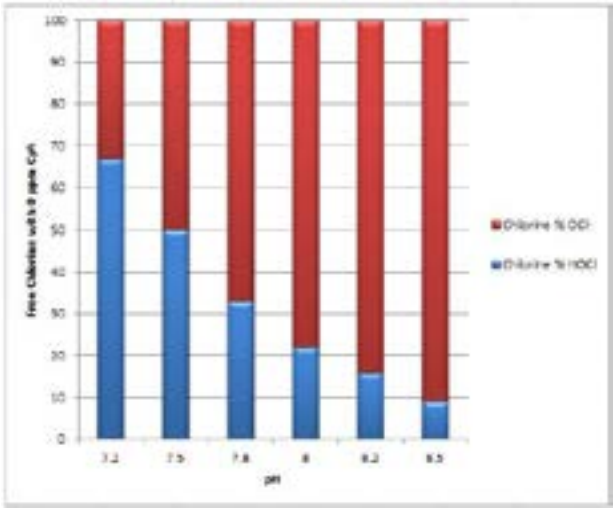
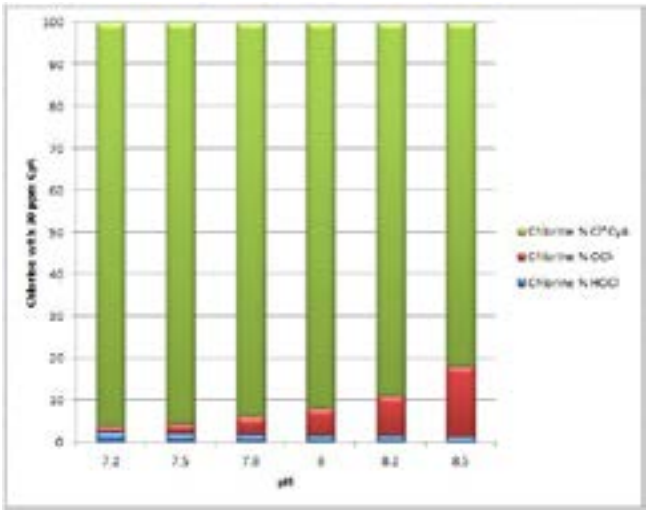
The Killing Strength of Chlorine

pH and Cyanuric Acid

onBalance – Que Hales, Doug Latta and Kim Skinner

Imagine finding out that something you have been taught in pool industry trade shows, classes and literature for half a century is incorrect. Yes, that is difficult to believe. But we have all seen it: the species distribution chart that shows hypochlorous acid (HOCl, the fast killing form of free chlorine) at about a 50:50 percent ratio with hypochlorite ion (OCl^-, the slower form) at a pH of 7.5. At a pH of 7.8 the HOCl is around 33 percent (see Chart 1 on the left). When the pH is 8.0, the HOCl content is about 22%, and at a pH of 8.2, it is 16%.





And why do they teach us that? To justify a standard with a mid-7 range pH in the pool. We have been taught that as the pH rises, the killing power of the chlorine is drastically reduced.

But is that really true? You may have wondered, since the pH rises (usually above 7.8) from week to week on most pools, especially salt or bleach pools... yet the water is NOT constantly turning green or cloudy! Why is that?

The fact of the matter is that the chemistry depicted in that chart is ONLY VALID IN UNSTABILIZED WATER! Think about that… how many outdoor, chlorinated pools are maintained without cyanuric acid? Only a small minority. Most of your pools have a reasonable amount of stabilizer, a pH that constantly drifts toward 8.2ish, and no algae.

So, what are the correct HOCl/OCl^- equilibria for STABILIZED pools? See Chart 2 on the right. In stabilized pools, suddenly the major determining factor on chlorine killing power is actually NOT the pH, but rather the cyanuric acid (CyA). This chart shows that pH actually plays only a very minor role in the chlorine activity in a stabilized pool. (Chart 2 represents HOCl/OCl^-/Cl·CyA when the CyA is 25 ppm and the total chlorine is 2 ppm.)

So, if cyanuric acid has such a major effect on the chlorine in pool water, what are the relative benefits of using it?

- First, of course, cyanuric acid stabilizes chlorine, or protects it from UV degradation. In direct sunlight, chlorine is lost relatively rapidly from pool water, but CyA shields the chlorine.
- CyA buffers pH at a higher pH range than bicarbonate. In other words, when acid is added to a non-stabilized pool the pH drops further than it would if the same amount of acid were to be added to a stabilized pool.
- CyA lowers the LSI – which, depending on the situation, may be a benefit or a disadvantage.
- The presence of CyA may slow the rate of formation of disinfection byproducts in swimming pool water.
- The use of CyA allows a higher level of chlorine without significantly higher HOCl, which may affect chemical toxicity or sensitivity, bleaching, or other related side effects.
- You can legitimately maintain a pH in the 7.8 to 8.2 range if desired, and still have all the killing power needed from the chlorine. (Note: pH levels in this range DO NOT cause cloudy water, eye irritation, or unsafe water... as long as the chlorine is in the right range and as long as the water is balanced.)

And what are the disadvantages resulting from CyA?

- CyA increases the C_T of chlorine. (C_T is the contact/time required to affect an organism by a specific amount...)
- CyA lowers the LSI (again, a benefit or drawback, depending)

When CyA is used, the amount of free chlorine should be maintained higher than in unstabilized pools. In the sunbelt, chlorine levels are often above 4 ppm in residential pools anyway, and many service techs and pro-active pool owners super-chlorinate their pools on a regular basis.

CyA will continue to be widely used in the industry, so it is important to understand what impact it has on the chlorine and other chemistry in the pool. We always feel that we should not sell pool professionals short: lets teach the right chemistry and let them learn it and use it as they deem best for their conditions and situations.

The EPA's chlorine limit of 1 to 4 ppm does not seem to be based on pool water that contains CyA. Higher amounts of chlorine should be allowed in stabilized pools, which in many cases would better help to ensure safe, healthy, and enjoyable pool water.

For more in-depth information on this topic go to our website (www.poolhelp.com) and click on ***onBalance***, then ***Research***, and then ***HOCl and OCl^- With and Without the Presence of Cyanuric Acid***