Environmental Public Health Division
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Indoor Swimming Pool Irritants

According to the Center for Disease Control, irritants in the air at indoor swimming pools are usually the combined chlorine by-products of disinfection. These by-products are the result of chlorine binding with sweat, urine, and other waste from swimmers.

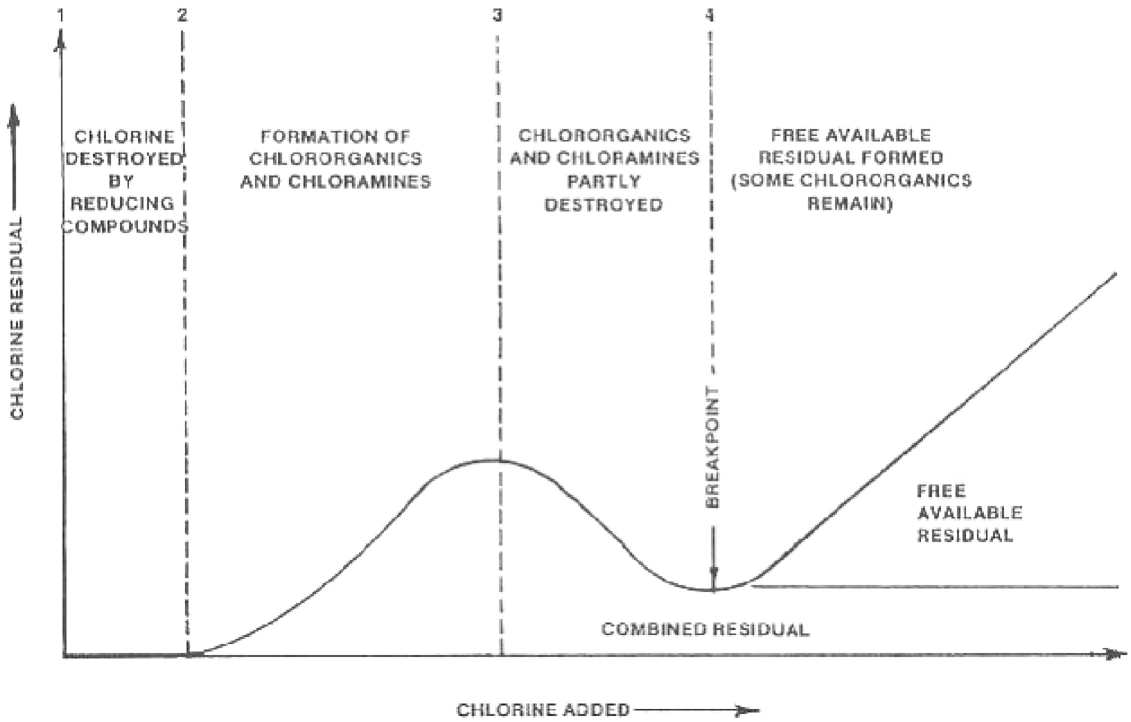
A multi-faceted approach to address this issue is the best way to minimize these contaminants.

1. Insisting swimmers shower prior to entering the pool will reduce the nitrogen products that are instrumental in creating the chloramines. The facility is required to have signage requiring showering as specified in 410 IAC 6-2 Sec. 36 (b) (3)
2. Educate swimmers, teachers, and coaches on the causes of the chloramines, and steps they can take to reduce the chloramine production so the air they breathe will be healthier.
3. Ensuring fresh air supply and exhaust in the pool area meets or exceeds the ASHRAE 62.1 ventilation standard found in ASHRAE 62.1, Table 6-1.
4. Properly maintaining the pool chemistry to minimize the chloramine production in the water is a key step in minimizing airborne chloramines. A low pH in the pool water has been found to contribute to chloramine production in indoor pool facilities.

Chloramines (combined chlorine) depending on the stage in the chemical reaction are monochloramine, dichloramine and trichloramine. The chloramines, especially the trichloramines, are irritating to the eyes, nose and lungs. Trichloramines cause the "chlorine" smell and hang in the air directly above the pool water level, often causing competitive or frequent swimmers to have asthma like symptoms. High levels of chloramines will also cause corrosion to surfaces and equipment in the pool area.

Chloramines can usually be eliminated from the pool water by performing breakpoint chlorination with chlorine or superoxidation with a non chlorine oxidizer. Indiana Department of Health Swimming Pool Rule 410 IAC 6-2.1, Section 30(e) states: "The pool water shall be superchlorinated to breakpoint or superoxidized with a nonchlorine oxidizer, when the pool test kit reveals a combined chlorine (chloramine) concentration of five-tenths (0.5) parts per million (ppm) or greater." 410 IAC 6-2.1, Sec. 30 (g) states: "The pool shall be closed and remain closed during breakpoint chlorination until the chlorine concentration drops to the maximum level referenced in subsection (b)."

Breakpoint chlorination is the point at which enough free chlorine is added to break the molecular bonds, specifically the combined chlorine molecules, ammonia or nitrogen compounds. It takes a ratio of chlorine to ammonia atoms of 7.6 to 1 to reach breakpoint, other contaminants (i.e., bacteria, algae) are also present that must be oxidized, so 10 times the amount of combined chlorine must be added. Any excess



chlorine leftover will become the chlorine residual (FC).

To reach breakpoint, the following calculation is used:

Example: Calculate the chemical change to achieve Breakpoint Chlorination in 60,000-gallon pool with FC of 1.5 ppm and TC of 2.3 ppm. Using 67% Calcium Hypochlorite where the label states that 2 oz will produce a chemical change of 1ppm in 10,000 gallons of water:

STEP 1: Determine the amount of Combined Chlorine (CC)

Total Chlorine (TC) – Free Chlorine (FC) = Combined Chlorine (CC)

2.3 ppm – 1.5 ppm = **0.8 ppm**

STEP 2: Calculate the breakpoint Chlorination (BPC) amount

Breakpoint (BPC) = CC × 10

0.8 × 10 = 8.0 ppm

STEP 3: Determine the desired change amount

Desired Change = BPC – FC

8.0 ppm – 1.5 ppm = **6.5 ppm**

STEP 3: Determine the amount of chemical to add:

Amount of chemical from product label	**Actual Pool Volume**	**Desired Chemical Change**	**Total**
	60,000	6.5	
	÷ 10,000 from product label	÷ 1.0 ppm from product label	
2 oz.	× 6	× 6.5	78 oz

Convert answer to pounds: 78 ÷ 16 = 4.875 lbs; rounded to 5 pounds.

Steps 1 must be done using a DPD test, using the test kit instructions.

- Sodium hypochlorite (liquid) or lithium hypochlorite may also be used.
- Calcium hypochlorite is most commonly used because of the high available chlorine concentration and it retains its strength in storage.

- NOTE: When shocking a pool, the chlorine-based chemical used for shocking the water must be added all at once so that the concentration throughout the pool reaches breakpoint chlorination.

This is an "all or nothing" process. Not adding enough chlorine to reach breakpoint will make the problem even worse as the result is the formation of more chloramines and re-dissolving of chloramines back into the pool water. Continual "shocking" but not reaching breakpoint will result in the pool reaching a point of no return. Partial or complete draining of the pool water and refilling with fresh water may be the only remedy at this point. If an indoor pool facility has inadequate air exchange with outdoor fresh air, it will be necessary to add air circulation fans with doors and windows open to keep the air above the pool water level moving to prevent re-dissolving of nitrogen (by product of breakpoint chlorination) leading to more chloramine formation.

Please note that adding too much chlorine, beyond breakpoint, will yield high chlorine residual that may require the pool to remain closed until the free chlorine residual drops to an acceptable level as required in 410 IAC 6-2.1, Sec. 30(b).

Additionally, 410 IAC 6-2.1, Sec. 30 (k) states: "Chlorinated isocyanurates and cyanuric acid stabilizers shall not be used in any indoor pool." Stabilized chlorine compounds, such as DICHLOR or TRICHLOR may **not** be used for breakpoint chlorination or continuous chlorination in an indoor pool.

NON-CHLORINE OXIDIZERS

Non-chlorine oxidizers may be used instead of chlorine breakpoint chlorination, but the pool will still have to be superchlorinated periodically with a chlorine compound to kill off the bacteria that become resistant to constant exposure to low levels of disinfectant (chlorine or bromine). Non-chlorine oxidizer products will oxidize or destroy ammonia, nitrogen and some swimmer waste, but will not kill bacteria or algae.

Although an advertised advantage to using a non-chlorine oxidizer is the shut down time may be as little as one half-hour; however, 410 IAC 6-2.1-30(s) requires that "The pool shall be closed for a period equal to at least one (1) hour following the manual addition of chemicals."

If the manufacturer's label requires closure for more than one hour, then 410 IAC 6-2.1-30(h) states that "… the pool shall be closed and shall remain closed in accordance with the specifications on the product label."

Potassium monopersulfate is the ingredient used in most non-chlorine oxidizers. As an oxidizer, it reacts with contaminants and prevents combined chlorine from forming (short term). The use of potassium monopersulfate will result in false readings of chlorine for up to 6 hours as it oxidizes the iodide in the reagent as if it were combined chlorine. There is a reagent available to correct this.

The use of non-chlorine shock chemicals will also interfere with oxidation reduction potential (ORP) readings because it measures the oxidizing potential of the water. These products are an oxidizer causing high ORP readings, but again it is not a disinfectant. In the end, the required free chlorine residual level for disinfection in the pool water may be below the required level as stated in 410 IAC 6-2.1.

Other options:

1. Adding a medium pressure UV (ultraviolet) light or ozone system to eliminate chloramines in the pool water. Many large indoor pools used for competition (i.e., colleges and high schools) have had success with using UV. Please note that either system can only be permitted as supplemental disinfection to chlorine disinfection in the State of Indiana.

   In addition to the disinfection of bacteria and viruses, UV-C will oxidize chloramines. UV-C that is used for chloramine destruction in indoor pools and spas must be polychromatic that produces wavelengths of 200-350 nanometers with a minimum dosage (fluence) of 600 J/m^2 (60 mJ/cm^2). Multiple wavelengths are necessary to destroy chloramines as listed below:

Monchloramine	245 nanometers
Dichloramine	297 nanometers
Trichloramine	260 and 340 nanometers

2. Some municipal water companies are using chloramines for additional disinfection in the distribution system, so there may be significant background levels in the pool supply water. In this case, carbon filters may be an option to reduce the chloramines in the source water.
3. Increasing the amount of fresh water added daily to the pool.
4. For spas, it may be best to drain and refill with fresh water more often. Recommended drain and refill calculation is:

   Spa gallons ÷ 3 ÷ users per day = replacement interval (days)

The science behind the chloramine production is evolving and as science adds to the knowledge, this document will be changed, as appropriate, to reflect those improvements. For the most up to date information on chloramines in indoor swimming pools see the Environmental Public Health Division's swimming pool web page at www.pools.isdh.in.gov.

Resources:

- www.in.gov/isdh/files/How_To_Shock_The_Pool.pdf
- www.cdc.gov/healthywater/swimming/pools/irritants-indoor-pool-air-quality.html
- https://www.health.nsw.gov.au/environment/factsheets/Pages/breakpoint-chlorination.aspx