much less than a pool, but the temperature and concentration of contaminants is typically much higher.

Who Has Low Chem Pools?

Pools with low and even ultra-low chlorine have been in use for years and are enjoyed by a large number of discriminating customers including stars in the entertainment industry, doctors, and other health-conscious professionals. Advances in ozone system technology have lowered costs, making these systems affordable to many pool owners who may have never heard of this concept before.

Before you start calling for quotes, you should arm yourself with as much information as possible. We've prepared a facts and myths section to help you get beyond any claims and hype when considering a low to ultra-low chlorine pool or spa.

Low Chem Pools: Ozone Facts and Myths

Ozone has been available for use in swimming pools for many years. The results depend on having a properly designed and installed system that has the capability to dissolve sufficient ozone in your pool water. Over the years, there have been occasional claims for ozone generation equipment that would leave a pool short of the mark and potentially unsafe. Let's take a look at some facts and myths that you should know.

MYTH: If you can see bubbles and smell ozone, you know it's working.

If you hear this, run away. For most ozone systems with a contact vessel, you should see little to no evidence of bubbles, and smell little to no ozone odor. For installations where it is not applicable to use a contact vessel, there will be fine bubbles visible in the pool. However, if the ozone system is sized correctly there should be little or no ozone odor.

If you see large bubbles and get a strong ozone odor, ozone is rapidly leaving your pool water and going into the atmosphere. The only way ozone can oxidize and disinfect pool water is to stay dissolved in the water.

The all-important Ct value is based on the concentration of ozone dissolved in the water multiplied by the amount of time it stays dissolved, not what's escaping into the air. Very tiny bubbles (like those in fine champagne) coming out of the return line are fine. Large, burping bubbles are not.

FACT: You may be able to tell if your ozone generator is working just by looking at it or at the swimming pool.

Modern ozone generators are equipped with status indicator lights that can help you, the homeowner; easily check to see if the ozone system is operating correctly. Some manufacturers do not provide this simple innovation and leave the owner guessing by simply checking for an ozone smell (it's not a good idea to remove the ozone supply line and smell it; you could inhale a very strong dose); however, looking at the water in your pool should tell you a lot. Though it is not a direct science, pool water that is treated with ozone – whether low-chlorine or ultra-low chlorine – should look clear (typically no cloudiness, however cloudiness can also be a cause of poor filtration), and smell clean (no chloramine smells or earthy smells). Although to be sure the ozone system is operating correctly, you can certainly test the water for free available ozone ppm or monitor your pool using ORP.

MYTH: Ozone is unsafe for use with pools.

Ozone in air is irritating to mucous membranes and tear ducts as well as the trachea and bronchia, but is not an irritant when dissolved in water. A properly designed and installed ozonation system will not expose swimmers to irritating concentrations of ozone in the air around the pool. Compared to other sanitizing chemicals, ozone has the safety benefits of not having to be handled, transported, or stored. Many commercial pools rely on ozone to perform oxidation of pool contaminants, including all Olympic pools, which are mandated to use ozone as a part of their sanitation systems.

FACT: Ozone is not a cure-all for pool water problems.
Algae may be able to survive under certain conditions in an ozonated pool. Ozone will kill algae spores that pass directly through the ozonation contacting system. However, algae may still grow in low-circulation areas that get a lot of sun. The easiest way to remedy localized algae growth is to scrub. If the algae bloom grows, a shock treatment or other algae control products can be used. Consult your pool professional for the products most effective in your area.

MYTH: Chlorine is legally required for all pools.
Chlorine is required for public pools for several reasons. The contamination (or oxidation demand) levels in public pools can be extreme and unpredictable, therefore several forms of sanitation are well advised. Ozone tends to be very fast acting and does the heavy lifting in the equipment room while chlorine has a longer half life and provides good protection in the body of water. Ozone is gaining acceptance in public pools across the United States, allowing public pool operators to reduce the amount of free chlorine needed and eliminate the annoyances and health risks associated with chloramines and THMs.

FACT: Ozone works well with chlorine.
Most modern municipal water systems, including the City of Los Angeles, use ozone as their primary oxidizer. They then inject a small amount of chlorine into the water while it travels through the distribution pipe network to the point of use.

Again, using a small residual of chlorine in your pool [with ozone as the primary oxidizer and sanitizer] can go a long way. The amount of free chlorine you use is up to you, but typically should be between 0.2 ppm and 1.0 ppm. Ozone and chlorine are an effective one-two combination as long as ozone is allowed to perform oxidation before chlorine is introduced. This ozone-chlorine sequence will significantly reduce the production of chloramines. If chlorine is introduced to the water first or upstream of the ozone system, injected ozone will react with and eliminate both the ozone and the chlorine.

FACT: It's easier to maintain pH in a chlorine-free pool.
Ozone is pH-neutral; it neither raises nor lowers your pool's pH. However, chlorine causes pH to fluctuate. The less chlorine you put in your pool, the fewer stabilizers and other chemicals you'll need. As a result the fewer pH-affecting chemicals you use, the easier it will be to keep your pool's pH in the neutral zone. No matter which direction you choose, the pH range for a pool that is using ozone should be 7.0 to 7.6.

MYTH: It doesn't matter if ozone comes from UV lamps or from corona discharge units.
Ozone produced from ultra-violet (UV) energy works well for air treatment and for aquariums or anywhere marine life can be exposed to ozone.

If you took Chemistry you've probably heard of Henry's Law, which states that the concentration of a substance in liquid phase (dissolved) is proportional to its concentration in gas phase (in air).[8] There have been many studies showing that the maximum dissolved ozone concentration (known as the equilibrium concentration) in water varies according to its gas phase concentration.

In practice, low gas-concentration UV ozone cannot achieve its solubility equilibrium, because so much air is injected into the pool water along with the minute percentage of ozone that the combination of air and ozone off-gasses from the water quickly. Because the effectiveness of ozone in water depends on the product of its dissolved concentration multiplied by the amount of time it's in the water (Ct value), there is a greater advantage to using CD ozone over UV ozone. Ozone produced at higher concentration will dissolve into water more easily with less total amount of gas injected to the water (ozone + dry air/oxygen). This will effectively reduce other parts of the total system (booster pump, plumbing), saving space and money.

FACT: Some corona discharge ozone generators can be fed ambient air, although most require an air preparation system.
A corona discharge ozone generator makes ozone electrically, simulating a lightning storm. (You may have noticed a fresh scent in the air following an electrical storm – that's ozone.)

Some smaller corona discharge (CD) ozone generators can provide higher outputs and concentrations of ozone using ambient air compared to UV ozone systems. However, larger CD ozone generators use a high-energy reaction, which is very efficient in producing ozone, but because of the high energy, other chemical reactions can take place in the ozone "reaction chamber". Ambient, or natural, air gas is about 78% nitrogen, 21% oxygen, almost 1% argon, and traces of other elements. Along with the gas is water vapor, responsible for humidity.

The problem with feeding these types of high-energy CD ozone generators with ambient air is the production of nitrogen by-products, which can include nitrates, leading to nitric acid buildup in the CD reaction chamber. These nitrogen by-products will shorten the life of your CD ozone generator and increase maintenance costs. Though much more powerful than UV ozone generators, CD ozone generators produce lower gas-phase concentrations of ozone when fed with ambient air, than when fed with dry-air or oxygen.

Dry Air

If the air feeding a CD ozone generator is very dry, nitric acid production will decrease substantially. The typical method of drying the ambient air is by using a heat plus desiccant design, known as a heat-regenerative dry-air system. These dry-air systems can be a very efficient low cost solution; however, it is typical that an ozone concentration no more than 1% by weight can be produced when used with a CD ozone generator. There are many types of heat regenerative dryers, typically rated for use in humidity less than 70%, and not to be used for more than 8-10 hours of use per day.

Oxygen Concentration

To substantially improve the output capabilities of the ozone generator, an "oxygen concentration" system, called pressure swing adsorption (PSA), can be employed. These oxygen concentrators produce up to 93% pure oxygen with a molecular sieve providing sufficient air preparation in humidity conditions up to 95% and able to operate 24/7.

CD ozone generators produce much higher gas-phase ozone concentrations when oxygen is employed than they do with dry air, typically 3% and as much as 10% by weight with oxygen feed gas. In practice, a 1-gram per hour ozone generator producing 3% concentration by weight ozone will give the same or better results than a 3-gram per hour ozone generator producing 1% concentration by weight.

MYTH: Diffusing ozone is just as good as using a venturi injector

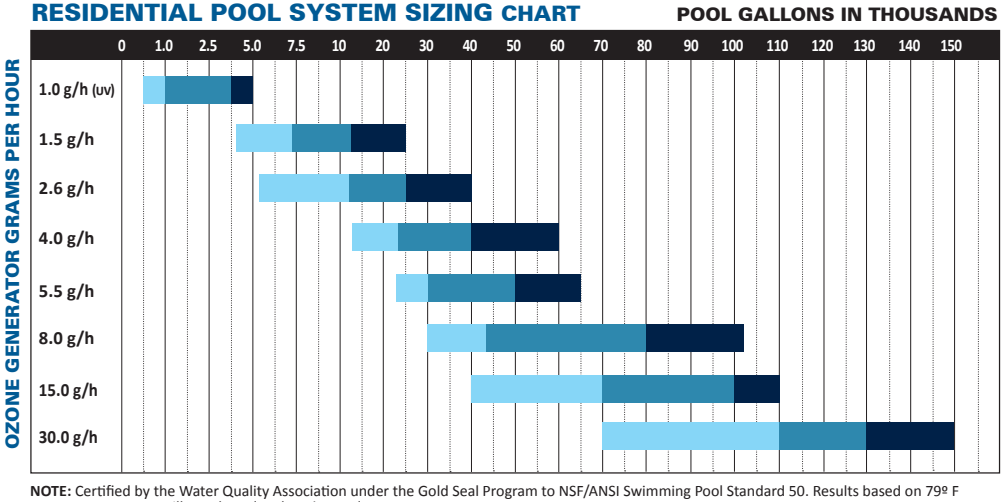
Modern injection systems do a far better job of dissolving ozone into water than do diffuser systems, often by a margin of 5 to 1. Again, the key to proper water sanitation is to dissolve the ozone into the water, so that it can oxidize and destroy those contaminants that are suspended in the water.

A diffuser produces relatively large bubbles by design. Even with diffusion, some ozone will dissolve into the pool water, but the efficiency of dissolving the ozone is better as bubble size is smaller. The venturi injection system draws ozone from the generator into a stream of water by creating a vacuum, and the ozone is then dissolved in the water with fine bubbles. Achieving a high concentration of dissolved ozone in the treatment stream is key to pool sanitation and exceptionally clear water.

The next step is up to you

If you are interested in achieving the low or ultra-low chemical approach to clear, clean swimming pool water, we have developed a chart below to aid you in the sizing and selection of ozone equipment. Based on volume of water and chlorine dosage, you can choose the ozone system to suit your needs.

RESIDENTIAL POOL SYSTEM SIZING CHART



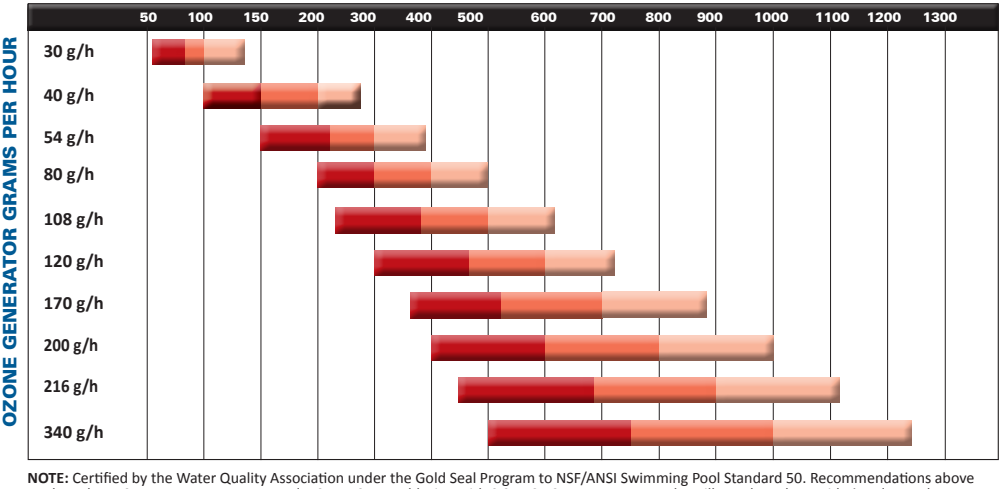
NOTE: Certified by the Water Quality Association under the Gold Seal Program to NSF/ANSI Swimming Pool Standard 50. Results based on 79º F water temperature, will vary based on location and usage.

ULTRA-LOW CHLORINE
< 0.50 ppm chlorine

LOW CHLORINE
0.50 - 0.80 ppm chlorine

TYPICAL CHLORINE
0.80 - 1.50 ppm chlorine

COMMERCIAL POOL SYSTEM SIZING CHART



NOTE: Certified by the Water Quality Association under the Gold Seal Program to NSF/ANSI Swimming Pool Standard 50. Recommendations above are based on 79ºF water temperature and 1.0 - 1.50 ppm chlorine with 0.25 - 0.50 ppm ozone. Results will vary based on oxidation demand.

HIGH OXIDATION DEMAND
- Heavy bather load
- Minimal turn-over rate < 4.0/day
- Water temperature > 82ºF

AVG. OXIDATION DEMAND
- Average bather load
- Average turn-over rate = 4.0/day
- Water temperature 79ºF - 82ºF

LOW OXIDATION DEMAND
- Low bather load
- High turn-over rate = 4.0/day
- Water temperature 79ºF - 79ºF

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