Home » 2019 » A Healthy Respect for Pool Chemicals Can Help Avoid Accidents and Injuries

2019

A Healthy Respect for Pool Chemicals Can Help Avoid Accidents and Injuries

AUGUST 15, 2019 11 MINS READ

Facebook Twitter LinkedIn

By Mary Ostrowski and Robyn R. Brooks

Pool treatment chemicals are essential for safe, healthy swimming pools, but unless used and stored properly, pool chemicals can pose a safety risk themselves. The US Centers for Disease Control and Prevention (CDC) notes the public health value of pool treatment chemicals: "Chlorine and pH, your disinfection team, are the first line of defense against germs that can make swimmers sick."1 Pool disinfectants destroy a wide variety of germs (e.g., *Shigella, norovirus, E. coli 0157:H7* and *Pseudomonas aeruginosa*) that can cause diarrhea, swimmer's ear and more serious illnesses.

Acids or bases help maintain appropriate pH for the optimum use of disinfectants. For example, the CT value (concentration of chlorine X contact time needed to destroy *Cryptosporidium* to a three-log reduction) is about 7,200. If chlorine concentration is raised to 20 ppm, that concentration would have to be maintained for 360 minutes to destroy *Cryptosporidium* (which causes the majority of outbreaks of acute gastrointestinal illnesses in swimming pools). *Giardia* is also chlorine resistant but not quite as resistant. CDC's developing *Model Aquatic Health Code* will require secondary disinfection (either ozone or UV) to supplement chlorine or bromine primary disinfection in high-risk venues, such as interactive water play areas and wading pools.

chemicals are chemicals that do not react to any significant extent when mixed at normal conditions. Monochloramine in drinking water is not hazardous, but mixing ammonia cleaners and chlorine-based products is certainly hazardous. Concentration is the key. As a general rule, different pool chemicals should not be mixed. If mixing is required, it should be done exactly according to label directions. Inadvertent mixing and potentially hazard chemical reactions can occur when buckets and measuring tools become contaminated with incompatible substances. Residue of a substance remaining in a container or a scoop could react with other substances with dangerous consequences. Similarly, incompatible chemicals should be stored separately. It is helpful to anticipate what could happen if liquid chemicals leak: would two incompatible products mix? Liquids should be stored low, in a containment tray, to avoid a potentially dangerous scenario.

Figure 1. Never store liquids above dry chemicals

Chlorine-based products and acids are incompatible and produce chlorine gas when they combine chemically. Exposure to chlorine gas can result in difficulty breathing, even at low concentrations, and may require a trip to the hospital. In February, a Sydney, Australia hotel was forced to evacuate approximately 100 guests and staff2 when the following chemical reaction occurred accidentally: $HOCl + HCl \rightarrow Cl_2 + H_2O$

Chlorine gas production is particularly vigorous when hydrochloric acid (HCl, also known as muriatic acid) is involved because chlorine gas generation requires the chloride ion. The reaction above is actually an equilibrium reaction, so adding hydrochloric acid to aqueous chlorine solutions drives the reaction to the right, producing chlorine gas. Keep in mind that popular summer drinks such as lemonade and carbonated soft drinks are acids and should not be allowed near pool chemicals.

Chlorine-based products (which form hypochlorous acid, HOCl) and ammonia-based products (e.g., certain cleaning products) are incompatible; these products react to produce hazardous chemicals. In dilute solution, they produce mono-, di- and trichloramine (NH_2Cl, $NHCl_2$ and NCl_3) respectively, depending upon the chlorine/ammonia ratio, the water temperature and pH.3

i. $NH_3 + HOCl \rightarrow NH_2Cl + H_2O$
ii. $NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$
iii. $NHCl_2 + HOCl \rightarrow NCl_3 + H_2O$

In swimming pool water at pH 7.0, reaction (i), producing monochloramine, usually is completed irritating and nearly as toxic as chlorine gas, so a large amount of toxic fumes can be generated almost immediately.

If an excess of an ammonia-based (NH_3) cleaner is mixed with a chlorine-based product, such as bleach ($NaOCl$), one product of the chemical reaction) is hydrazine, N_2H_2, which is also toxic and potentially explosive.4

$$2\ NH_3 + NaOCl \rightarrow N_2H_4 + NaCl + H_2O$$

Even though they may look similar, different chlorine-based products are incompatible with each other. In particular, trichloro-s-triazinetrione (trichlor) should not be mixed with calcium or sodium hypochlorite. If trichlor tablets, which are acidic, are mixed in water with calcium hypochlorite tablets, which are alkaline, they will react as they dissolve. The reaction produces considerable heat and toxic fumes, including chlorine gas. For example, in 2009, an Illinois family tried mixing two brands of pool chlorine in the kitchen, resulting in an explosion. Three members of the family were taken to the hospital with breathing difficulty.5 If the mixture is sealed inside a tablet feeder, the hot gas can produce enough pressure to blow the lid off the feeder or the reaction can be violent enough to blow the feeder apart.6 The labels for both chemical products warn against mixing with other chemicals.

Example #2. Never add water to pool chemicals

Last summer, according to an *Associated Press* report on *NJ.com*, a hot tub owner in New Jersey was injured as he diluted chlorine7 (presumably a chlorine-based liquid or solid disinfectant or a mixture of disinfectants) with water inside his home.8 A violent reaction ensued and the man was treated for burns to the face and difficulty breathing, according to the media report.

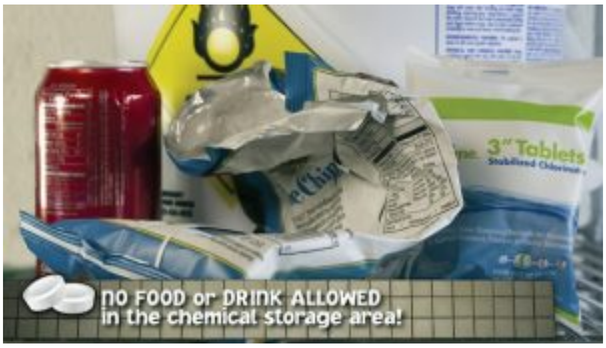

Figure 2. No food or drink in chemical storage areas

A common way that pool chemicals are mixed improperly is when they are introduced into the water. Pool chemicals should be added directly to the pool; water should not be added to pool chemicals. Adding small amounts of water to a chemical results in a very concentrated solution. If the dissolution process is exothermic (as when water is added to sulfuric acid, for example), so much heat could be released that the product could begin to decompose, leading to additional heat release or gas generation. The solution could boil and splash out of the container, causing chemical burns to the handler. Using proper protocol, the handler adds chemical to the pool, not the other way around. There is a large volume of water in the pool and the resulting solution is accelerates minutes or hours later or dangerous fumes can be generated, exposing the user the next time the container is opened.

Example #3. Make sure pool chemical storage areas are well-ventilated, dry and free of combustible and flammable materials

When stored improperly, pool chemicals may chemically decompose, releasing chlorine gas, bromine gas or other toxic substances, which in poorly ventilated areas may corrode packaging, piping, electronics and other metal equipment. Fire is a danger when heat, an oxidizer and fuel combine. Common pool treatment chemicals (e.g., calcium hypochlorite, sodium dichloro-s-triazinetrione, 1-bromo-3-chloro-5,5-dimethylhydantoin, trichloro-s-triazinetrione and potassium monopersulfate) can release oxygen or other oxidizing gases, including chlorine and bromine and chemical packaging (plastic and cardboard) can constitute fuel. That is why combustible or flammable materials, including gasoline, oil, solvents and oily rags, must never be stored near chemicals. Never allow ignition sources, such as barbeque pits, diesel generators, cigarette lighters or gas-powered equipment, such as lawn mowers, motors or welding machines, around pool chemicals.

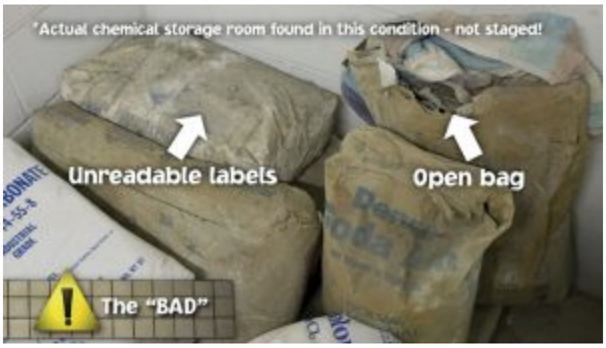

Figure 3. Example of improper chemical storage

Oxidizers are not flammable themselves, but they increase the fire hazard because they can increase the intensity of a fire by increasing the rate at which the fuel burns. The National Fire Protection Association classifies oxidizers into four classes (1 to 4).11 A higher class denotes a higher hazard; that is, each higher class increases the intensity of a fire to a greater extent.

Develop a healthy respect for pool chemicals

Pool treatment chemicals provide the benefit of healthy pools for healthy swimming. Untreated or inadequately treated pool water poses unacceptable health risks to swimmers. In the full risk-benefit equation representing the swimming pool system, the pool operator can minimize the risk of chemical accidents by understanding and actively engaging in proper chemical storage and handling. Available pool chemical safety resources include free, laminated chemical safety posters for pool operators, which may be ordered on the CDC website. Additionally, the Chlorine Institute and the American Chemistry Council recently produced a readily accessible *You Tube* Pool Chemical Safety video that includes messages from CDC. Pool operators can access the video from a computer or smart phone. This summer, help spread the word about pool chemical safety!

References

Chloramines).

4. *Mixing Bleach and Ammonia*. http://chemistry.about.com/od/toxicchemicals/a/Mixing-Bleach-And-Ammonia.htm
5. www.daily-chronicle.com/articles/2009/08/11/03750281/index.xml
6. *Pool Safety*. www.achd.net/housing/PoolSafety.html
7. Many chemicals, including chlorine, often are referred to by an incorrect term. Liquid chlorine (Cl2) is not the same as sodium hypochlorite (NaOCl) solution. Liquid chlorine is stored in pressurized vessels and readily turns to gas at room temperatures. The gas causes breathing difficulty at very low concentrations. Sodium hypochlorite solution (or chlorine bleach), however, is stored in plastic containers and commonly used in pool and household disinfection applications.
8. "Water-chlorine mixture explodes, burns Surf City man's face." *NJ.com* (August 3, 2013). Available: www.nj.com/news/index.ssf/2013/08/water-chlorine_mixture_explodes_burns_surf_city_mans_face.html#comments
9. "Why is acid always added to water, and not the reverse?" *General Chemistry Online!* Available: http://antoine.frostburg.edu/chem/senese/101/safety/faq/always-add-acid.shtml
10. National Swimming Pool Foundation, (2011). *Pool & Spa Operator Handbook.*
11. Buc, E. "Oxidizer classification research project: Tests and criteria," *Fire Protection Research Foundation, Final Report*, Nov 2009. Available: www.nfpa.org/research/fire-protection-research-foundation/reports-and-proceedings/hazardous-materials/chemicals.

About the authors

Mary F. Ostrowski has been employed by the American Chemistry Council's (ACC's) Chlorine Chemistry Division since December, 2000. As an issues manager, Ostrowski is responsible for chlorine disinfection issues, including benefits promotion, scientific research support and advocating in the regulatory and standard-setting arena for science-based policies. She has worked collaboratively on disinfection issues with public health entities, including the US CDC, the National Environmental Health Association, the Somerset County, New Jersey Department of Health and International Action (promoting safe water for Haiti). Ostrowski holds a Bachelor of Science Degree in chemistry and geology from the City University of New York at Brooklyn College; a Master of Science Degree in geology from Boston College and a Master of Science Degree in environmental management from the University of Maryland's University College. In addition to her career with ACC, Ostrowski has worked at the Commonwealth of Massachusetts' Division of Water Resources; as an adjunct lecturer at the University of Maryland's University College and for a science journal service.

Robyn R. Brooks, Senior Project Engineer, joined the Chlorine Institute (CI) staff in 2012. Prior to joining CI, she worked at The Mosaic Company, Alstom Power and The Dow Chemical Company in operations and engineering

Reprinted from *Water Conditioning & Purification International*, August 2014

Swimming pool chemicals

RELATED POSTS

Drink Up! Bottled Water Continues to Gain Market Share

SEPTEMBER 15, 2023

Wells, Pumps, Plumbing Service, and Water Conditioning Are All Important Elements to Wisconsin's Water Supply

SEPTEMBER 12, 2023

Parting Thoughts

SEPTEMBER 12, 2023

Setting Up a Successful Sales Process

AGUALATINOAMERICA.COM