Safe to Swim

Water disinfection techniques for swimming pools

By Thomas M. Lachocki, Ph.D.

The swimming pool field has traits that are unique and similar to other water treatment applications. The biggest difference, however, revolves around human exposure. Humans are active in swimming pool water, depositing nutrients, bacteria and disease-causing germs or pathogens into the water.

Because people swim in the water, pathogens can be inhaled, swallowed or infect the skin. Thus, the challenge with swimming pool water disinfection is to ensure that the water is kept sanitary with effective disinfection at all times.

The pool industry often uses the word "disinfectant" or "sanitizer" to describe the chemicals that keep water sanitary by killing or inactivating microbes.

Disinfection Regulations

Because humans are exposed, there are regulations that disinfectants must satisfy in order to be used in public swimming pools. Disinfectant products claim to kill or mitigate pests, including microbes such as bacteria, viruses and parasites. As a result, in the U.S. they must be registered with the Environmental Protection Agency (EPA) to make sure they are effective and have proper use directions and hazard warnings. Similarly, each state requires disinfectants to be registered in order to remain aware of which products are in commerce.

Canada has comparable agencies and regulations. State and provincial health departments often have requirements on how much disinfectant must be present in the water and other aspects of pool operation and construction.

There are three major classes of antimicrobial agents approved by the EPA for use in swimming pools as standalone disinfectants. The most widely used class is chlorinating agents, which release chlorine in the water. The second most widely used class is bromine, which has similar properties to chlorine. Although bromine is more expensive, it is used to a larger extent in environments with higher bather loads or where pH tends to increase above the ideal range of 7.2 to 7.8, such as in spas. The third class is biguanide (PHMB), which is used in a system with hydrogen peroxide, an oxidizer, and with an algicide. Because the biguanide system is not actively marketed for public pools, it will not be discussed further.

Chlorine & Chemicals

It is important to understand that the word "chlorine" is used to describe many chemicals. Chemicals that release hypochlorous acid into the water are commonly called "chlorine." More accurately, these chemicals are chlorinating agents. In fact, when any chlorinating agents are dissolved in water, they create the same disinfectant—a mixture of hypochlorous acid and hypochlorite ions. This mixture is called "free chlorine."

The acid and the hypochlorite in free chlorine changes back and forth into each other in what is called equilibrium, and their relative concentration is a function of the water's pH.

It is important that pH be maintained between 7.2 and 7.8 to ensure the disinfectant is effective, that the water does not damage surfaces and is mild to swimmers' eyes, skin and membranes. The amount of free chlorine is measured or estimated by a variety of technical tools including test kits, test strips, digital readers and automated testing systems.

Delivering Systems

Recreational water facilities operate with a host of systems to deliver one of several chlorinating agents. The most common technique pumps sodium hypochlorite liquid into the water. Because the sodium hypochlorite has a high pH, acid must also be added to the water in parallel to keep the pH in the ideal range.

Calcium hypochlorite is a widely available, solid chlorinating agent with a high pH. Calcium hypochlorite feeders are designed so that water contacts the solid, dissolves or erodes it and then returns the chlorinated water to the pool.

Systems that add the actual element chlorine into water are also used. When elemental chlorine dissolves in water, it lowers the pH; thus, these systems must also feed chemicals (bases) to raise the pH to the ideal range. Elemental chlorine is a toxic gas and its use is becoming rare because of the hazards of storing and handling.

The technique that has grown substantially in recent years uses a device mounted in the circulation system plumbing to oxidize regular salt (sodium chloride) into free chlorine. These electrolytic devices (chlorine generators) require an initial equipment investment and sufficient salt added to the water to have about 3,000 to 3,500 parts per million (ppm or mg/L). These generator systems reduce subsequent chemical purchases, transportation and storage and have very little impact on the water's pH.

There is a class of chlorinating agents called chlorinated isocyanurates (stabilized chlorine) that use chemicals where chlorine is bound to a solid carrier molecule. The most common chemical used is trichlor-s-triazinetrione (or trichlor) tablets. When trichlor dissolves in the water, it releases free chlorine and a chemical called cyanuric acid (stabilizer) into the water. The stabilizer helps protect the free chlorine from destruction by sunlight. Most state codes place restrictions on how much cyanuric acid can build up in the water out of concern that disinfection is slowed.

It is common practice for an automated feeder to add disinfectant (and pH control chemicals) into the water. It is becoming more common for chemical testing probes to measure water properties and to signal the chemical feeders. These probes interface with a controller that turns chemical feeders on and off. Most codes do not require automated testing; however, it is a worthwhile investment to more efficiently add chemicals and to better protect the facility and its users.

Chemical Testing

The most common chemical testing probes test for the oxidation-reduction potential (ORP), which is an indirect measure of the disinfectant in the water. ORP, however, is useful in providing quick response to changes in the water and also allows facility operators to focus on other responsibilities than frequently testing the water. Disinfectant levels and probe accuracy should be verified daily with a chemical water test. Other automated systems to test the water include amperometric probes and systems to titrate the water.

Bromine has many similarities to chlorine. It too is a generic term for chemicals that release hypobromous acid and hypobromite ions into water, a mixture called free bromine. The most common brominating agent used is a chemical called bromochlorodimethylhydantoin (BCDMH). It is fed into the water by a chemical feeder, and the amount of free bromine can be tested by test kits, test strips, digital readers and automated test systems.

There are other systems and chemicals used to supplement or improve a disinfectant, such as ultraviolet and ozone, which are useful to treat pool water. Because maintaining a residual to protect bathers is important, these technologies are not used on their own, but with either chlorine or bromine. These systems are particularly effective at inactivating chlorine-resistant pathogens like *cryptosporidium* (Crypto) and improving indoor air quality. Crypto is the leading cause of documented recreational water illness, with thousands experiencing diarrhea, vomiting and cramps.

People who work in other water treatment fields will find many similarities to swimming pool water disinfection, chemical feeding and testing. The differences revolve around human exposure, ingestion and possible inhalation. Humans also constantly contaminate the water with viruses, bacteria and parasites—some of which may cause illness. As a result, it is critical that the chemicals and systems that are used are fast acting and constantly present in the water. The chemicals must be mild to humans, the pool itself and its equipment. *wqp*

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