The Ultimate Swimming Experience

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 (THMs). 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 THMs.[1]

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 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 of 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.8

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

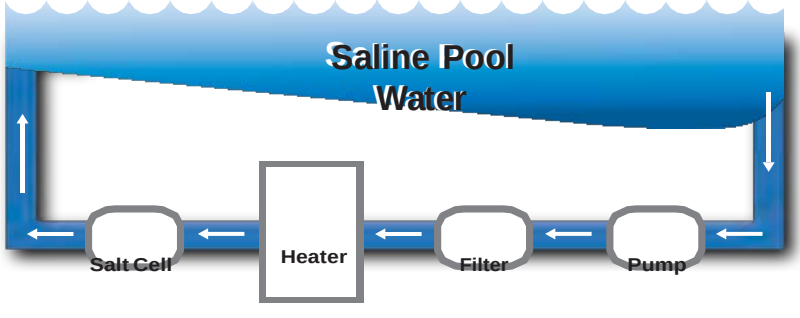
In a chlorinated pool, chlorine performs two sanitation jobs. First, it oxidizes contaminants; second, it kills microorganisms. In chlorine-only pools and spas, a residual amount of free chlorine is necessary for the pool water to remain sanitary. Oxidation consumes free chlorine and leaves chloramines 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 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.

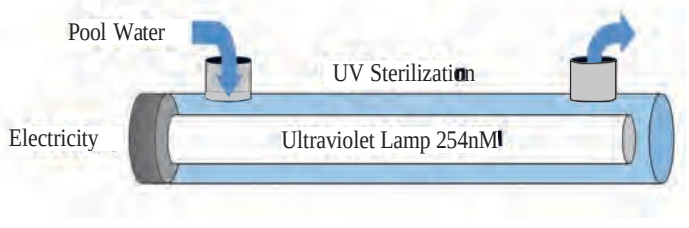
Mineral Filters and Ionizers

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.

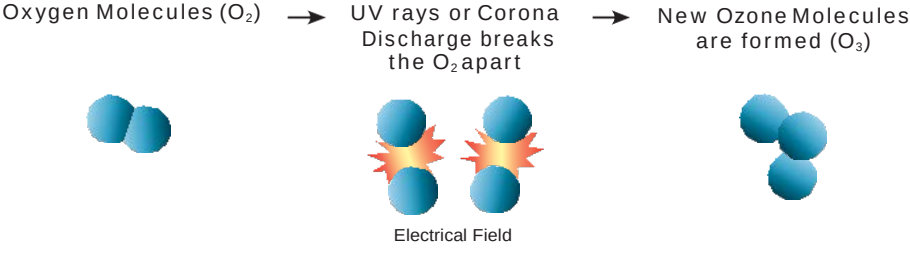
Ultraviolet sterilization has proven to be effective in neutering microorganisms, preventing reproduction. However, UV can actually break down chlorine, causing an increase of chlorine use, which will also require more stabilizing chemical. All in all, UV can be a valuable part of a water sanitation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