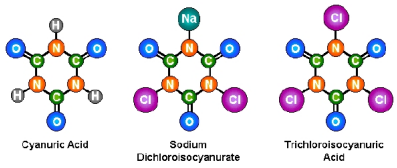
Without doubt, the most controversial topic in the Pool and Spa Industry is the existence, or otherwise, of "Chlorine Lock" arising from the use of cyanuric acid (also referred to as isocyanuric acid or, simply, CYA) as a chlorine stabiliser. The term is often bandied about without consideration of what it means, where it came from and whether it is indeed scientifically justified. With international interest growing on the back of legal proceedings in the US and South Africa, this Technical Information Bulletin is a timely reminder of the origins and nature of "Chlorine Lock".

Dichlor and Trichlor in Swimming Pools

Having the chemical structure illustrated below, cyanuric acid is a highly stable crystalline solid that decomposes above 360°C and is completely soluble in water.(1) After dissolution in a bucket of tap water, it can be added directly to pool water treated with one or more unstabilised chlorines. This category includes the soluble hypochlorites - sodium (liquid chlorine), calcium and lithium - gaseous chlorine, and chlorine generated electrolytically from salt. Alternatively, it can be added indirectly using one or both of the two stabilised chlorines, the rapidly dissolving sodium dichloroisocyanurate (dichlor) and the slowly dissolving trichloroisocyanuric acid (trichlor).



In 1958, dichlor and trichlor were introduced into the marketplace for swimming pool application.(2) Since that time, they have become the most widely used pool sanitisers in the US; Industry estimates put their share at around 75 to 80% of all sanitisers sold in the States. In contrast, the two stabilised chlorines barely make up 15% of the total Australian market, with liquid chlorine, calcium hypochlorite and salt chlorination the dominant forms of pool sanitation. A major contributory factor to this substantial difference between the US and Australian markets lies in the approach each country's health authorities have taken to the issue of "Chlorine Lock". Whereas many US states have adopted the view that cyanuric acid does not impair the bactericidal properties of chlorine (present as hypochlorous acid), Australian authorities have taken a much more restrictive stance on the issue.

This is reflected in Australian Standard AS3633-1989, the document that effectively governs the requirements for achieving and maintaining sanitary water conditions in private pools. The Standard states that the ideal concentration of cyanuric acid in pool water is between 30 and 50 ppm (mg/L), and that levels higher than 50 ppm retard the activity of chlorine against bacteria. It goes on to state that a pool should be at least partially drained if the CYA level exceeds this cut-off value.(3) Later in the document, it advises against the use of CYA in indoor pools and spas because there is no need for UV stabilisation in the absence of direct sunlight.(4) Irrespective of the veracity of CYA-induced "Chlorine Lock", this last statement has two major flaws. Firstly, a reasonable proportion of indoor pools are housed in enclosures with large expanses of glass that are regularly exposed to the sun. If anything, the UV radiation hitting the surface of the pool water is intensified by the glass, increasing the need for chlorine stabilisation. Secondly, the statement assumes that CYA build-up will be very much greater indoors, yet tests have shown this not to be the case.

It is important to note that, due to its extremely stable nature, cyanuric acid does not decompose in water. It can only be lost from pool water by splashout or dilution, irrespective of the pool's location. There are microorganisms commonly found in soil that metabolise CYA, breaking it down to simple nitrogen compounds and carbon dioxide, but these microorganisms cannot survive under conditions normally found in pools.

"Chlorine Lock" - An Historical Perspective

"Chlorine Lock" is the perceived ability of cyanuric acid to reduce the efficacy of chlorine against bacteria and other microorganisms; in essence, the chlorine is "locked up" in such a way that it can't perform its sanitising function. The origin of the "Chlorine Lock" theory can be traced back to scientific papers by Anderson in 1965,(5) and Fitzgerald and Der Vartanian in 1967.(6) In both, it was reported that cyanuric acid reduced the bactericidal activity of chlorine. For example, Fitzgerald and Der Vartanian6 found that the 99% kill time for Streptococcus faecalis bacteria by 0.5 ppm of chlorine at pH 7.4 and 20°C was less than 15 seconds in the absence of CYA. With 25 ppm of cyanuric acid present, 0.5 ppm of chlorine took 4 minutes to achieve the same kill; with 100 ppm present, the time had increased to 12 minutes.

However, there are two critical issues here. Firstly, the results in both investigations were obtained in a controlled environment using distilled water and pre-washed, artificially-cultured bacteria. Andersen (5) even concluded his paper with the quote, "... these results were obtained under laboratory conditions and caution should be used if extended to actual swimming pool operation", a statement conveniently overlooked by many advocates of "Chlorine Lock". Secondly, the negative effect of cyanuric acid on chlorine efficacy was only observed in the absence of ammonia and other nitrogenous compounds, both of which are known to have a substantial negative effect on the efficacy of chlorine. Indeed, Fitzgerald and Der Vartanian6 found that the 99% kill time for S.faecalis by 0.5 ppm of chlorine increased dramatically from

less than 15 seconds in the absence of ammonia, to around 20 minutes in the presence of 0.05 ppm ammonia. More importantly, when 100 ppm of cyanuric acid was added to a solution containing 0.075 ppm of ammonia, the 99% kill time of the chlorine was less than that for the same system in the absence of cyanuric acid. Similar findings were reported by Swatek et al,(7) who compared laboratory tests on distilled water with field tests on swimming pool water.

Field studies have revealed that levels of ammonia nitrogen in public pools are often far higher than the levels examined by Fitzgerald and Der Vartanian; one study in Southern Ontario reported mean concentrations of 0.25 ppm in swimming pools and 0.48 ppm in wading pools.(8) As such, chlorine in pools treated with cyanuric acid should outperform counterparts without stabiliser. This hypothesis was confirmed in field studies carried out by Swatek et al (7) and Vattimo.(9) In summarising the scientific literature supporting or refuting "Chlorine Lock", Mitchell (2) found that there was very little correlation between laboratory studies and actual swimming pool field trials. Reaching the same conclusion as Kowalski and Hilton, (10) he added that cyanuric acid levels in excess of 200 ppm had no impact whatsoever on a pool's sanitation provided that the chlorine residual was maintained between 2 and 3 ppm.

True "Chlorine Lock"

Whilst "Chlorine Lock" due to the presence of cyanuric acid has largely been disproved, the phenomenon does exist, but usually for a very different reason. It is widely accepted that nitrogenous wastes (urine, faecal matter, decomposing plant material, etc.) combine with chlorine in pools to form chloramines, the compounds most commonly responsible for bathers complaining of skin and eye irritations or unpleasant chlorine-like odours. These compounds decompose in a large excess of hypochlorous acid, achieved by the process of superchlorination or shocking. The fact that chloramines are of no practicable use as sanitisers, whilst also reducing the level of chlorine available to kill bacteria and algae, suggests that they are the true source of "Chlorine Lock" in many cases. As a matter of routine pool maintenance, a Total Chlorine test using DPD #3 or DPD #4 should ALWAYS be performed. For pools where chlorine (or bromine) residuals have been difficult to maintain for some time, a Chlorine Demand Test should also be performed to ascertain the "breakpoint" dosage rate.

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