CORROSION AND SWIMMING POOLS

Recent studies (see Attached Research Report) of free chlorine levels, cyanuric acid and salt (chlorides) in the pool water have reached the following CONCLUSIONS about corrosion rates in pools with electrolytic chlorine generators:

1. At levels below 3000 ppm (mg/l), chlorides in the water had an "INSIGNIFICANT EFFECT" on TYPE 304 Stainless Steel.
2. Type 304 Stainless is, however, extremely susceptible to rapid corrosion at high free chlorine levels (20 ppm), regardless of the Source of chlorine.
3. Field Studies confirmed that pools with corrosion problems unknowingly being operated at very high chlorine levels. Most common test kits lose their accuracy over 4.0 to 5.0 ppm free chlorine. Pool Owners did not realize their pools carried excessively high chlorine levels.
4. Moderate levels of Cyanuric Acid effectively inhibit corrosion caused by high chlorine levels.

Experts in pool water chemistry generally agree that WATER BALANCE GUIDELINES, using LANGELIERS INDEX, will create a HAPPY pool environment and a long service life for the equipment on the pool. Today's modern plastics technology has provided a real strategic advantage for many products (ie., pumps, filters, valves). However, many uses still exist for stainless steel (tanks, ladders), cupronickel (heat exchangers) and other metals (motors, etc.).

Awareness of the effect of high chlorine levels on metals and the limitations of test kit ranges will eliminate the corrosion issue, allowing the pool owner the substantial advantages of automation of the water sanitizing process.

Lectranator; a simple answer to the pool owner's biggest challenge!

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In 1982 ELTECH Systems Corporation, an affiliate of Diamond Shamrock, initiated a research effort that focused on the following three factors, which were believed to contribute to corrosion:

1. Chlorine Level
2. Cyanuric Acid
3. Salt

By combining long-term laboratory tests, field evaluations, studies by Professor Robert F. Hehemann, Ph.D. (1), and an analysis of reported incidents of corrosion dating back to 1979, they reached the surprising conclusions that follow.

Chlorine Level

At the request of ELTECH Systems Corporation, Professor Hehemann conducted quantitative measurements of corrosion rates of stainless steel in simulated pool water. His finding indicated that high chlorine concentration was the key factor causing corrosion. Although Professor Hehemann's report was issued to ELTECH in 1982, there was a reluctance to publish his finding until a comprehensive study had been completed.

Long-term laboratory corrosion studies were then conducted in two systems: a 400-gallon tank system and a 5000-gallon test pool system. The 400-gallon system was used to demonstrate that a corrosion-induced leak can occur in a 304 stainless steel filter within eight days of exposure to pool water containing 20 ppm chlorine and no Cyanuric acid stabilizer. Similar results were obtained in the test pool system. With free chlorine levels maintained at 30 ppm, without stabilizer, every stainless steel filter tested developed rust and pits within a few days. By contrast, stainless steel filters showed no sign of corrosion when exposed to pool water containing 1.0-3.0 ppm chlorine throughout a one-year test period.

A number of controlled corrosion tests were conducted on stainless steel samples. A 304 L stainless steel rod exposed to 20 ppm chlorine developed pitting corrosion within one week, while a sample exposed to standard levels of chlorine remained free of corrosion.

A variety of typical 304 stainless steel pool filters were found to exhibit pitting corrosion along weld lines and in non-weld areas, when exposed to 20 ppm chlorine. These same filters were found to be free from attach when exposed to standard levels of chlorine.

Field studies were conducted following the results of the laboratory tests, which suggested high chlorine as a prime cause of corrosion. An independent survey of pool owners in southern Florida showed that they all believed they maintained chlorine at low, safe levels. However, when their pool water samples were analyzed, using a dilution technique, 75% of the pools chlorinating by electrolysis had chlorine levels above the upper range of their test kits. This situation occurs because pool owners are generally unaware of the fact that most colorimetric chlorine test kits lose accuracy above 3 to 4 ppm. The test kit color may indicate 3 ppm while the actual value may be much higher.

A similar survey in Texas showed 83% of the pools tested had chlorine levels above the upper range of the test kit. Many of these consumers had operated their chlorinators for extended periods during the cool winter months without adjusting for the seasonal variation in chlorine demand. This resulted in very high chlorine levels. One Texas pool showed an incredible 250 ppm free chlorine! Many of these same pool owners experienced severe corrosion problems.

The combined results of Professor Hehemann's studies, ELTECH's long-term corrosion studies, and the field studies in Florida and Texas, confirm that excessive chlorine is a primary cause of corrosion to pool equipment on pools equipped with electrolytic chlorinators.

Cyanuric Acid

The second factor studied was cyanuric acid. Theory suggests if high chlorine causes corrosion, then materials, which react with chlorine, should inhibit corrosion. Cyanuric acid reacts with chlorine to form a less active form of available chlorine. For example, it is reported that the presence of cyanuric acid will lower the rate at which chlorine will kill certain resistant bacteria. (2)

ELTECH's research shows that cyanuric acid also inhibits the corrosive action of chlorine on stainless steel. Figures 1 and 2 show that even small amounts of cyanuric acid (10 and 20 ppm respectively) can stop corrosion caused by a high level of chlorine (13 and 45 ppm respectively). Addition of cyanuric acid slows down and eventually stops the periodic spikes in the filter ORP (Oxidation Reduction Potential). These periodic spikes are caused by individual corrosion pits activating and then healing over. This phenomenon or regular oscillation in ORP has been reported previously in the scientific literature on corrosion. However, the effect of cyanuric acid on corrosion appears to be a new discovery.

While cyanuric acid can protect the pool from corrosion, loss of cyanuric acid can increase the risk of corrosion problems. A U.S. patent No. 4,075,094 shows that very high levels of chlorine can rapidly destroy cyanuric acid. Even moderately high levels of chlorine may destroy the stabilizer that would normally protect the pool against corrosion.

Salt

It is common knowledge that salt causes corrosion. It is, therefore, not surprising that pool owners might be concerned about adding salt to their pools in order to operate their electrolytic chlorinators. This concern was addressed early in the technical development of Diamond Shamrock's electrolytic ch1orinator.

Experience with a comparable electrolytic unit from Australia suggested that there was a threshold level of salt that could activate corrosion. This threshold level was reported to be about 6000 ppm.

During the summer of 1982, ELTECH Systems Corporation enlisted the services of an independent consultant, Mr. Boris Petrov (3), to study the commercial swimming pool industry. As part of his study he obtained dissolved salt analyses from thirty-three commercial pools in California. He found that eighteen of these pools had dissolved salt concentrations exceeding 1500 ppm and that twelve of them had more than 2000 ppm dissolved salt.

It is significant to note that none of the owners of operators of these pools reported any unusual corrosion problems.

This threshold of salt effect was studied by Professor Hehemann. He confirmed that the effect of dissolved salt on corrosion was insignificant in the 1500 to 3000 ppm range.

In summary, these studies have demonstrated that excessive chlorine is, indeed, a key factor in corrosion of pool equipment. In addition, they have revealed that cyanuric acid inhibits the corrosive effects of excessive chlorine and that low levels of dissolved salt (below 3000 ppm) have a relatively insignificant effect on corrosion.

This article is based on a technical report prepared by Mr. D. S. Novak of ELTECH Systems Corporation titled "Review of Factors Influencing Corrosion in Swimming Pools," June 20, 1984.

(1) Department of Metallurgy and Materials Science, Case Western Reserve University Cleveland, Ohio.
(2) Robinton, Elizabeth D., and Eric W. Mood, An Evaluation of the Inhibitory Influence of Cyanuric Acid upon Swimming Pool Disinfection, American Journal of Public Health, Vol 57 (2), 1967.
(3) Mr. Boris Petrov, President, Petrov Group, 21835 Black Mountain Road, Los Altos, California